PAPE–DAWSON

Specifications for

GUAJOLOTE EAST LIFT STATION & FORCE MAIN

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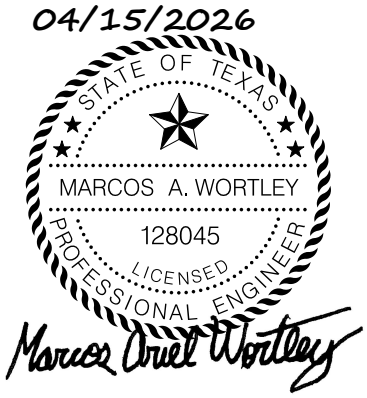
SPECIFICATIONS

APRIL 2026



APRIL 2026
Marcos A. Wortley, PE 128045

SECTIONS 02316, 03055, 03100, 03211, 03310, 03350, 03390, 03600, 05500, 05512

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*The technical and material specifications for this project are published by SAWS and TCEQ. Reference to those documents shall apply as if the entire specification was reproduced herein. Applicable modifications to this document and additional specifications are included herein.

SPECIAL CONSTRUCTION CONDITIONS

SC-1.0 Except where bid items are specifically provided in the Proposal, payment to the CONTRACTOR to accommodate the requirements specified herein shall be considered to be subsidiary to the various items of work under this contract and no direct payment will be made.

SC-2.0 The CONTRACTOR shall perform all work necessary for the proper installation and functioning of the various types and sizes of pipe, equipment and associated appurtenances at the locations shown on the plans.

SC-3.0 The CONTRACTOR shall obtain all necessary permits that are required for the project. Any fees required for the obtaining of permits will be considered subsidiary and no additional direct payment will be made to the CONTRACTOR.

SC-4.0 The use of explosives of any kind for this project is strictly prohibited.

SC-5.0 The CONTRACTOR, at his/her own expense, is responsible for performing quality control inspection and testing to assure compliance with all Contract Documents. All observation/inspection of the work, and quality assurance testing performed by the Owner or by Owner's Consultant and/or Engineer is for the sole benefit of Owner and CONTRACTOR agrees not to rely thereon for any reason.

SC-6.0 Trench protection will be required on this project. The CONTRACTOR will be required to provide the Owner and Engineer copies of a trench protection plan that meets the more stringent rules of SAWS, TCEQ, OSHA or other applicable agency. The CONTRACTOR shall be solely responsible for the development of a Site Safety and Health Plan for the project. Neither the professional activities of the Consultant, nor the presence of the Consultant or its employees and subconsultants at a construction/project site, shall relieve the CONTRACTOR of its obligations, duties and responsibilities including, but not limited to, construction means, methods, sequence, techniques or procedures necessary for performing, superintending and coordinating the Work in accordance with the contract documents and any health or safety precautions required by any regulatory agencies. The Consultant and its personnel have no authority to exercise any control over any construction contractor or its employees in connection with their work or any health or safety programs or procedures. The Owner agrees that the CONTRACTOR shall be solely responsible for jobsite safety, and warrants that this intent shall be carried out in the Owner's contract with the CONTRACTOR.

SC-7.0 The CONTRACTOR shall be responsible to make all necessary adjustments resulting from the installation of the "lift station" pump and motor assembly in the relevant electrical and control equipment, as well as any adjustments to project equipment, materials and dimensioning such as, but not limited to, the wet well, piping, and valves, etc. at no additional costs to the Owner.

SC-8.0 All valve assemblies, including gate valves, check valves, plug valves and air release valves shall be furnished complete and adequate for the specified or shown purpose, and shall include all essential components of equipment, together with all mountings and other appurtenances normal and necessary for proper installation and operation, whether shown or not.

SC-9.0 It is the responsibility of the CONTRACTOR to coordinate and provide adequate electrical power supply to the lift station with New Braunfels Utilities. The costs to extend power lines, erect power poles, electrical duct banks, pole supports and foundations, transformers, etc. shall be considered subsidiary to the cost of the project.

SC-10.0 Revegetation shall be in accordance with TxDOT Items 160, 164, 166, 168, 169, and 170 and as shown in the plans. Revegetation is required for all disturbed areas; however, the bid item pay limits are restricted to the easement and public right-of-way areas for the gravity sewer mains, force mains, unimproved areas of the access road easements, electrical easement and water service line easement. Areas other than those listed that may be impacted by construction activities such as staging and storage areas and areas outside of the prescribed easements shall be revegetated with 4" of topsoil and hydroseeding at the CONTRACTOR's expense.

SC-11.0 It is understood and agreed that CONTRACTOR has, by careful examination, satisfied himself/herself as to the nature and location of the Work, the conformation of the ground, the character, quality and quantity of the materials to be encountered, the character of equipment and facilities needed preliminary to and during the prosecution of the Work, the general and local conditions, and all other matters which can in any way affect the Work under this Agreement. No verbal agreement or conversation with any officer, agent or employee of Owner either before or after the execution of this Agreement shall affect or modify any of the terms or obligations herein contained.

SC-12.0 The CONTRACTOR shall be responsible for payment of all related Water Impact Fees, Water Supply Development fees and water meter installation fees associated with the cost of the construction of the sanitary sewer lift station. These fees will be considered as a no separate pay item and subsidiary to the Lift Station bid item.

SC-13.0 CONTRACTOR shall be solely responsible for coordinating and/or negotiating with the property owner as necessary to secure an area for the staging and storing of materials and equipment. Any cost or expense associated with securing a staging and storage area shall be the CONTRACTOR's sole responsibility.

SC-14.0 Construction Inspections and Consultant Observation: During construction, the contractor shall coordinate periodic site inspections by the Owner's Inspector. The Contractor shall coordinate the above noted Owner's inspections every (2) weeks. The Contractor shall notify the Inspector of pending features of the Lift Station that will require specific inspection and indicate to the Inspector if the Owner's electrical, civil or mechanical inspection staff are required for the subsequent lift station inspection.

SC-15.0 The Contractor shall coordinate with the Structural Engineer for the engineer to perform construction observations of concrete structures including foundations, excavations, steel reinforcement, foundation pad material, prior to placing concrete.

SC-16.0 The Contractor shall coordinate with the Electrical Engineer for periodic construction observations during the installation of all electrical equipment, including but not limited to, conduits, conductors, grounding, instrumentation, and control panels.

SC-17.0 The Contractor shall coordinate with the Civil Engineer for periodic construction observations for the installation of the wetwell, pumps, piping, and pavements during construction.

SC-18.0 The Owner's Inspection staff and Consultants shall note deficiencies during construction observation and provide a report to the Contractor.

SECTION 01010

SUMMARY OF WORK

PART 1 - GENERAL

1.01 GENERAL

A. The work of this Contract comprises the construction of one (1) sanitary sewer lift station; 10" HDPE (DIPS) DR 13.5 force main, connection to an existing manhole, gravity main, and manhole along with associated equipment, materials, fittings and appurtenances as shown on the plans.

B. All work done under this Contract shall conform to local ordinances. CONTRACTOR shall arrange and pay all cost of permits and inspection fees, and shall confine his operations to the limits set by law.

C. It is the intent of the Owner to award this project to one CONTRACTOR.

D. Portions of this project may be subject to review and acceptance by various agencies. The CONTRACTOR will be required to coordinate with these agencies for such items as issuance of permits or work orders, inspections during construction, final acceptance, etc. The agencies for this project that may require coordination include, but are not limited to, the following:

1. Texas Commission on Environmental Quality (TCEQ)

E. All work shall be performed in accordance with, but not limited to, the following agencies:

1. San Antonio Water System (SAWS) Lift Station Design & Construction Guidelines
2. Texas Commission on Environmental Quality (TCEQ)
3. Texas Department of Transportation (TxDOT)

1.02 EXISTING CONDITIONS

A. Locate and protect all existing utilities.

B. Protect all existing public and private aboveground fixtures.

1.03 WORK SEQUENCE

A. Coordinate the construction schedule and operations with the Owner's Representatives.

1.04 CONTRACTOR'S USE OF PREMISES

A. CONTRACTOR shall limit his use of the premises for Work and storage, to allow for work by other CONTRACTORS.

B. Assume full responsibility for the protection and safekeeping of products under this Contract, stored on the site.

C. Move any stored products, under CONTRACTOR's control, which may interfere with operations of the Owner or separate CONTRACTOR.

D. Obtain and pay for the use of additional storage or work areas needed for operations.

END OF SECTION

SECTION 01300

SUBMITTALS

PART 1- GENERAL

1.01 DESCRIPTION OF WORK:

This section describes the requirements for preparing and presenting submittals that are necessary for the execution of this contract. Requirements within the following subject areas are included:

A. Definitions

B. Procedures

C. Product Data

D. Shop drawings

E. Samples

F. Manufacturer's certificates

1.02 DEFINITIONS:

A. Product Data and Shop Drawing, General Definition
Drawings, diagrams, illustrations, brochures, schedules, bills of materials and other data prepared by the CONTRACTOR, his subcontractors, suppliers or distributors, or equipment manufacturers and fabricators; illustrating the manufacture, fabrication, construction, or installation of the Work or a portion thereof.

B. Shop Drawings
Assembly and fabrication drawings, bills of materials for items shop fabricated exclusively for this project. In addition, shop drawings should show fabrication details of each part, the assembly of each part and how each part and/ or assembly is integrated into the project including existing parts or assemblies.

C. Manufacturer's Representative
A representative from the manufacturer's plant with 5 years of experience in the actual problems of manufacturing, installing and operating the particular product. Sales representatives or agents of the manufacturer will not be acceptable.

D. Working Drawings
CONTRACTOR-prepared plans for temporary structures and facilities. Working drawings for elements of work that may affect the safety and health of persons or property will be certified by an engineer licensed in the state of Texas. Calculations, as necessary, will accompany working drawings.

1.03 PROCEDURES:

A. CONTRACTOR's Responsibilities

1. Submit a schedule of specified submittals for all materials to be installed for the Project to the Engineer within 14 calendar days of receipt of the notice to proceed.

2. Submissions will be made to the Engineer's office. Data and correspondence that originates with subcontractors and suppliers must be submitted to the Engineer through the CONTRACTOR. CONTRACTOR to approve all submittals prior to submission.

3. The CONTRACTOR will submit dimensional and layout drawings and product data, certified correct for construction, for review by the Engineer.

4. Submit shop drawings and product data in accordance with the approved submittal schedule. Also submit shop drawings to the Engineer for review prior to their need in the Work, allowing sufficient time for the Engineer's review and response.

   a. The CONTRACTOR shall limit each submittal to only one item of material or equipment for review by the Engineer.

5. The CONTRACTOR will make specific mention of those items that vary from the requirements of the Plans and Specifications in the letter of transmittal.

6. Submit shop drawings and product data covering related items of equipment or material or integrated systems of equipment or material at the same time. Partial submissions will not be accepted.

7. The CONTRACTOR will coordinate shop drawings and product data with drawings previously submitted, with drawings being prepared, and with drawings and data previously approved. All such coordination shall be indicated by reference.

8. The CONTRACTOR will assign a sequential number to each submittal (1, 2, 3, etc.). The CONTRACTOR shall assign each piece of material or equipment its own submittal number. Multiple items under the same submittal number will not be accepted. Re-submittals will be identified with their original number followed by a sequential letter (A, B, C, etc.). For example, submittal 12-C is the third submittal of the twelfth item for the project.

9. The CONTRACTOR will not deliver to the site, storage, or incorporate into the Work, any materials or equipment for which approved submittals have not been obtained.

B. Engineer's Review:

1. The Engineer will conduct a review after its receipt in the Engineer's office so as not to create delay. This review will be for general conformance, subject to the requirements of the Contract Documents, and will be an effort to assist the CONTRACTOR to discover errors and omissions in submittals.

2. Engineer's review or other appropriate action regarding CONTRACTOR's submissions will be only to check conformity with the design concept of the Project and for compliance with the information contained in the Contract Documents and shall not extend to means, methods, techniques, sequences or procedures of construction (except where a specific means, method, technique, sequence or procedure of construction is indicated in or required by the Plans and Specifications) or to safety precautions or programs incident thereto. The review and approval of a separate component item will not indicate approval of the assembly into which the item is functionally integrated. CONTRACTOR shall make corrections required by Engineer, and shall return the required number of corrected copies of Shop Drawings to the Engineer. CONTRACTOR may be required to resubmit as required revised Shop Drawings or Samples for further review and approval. CONTRACTOR shall direct specific attention in writing to any new revisions not specified by CONTRACTOR on previous CONTRACTOR submissions.

3. The Engineer's review does not relieve the CONTRACTOR of the obligation and responsibility to coordinate the Work and plan the details of the Work.

4. The Engineer reserves the right to require written confirmation from the CONTRACTOR that the comments placed on submittals stamped "Reviewed" will be implemented.

5. Review by the Owner or Engineer will not be construed as relieving the CONTRACTOR of the responsibility for the accuracy, proper fit, functioning, or performance of the Work.

1.04 PRODUCT DATA:

A. Product data, including materials reproduced from manufacturer's product catalogs, will not be larger than 8½" by 11" in size.

B. Catalog data will be explicit with regard to the name of the manufacturer and to the details of the products being furnished. It will also be complete enough to enable the Engineer to determine that the products being submitted conform to the requirements of the specifications.

C. For submittals with more than one style or size of a product on a sheet, the CONTRACTOR will clearly indicate which product is being submitted for review.

D. The CONTRACTOR will submit one (1) electronic copy of all product data to the Engineer.

1.05 SHOP DRAWINGS:

A. The CONTRACTOR shall reasonably check and verify all field measurements and will submit to the Engineer for review and approval. These shop drawings will bear a stamp from the CONTRACTOR that indicates that the CONTRACTOR has reviewed the shop drawings and that the submittal is complete and in compliance with Contract Documents.

B. The CONTRACTOR will submit detailed drawings and descriptions of proposed deviations from details or component arrangement indicated on the Plans.

C. Single line drawings will not be acceptable. Copies of the Plans will not be accepted for submission as drawings, nor will catalog numbers alone of materials or equipment.

D. The CONTRACTOR will submit one (1) electronic copy of each shop drawing to the Engineer for review.

1.06 SAMPLES

The CONTRACTOR will furnish samples of items and materials as required. Samples shall be submitted to the Engineer in duplicate. Each sample will be properly labeled and identified by providing the following:

A. Date

B. Job name for which it is offered

C. Specification section and paragraph

C. CONTRACTOR’s name

E. Supplier and trade name

E. Other data indicating conformance to specifications.

1.07 MANUFACTURER'S CERTIFICATES AND AFFIDAVITS:
Where specified in the Plans and Specifications that a certificate and affidavit shall be submitted to the Engineer for review of a particular product, or component of a product, such submittals shall be made in accordance with the following:

A. A certificate submitted for a product, or component of a product, indicates test results proving that product, or component of a product, meets the requirements of

the standard specified in the Plans and Specifications.

B. An affidavit consisting of a sworn statement by an official of the company manufacturing the product indicating that the information on the certificate is true and accurate shall accompany the certificate.

C. A statement from the CONTRACTOR, or his subcontractors, suppliers, or other agent which indicates that a particular item of equipment, or product, or component of a product, meets the requirements of the Plans and Specifications shall not be considered as certificate and will not be approved.

1.08 MANUFACTURER'S REPRESENTATIVE

The CONTRACTOR will include in the contract price the cost of furnishing competent and experienced manufacturer's representatives to represent the manufacturer on all products furnished and to assist the CONTRACTOR to install the products in conformity with the Plans and Specifications.

1.09 MISCELLANEOUS SUBMISSIONS:

A. Work plans - Submit 1 copy

B. Accident reports - 1 copy

C. Inspection and test reports - 1 copy

D. Guarantees and Warranties - 1 copy (Originals)

E. Operation and Maintenance Manuals - 1 copy

F. Course of Action Plan (Fuel Spill or Other Substances)

1. The CONTRACTOR must submit the Course of Action Plan (Fuel Spill or Other Substances) to the Owner prior to start of construction.

2. With regard to the accidental spill of fuel the Plan must address the procedures required by applicable regulations and laws.

PART 2 - PRODUCTS (Not used)

PART 3 - EXECUTION (Not used)

END OF SECTION

SECTION 01511

TEMPORARY UTILITIES

PART 1 - GENERAL

1.01 SUMMARY

A. Provide connections as necessary for temporary utilities.

1.02 TESTING

A. All power, water, light, ventilation, or heat required for completion and testing of the work shall be paid for by the CONTRACTOR.

B. All collection and disposal of refuse, debris, garbage and temporary sanitary sewer facilities from the work area shall be paid for by the CONTRACTOR.

C. Comply with Federal, State and local codes and regulations and with utility company requirements.

PART 2 - PRODUCTS

2.01 MATERIALS, GENERAL

A. Materials and equipment may be new or used, but must be adequate in capacity for the required usage, must not create unsafe conditions, and must not violate requirements of applicable codes and standards.

2.02 TEMPORARY ELECTRICITY AND LIGHTING

A. Provide connections as necessary, size and provide service required for power and lighting. CONTRACTOR to pay the costs of power used.

B. Install circuit and branch wiring, with area distribution boxes located so that power and lighting is available throughout the construction by the use of construction-type power cords.

C. Provide adequate artificial lighting for all areas of work when natural light is not adequate for work, and for areas accessible to the public.

D. CONTRACTOR shall provide for his extension cords and any additional lighting that may be required to complete his work.

E. Prior to final inspection remove temporary lamps and install new lamps if permanent fixtures were used for temporary lighting.

2.03 TEMPORARY HEAT AND VENTILATION

A. Provide temporary heat and ventilation as required to maintain adequate environmental conditions to facilitate progress of the Work, to meet specified minimum conditions for the installation of materials, and to protect materials and finishes from damage due to temperature or humidity.

B. Provide adequate forced ventilation of enclosed areas for curing of installed materials, to disperse humidity, and to prevent hazardous accumulations of dust, fumes, vapors or gases.

C. Portable heaters shall be units meeting applicable codes complete with controls. Pay all costs of installations, maintenance, operation and removal, and for fuel consumed.

D. Provide connections as necessary; extend and supplement with temporary units as required to comply with requirements. Pay all costs of installation, maintenance, operation and removal. CONTRACTOR to pay costs of fuel used from the existing system.

2.04 TEMPORARY TELEPHONE SERVICE (NOT USED)

2.05 TEMPORARY WATER

A. Make connections to existing facilities, provide water for construction purposes. CONTRACTOR to pay costs of water used.

B. Install branch piping with taps located so that water is available throughout the construction by the use of hoses. Protect piping and fittings against freezing.

C. CONTRACTOR shall provide distribution hoses as required to complete his work.

2.06 TEMPORARY SANITARY FACILITIES

A. Provide and maintain adequate temporary outdoor toilet facilities for use of persons working at the Site.

B. Keep toilets clean and in sanitary condition. Provide toilet tissue in suitable holders. Comply with applicable legal and health requirements.

C. Remove temporary toilets when construction is completed.

D. Existing plumbing facilities shall not be used by construction personnel.

2.07 TEMPORARY FIRE PROTECTION

A. Observe and enforce throughout the work during the whole period of construction all requirements of the local City Fire Marshal and Insurance Authorities to minimize the fire hazard during the progress of the work.

B. Make connections to existing facilities, provide water for fire protection purposes; CONTRACTOR to pay costs of water used.

C. Install branch piping with taps located so that water is available throughout the construction by the use of hoses. Protect piping and fittings against freezing.

PART 3 - EXECUTION

3.01 GENERAL

A. Maintain and operate systems to assure continuous service.

B. Modify and extend systems as work progress requires.

C. CONTRACTOR shall be responsible for coordinating material storage, parking and fencing with the Owner.

D. CONTRACTOR shall be solely responsible for providing temporary security systems to protect equipment, materials, etc. in the construction area.

3.02 REMOVAL

A. Completely remove temporary materials and equipment when their use is no longer required.

B. Clean and repair damage caused by temporary installations or use of temporary facilities.

C. Restore existing facilities used for temporary services to specified, or to original, condition.

END OF SECTION

SECTION 02010

SUBSURFACE INVESTIGATION

PART 1 - GENERAL

1.01 SUBSURFACE SOIL INVESTIGATION

A. A geotechnical investigation has been prepared for the sole purpose of the design of the wetwell. It should be noted that soil and/or rock conditions and characteristics can differ within the limits of the lift station site. The CONTRACTOR is encouraged to perform its own geotechnical investigation prior to beginning of the project.

B. CONTRACTOR is invited and encouraged to make his own interpretation and evaluations and by starting work shall be assumed to have fully accepted responsibility for the subsurface conditions that may hereafter be encountered in performing the excavation work.

C. CONTRACTOR is expected to examine the project site and the record of investigation and make, to whatever extent they deem appropriate, his own investigation of existing subsurface conditions to determine the nature, kind and character of materials to be encountered. Extra payment will not be authorized for work which should have been anticipated or could have been anticipated upon careful examination of the site, or upon soil investigation, or upon consideration of factors generally recognized as being inherent in excavation work of the nature indicated by the Plans and Specifications.

D. Advise Engineer of discovery of any unknown or undetermined items.

END OF SECTION

SECTION 02110

SITE CLEARING

PART 1 - GENERAL

1.01 DESCRIPTION

A. Scope: CONTRACTOR shall furnish all labor, materials, equipment and incidentals required to perform all clearing and grubbing as shown and specified.

B. The work covered by this Section consists of removing and disposing of trees, stumps, brush, roots, shrubs, vegetation, logs, and rubbish, including the removal of selective vegetation; removal of all poisonous vegetation, obnoxious shrubs and vines; protection of trees and plants designated to remain; and the removal of all trash and related materials and other objectionable material from the site as required to perform the work.

1.02 RELATED SECTIONS

A. Section 02221, Site Earthwork

1.03 QUALITY ASSURANCE

A. Codes and Standards
State and local laws and code requirements shall govern the hauling and disposal of trees, shrubs, stumps, roots, rubbish, debris and other matter. Nothing contained herein shall be construed as permitting work that is contrary to such rules, regulations and codes.

1.04 JOB CONDITIONS

A. Protection:

1. Streets, roads, adjacent property and other works and structures shall be protected throughout the entire project. CONTRACTOR, at his expense, shall restore to original condition, satisfactory to the Engineer, damaged facilities caused by the CONTRACTOR's operations.

2. Trees, shrubs and grassed areas designated to remain shall be protected by fences, barricades, wrapping or other methods as specified in related Sections. Equipment, stockpiles, etc., shall not be permitted within tree branch spread. Trees shall not be removed without authorization of the Engineer unless shown or specified.

1.05 GUARANTEE

A. CONTRACTOR shall guarantee that work performed under this Section will not permanently damage trees, shrubs, turf or plants designated to remain, or other adjacent work or facilities. If damage resulting from CONTRACTOR's operations appears during the period up to eighteen (18) months after completion of the project, the CONTRACTOR shall replace damaged items at no cost to the Owner.

PART 2 - PRODUCTS (omitted)

PART 3 - EXECUTION

3.01 CLEARING AND GRUBBING

A. Limits of clearing shall be all areas shown on the plans where proposed construction is to occur and as directed by the Engineer. These areas may include proposed street rights-of-way, and drainage and utility easements. Trees to be removed or relocated within the site shall be designated by the Engineer prior to commencement of clearing operations. The CONTRACTOR shall be required to survey and layout all proposed improvements within the Project area and notify the Engineer prior to any tree removal necessary for the execution of the work.

B. Except as noted in Paragraph 3.01.A of this Section, CONTRACTOR shall remove from the site and satisfactorily dispose of all trees, shrubs, stumps, roots, brush, masonry, rubbish, scrap, debris, pavement, curbs, fences and miscellaneous other structures not covered under other Sections as shown, specified or otherwise required to permit construction of the new work.

C. Burning on site shall not be allowed unless allowed by authorities having jurisdiction, and the Owner. If allowed, on-site burning shall be in complete accordance with rules and regulations of local authorities having jurisdiction, and the Owner.

D. Trees and shrubs shall be trimmed when doing so will avoid removal or damage. Trimmed or damaged trees shall be treated and repaired by persons with experience in this specialty who are acceptable to the Engineer. Trees and shrubs which are intended to remain and which are damaged beyond repair, or removed, shall be replaced by the CONTRACTOR at no cost to the Owner.

E. Air pollution caused by dust and dirt shall be controlled and comply with governing regulations.

END OF SECTION

SECTION 02200

SITE PREPARATION

PART 1 - GENERAL

1.01 DEFINITIONS

A. Interfering or Objectionable Material: Trash, rubbish, and junk; vegetation and other organic matter, whether alive, dead, or decaying; topsoil.

B. Clearing: Removal of interfering or objectionable material lying on or protruding above ground surface.

C. Grubbing: Removal of vegetation and other organic matter including stumps, buried logs, and roots greater than 2 inches caliper to a depth of 6 inches below subgrade.

D. Scalping: Removal of sod without removing more than upper 3 inches of topsoil.

E. Stripping: Removal of topsoil remaining after applicable scalping is completed.

F. Project Limits: Areas, as shown or specified, within which Work is to be performed.

1.02 SUBMITTALS

A. Shop Drawings: Drawings clearly showing clearing, grubbing, and stripping limits.

1.03 QUALITY ASSURANCE

A. Obtain Owner's approval of staked clearing, grubbing, and stripping limits, prior to commencing clearing, grubbing, and stripping.

1.04 SCHEDULING AND SEQUENCING

A. Prepare site only after adequate erosion and sediment controls are in place. Limit areas exposed uncontrolled to erosion during installation of temporary erosion and sediment controls.

1.05 RELATED WORK

Related work not included in this section can be found in the following sections.

A. Section 02221, Site Earthwork.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 GENERAL

A. Clear, grub, and strip areas actually needed for staging area or site improvements within limits shown or specified.

B. Do not injure or deface vegetation that is not designated for removal.

3.02 LIMITS

B. As follows, but not to extend beyond Project limits.

1. Excavation Including Trenches: 5 feet beyond top of cut slopes.

2. Fill:
   a. Clearing and Grubbing: 5 feet beyond toe of permanent fill.

   b. Stripping and Scalping: 5 feet beyond toe of permanent fill.

3. Staging Area:
   a. Clearing: 5 feet beyond perimeter.

   b. Scalping and Stripping: Not required.

   c. Grubbing: Around perimeter as necessary for neat finished appearance.

B. Remove rubbish, trash, and junk from entire area within Project limits.

3.03 CLEARING

A. Clear areas within limits of construction.

B. Fell trees so that they fall away from facilities and vegetation not designated for removal.

C. Cut stumps not designated for grubbing flush with ground surface.

D. Cut off shrubs, brush, weeds, and grasses to within 2 inches of ground surface.

3.04 GRUBBING

A. Grub areas within limits of construction.

3.05 SCALPING

A. Do not remove sod until after clearing and grubbing is completed and resulting debris is removed.

B. Scalp areas within project limits.

3.06 STRIPPING

A. Do not remove topsoil until after scalping is completed.

B. Strip areas within project limits to minimum depths. Do not remove subsoil with topsoil.

3.07 TREE REMOVAL OUTSIDE CLEARING LIMITS

A. Remove Trees Within Project Limits:

1. Dead, dying, leaning, or otherwise unsound trees that may strike and damage Project facilities in falling.

2. Trees designated by Owner.

B. Cut stumps off flush with ground, remove debris, and if disturbed, restore surrounding area to its original condition.

3.08 PRUNING

A. Remove branches below the following heights: 20 feet above roadways and shoulders.

B. Prune as specified in local ordinances.

3.09 SALVAGE

A. Saleable logs timber may be sold to CONTRACTOR’s benefit. Promptly remove from Project site.

B. Sod with commercial value may be sold to CONTRACTOR’s benefit. Promptly remove from Project site.

3.10 DISPOSAL

A. Clearing and Grubbing Debris:

1. Dispose of debris offsite.

2. Burning of debris onsite will not be allowed.

3. Woody debris may be chipped. Chips may be sold to CONTRACTOR's benefit or used for landscaping onsite as mulch or uniformly mixed with topsoil, provided that resulting mix will be fertile and not support combustion. Maximum dimensions of chipped material used onsite shall be 1/4-inch by 2-inch. Dispose of chips that are unsaleable or unsuitable for landscaping or other uses with unchipped debris.

4. Limit offsite disposal of clearing and grubbing debris to locations that are approved by federal, state, and local authorities, and that will not be visible from Project.

B. Scalpings: As specified for clearing and grubbing debris.

C. Strippings:

1. Dispose of strippings that are unsuitable for topsoil or that exceed quantity required for topsoil offsite.

2. Stockpile topsoil in sufficient quantity to meet Project needs. Dispose of excess strippings as specified for clearing and grubbing.

END OF SECTION

SECTION 02221

SITE EARTHWORK

PART 1 - GENERAL

1.01 SUMMARY

A. CONTRACTOR shall furnish all labor, materials, equipment and incidentals as shown, specified and necessary to complete the work of site preparation, erosion control, surface drainage, ground water control, construction of compacted fills, excavations, trenching, and backfilling of concrete foundations and structures, installation and removal of sheeting and bracing, backfilling and final site grading.

B. This Section also includes providing backfill materials for all excavations including select backfill, backfill, fill, granular embedment, and the satisfactory disposal of surplus and unacceptable materials.

C. No classification of excavated materials will be made. Excavation includes all materials regardless of type, character, composition, moisture, or condition thereof.

D. The CONTRACTOR shall perform all earthwork as specified in this Section. All trenching shall conform to the requirements of SAWS Specification Section 550, "Trench Excavation Safety Protection".

1.02 RELATED SECTIONS:

A. Section 01300, Submittals

B. Section 02200, Site Preparation

C. Section 02500, Site Pavement

1.03 REFERENCE STANDARDS

The CONTRACTOR shall comply with applicable provisions and recommendations of the most recent versions following:

A. ASTM A 36, Structural Steel.

B. ASTM D 422, Particle-size Analysis of Soils.

C. ASTM D 423, Liquid Limit of Soils.

D. ASTM D 424, Plastic Limit & Plasticity Index of Soils.

E. ASTM D 427, Shrinkage Factors of Soils.

F. ASTM D 698, Moisture-Density Relations of Soils, using 5.5 lb. (2.5 kg) Rammer and 12-inch (304.8 mm) Drop.

G. ASTM D 1140, Amount of Material in Soils Finer than the No. 200 Sieve.

H. TxDOT TEX-113-E, Moisture-Density Relations of Soils, using 5.5 lb. 2.5 kg) Rammer and 12-inch (304.8 mm) Drop.

I. ASTM D 2321, Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.

J. ASTM D 2922, Density of Soils and Soil-Aggregate in Place by Nuclear Methods.

K. Texas Department of Transportation (TxDOT) Standard Specifications for Construction of Highways, Streets and Bridges.

L. SAWS Specifications for Sewer and Water Construction.

1.04 SUBMITTALS

Provide the following in conformance with applicable requirements contained in Section 01300, Submittals.

A. Test Reports
The testing laboratory shall submit copies of the following reports directly to the CONTRACTOR, with copy to the Engineer:

1. Field Density (Compaction) Tests.

2. Optimum Moisture - maximum density curve for each soil used for backfill.

3. Concrete Slump and 28-day compressive strength test.

B. Samples of all select backfill, backfill, fill, granular embedment, and drain gravel, shall be submitted by the CONTRACTOR to the Testing Laboratory. Samples of the proposed material shall be submitted at least fourteen (14) days in advance of its anticipated use.

C. The Project will not be accepted unless test reports are submitted to the Engineer and Owner by the CONTRACTOR.

D. Testing frequency and intervals shall be in accordance with SAWS Specification Item 804 – "Excavation, Trenching, and Backfill."

1.05 QUALITY ASSURANCE

A. Testing Services

1. General:
   Testing of materials, testing for moisture content during placement and compaction of fill materials, and of compaction requirements for compliance with technical requirements of the Specifications shall be performed by a testing laboratory.

2. Testing Services Include:

   a. Test the CONTRACTOR's proposed materials in the laboratory and/or field for compliance with the Specifications.

   b. Perform field moisture content and density tests to assure that the specified compaction of backfill materials has been obtained.

   c. Report all test results to the CONTRACTOR and the Engineer.

1.06 SITE CONDITIONS

A. All traffic during construction shall confine their limits to an established "traffic route" submitted by the CONTRACTOR and reviewed by the Engineer.

1.07 COORDINATION

A. The CONTRACTOR shall expedite placement of compacted fills and embankments at the earliest practical time.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Backfill, Fill, Select Backfill

1. Materials used for backfill, fill, and select backfill shall be in accordance with SAWS Specification Item 804 “Excavation, Trenching, and Backfill.”
2. All material for use as backfill, fill, and select backfill shall be tested and verified by the Testing Laboratory.

B. Granular Sanitary Sewer Pipe Embedment Material (Initial Backfill)
Granular embedment material shall meet the requirements of SAWS Specification Item 804 “Excavation, Trenching, and Backfill.” Section 804.5.2.a(3).

C. Drain Gravel

1. Drain gravel shall be washed gravel conforming to the following gradation:

Sieve Size	Percent Retained on Sieve
2 inch	0
1 ½ inch	0-10

1 inch	45-75
½ inch	90-100
¼ inch	95-100

2. The material shall have a LA abrasion number of 35 or less.

3. All drainage material must be tested and accepted by the Testing Laboratory.

4. No drainage material shall be placed without authorization.

PART 3 - EXECUTION

3.01 SITE PREPARATION

A. The portions of the site on which the work is to be constructed shall be cleared of all objectionable materials and debris. All materials and debris shall be disposed of off the project site in accordance with applicable regulations.

3.02 EROSION CONTROL, DEWATERING AND POLLUTION CONTROL

A. Erosion Control

1. In general, the construction procedures outlined herein shall be implemented to ensure minimum damage to the environment during construction.

2. Whenever possible, access roads shall be located and constructed to avoid environmental damage.

3. Temporary Measures shall be coordinated with the construction of permanent drainage facilities and other work to the extent practicable to assure economical, effective and continuous erosion and siltation control.

4. The CONTRACTOR shall prevent blowing and movement of dust from exposed soil surfaces to reduce on and off-site damage and health hazards.

B. Dewatering

1. The CONTRACTOR shall provide and maintain adequate dewatering equipment to remove and dispose of all surface and groundwater entering excavations, trenches, or other parts of the Work. Each excavation shall be kept dry during subgrade preparation and continually thereafter until all backfill operations have been completed. All dewatering operations by the CONTRACTOR shall be at no additional cost to the Owner.

a. The different working areas on the site shall be kept free of surface water at all times. The CONTRACTOR shall install drainage ditches and dikes and shall perform all pumping and other work necessary

to divert or remove rainfall and all other accumulations of surface water from the excavations and fill areas. The diversion and removal of surface water shall be performed in a manner that will prevent the accumulation of water behind temporary structures or at any other locations within the construction area where it may be detrimental.

b. Water used for working or processing, resulting from dewatering operations, or containing oils or sediments that will reduce the quality of the water downstream of the point of discharge shall not be directly discharged. Such waters shall be diverted through a settling basin or filter before being discharged.

c. The CONTRACTOR will be held responsible for the condition of any pipe, conduit or channel which he may use for drainage purposes and all such pipes, conduits or channels shall be left clean and free of sediment.

2. The CONTRACTOR shall provide, install and operate sufficient trenches, sumps, pumps, hose, piping, wellpoints, deep wells, etc., necessary to depress and maintain the ground water level below the base of the excavations during all stages of construction operation. The ground water table shall be lowered in advance of excavation and maintained two feet below the lowest subgrade excavation made until the structure has sufficient strength and weight to withstand horizontal and vertical soil and water pressures from natural groundwater. The system must be operated on a 24-hour basis and standby pumping facilities and personnel shall be provided to maintain the continued effectiveness of the system. If, in the opinion of the Engineer, the water levels are not being lowered or maintained as required by these Specifications, the CONTRACTOR shall install additional or alternate dewatering devices as necessary, at no additional cost to the Owner.

a. Elements of the system shall be located so as to allow a continuous dewatering operation without interfering with the construction of the permanent work. Where portions of the dewatering system are located in the area of permanent construction, the CONTRACTOR shall submit details of the methods he proposes to construct the permanent work in this location for the review of the Engineer. Controls of groundwater shall continue until the permanent construction provides sufficient dead load to withstand the hydrostatic uplift of the normal ground water, until concrete has attained sufficient strength to withstand earth and hydrostatic loads, until all waterproofing work below normal ground water level has been completed, and until pipelines are properly jointed.

Dispose of all water removed from the excavation in such a manner so as not to endanger any portion of the work under construction or completed. Convey water from the excavations in a closed conduit.

Do not use trench excavations as temporary drainage ditches. Before discontinuing dewatering operations, or permanently permitting the rise of the ground water level, computations shall be made to show that any pipeline or structure affected by the water level rise is protected by backfill or other means to sustain uplift. Use safety factor of 1.25 when making these computations.

b. Dewatering operations shall not be discontinued without the prior authorization of the Engineer.

3.03 EXCAVATION

A. General

1. The CONTRACTOR shall excavate and backfill, in advance of the construction, test pits to determine conditions or location of the existing utilities. The CONTRACTOR shall perform all work required in connection with excavating, stockpiling, maintaining, sheeting, shoring, backfilling and replacing pavements for the test pits.

   The CONTRACTOR shall be responsible for the definite location of each facility constructed by others involved within the area of his excavation for work under this contract. Care shall be exercised during such location work to avoid damaging and/or disrupting the affected facility. The CONTRACTOR shall be responsible for repairing, at his expense, damage to any structure, piping, or utility caused by his work.
   Blasting shall not be permitted.

2. Excavation of every description and of whatever substance encountered within the grading limits of the project shall be performed to the lines and grades indicated on the Drawings. All excavation shall be performed in the manner and sequence as required for the work.

   a. Excavation work shall be performed in a safe and proper manner with appropriate precautions being taken against all hazards. Excavations shall provide adequate working space and clearances for the work to be performed therein and for installation and removal of concrete forms. In no case shall excavation faces be undercut for extended footings.

   b. Subgrades for wetwell, concrete pads, concrete foundations, and pavements shall be firm, dense and thoroughly compacted.

   c. Exposed soil after excavations have been made shall be protected against detrimental damage and change in condition from physical disturbance and rain. Wherever possible, concrete footings shall be done the same day the excavation is made. If this is not done, the footing excavations shall be properly protected.

3. All excavated materials that meet the requirements for backfill shall be stockpiled within the site (but not less than 25 feet from the surface borders of any excavation) for use as backfill, or for providing final site grades. All excavated materials which are not considered suitable for fill, and any surplus or excavated material which is not required for fill shall be disposed of off the site by the CONTRACTOR. Upon completion of the fill, all on-site waste and disposal areas shall be cleaned and the debris removed from the site.

   Materials deposited off the site shall be transported and placed in accordance with all applicable rules and regulations of all authorities having jurisdiction thereof. No surplus or unacceptable excavated materials of any kind shall be deposited in any stream or water course or dumped on public property.

B. Excavations for Lift Station Concrete Pads, Concrete Foundations and Pavements.

1. Excavations for the construction of concrete pads, and foundations shall be carefully made to the depths indicated on the plans. Bottoms for footings and slabs shall be level, clean, dry and clear of loose material and the lower sections true to size. Footings and slab excavations shall be verified by the Testing Laboratory, and reviewed by the Structural Engineer, before concrete is placed thereon.
2. In excavations for structures where, in the opinion of the Testing Laboratory, the ground, not affected by high water level, is spongy or otherwise unsuitable for the contemplated foundation, the CONTRACTOR will be required to remove such unsuitable earth and replace it with suitable material in accordance with this Section.

3. Excavations for structures which have been carried below the depths indicated shall be refilled to the proper grade with select backfill material properly compacted, in accordance with this Section.

4. All structure excavations shall be hand-trimmed to permit the placing of full widths and lengths of footings on horizontal beds. Rounded and undercut edges will not be permitted.

5. Excavations shall be extended to the recommended dimensions shown in the plans for this project on each side of structures, footings, etc., unless otherwise shown or specified.

6. When the excavation has reached the design subgrade, the exposed subgrade shall be compacted and moisture conditioned.

7. Pavement excavation shall consist of excavation for the lift station pavement and driveway, in conformity with the typical sections shown on the plans, and to the lines and grades established by the Engineer, by the removal of existing material or addition of acceptable material. All unstable

or otherwise objectionable material shall be removed from the subgrade and replaced with acceptable material. All holes, ruts, and depressions shall be filled with acceptable material. The surface of the subgrade shall be finished to the lines and grades as established, and be in conformity with the typical sections shown on the plans. Any deviation in excess of one-half inch (1/2") in cross section, and in a length of sixteen feet (16'), measured longitudinally, shall be corrected by loosening, adding, or removing material, reshaping and compacting by sprinkling and rolling. Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work.

C. Excavation, Trenching and Backfill for Piping

1. All excavation, trenching and backfilling for pipe trenches shall conform to SAWS Specification Item No. 804 “Excavation, Trenching, and Backfill.”

3.04 UNAUTHORIZED EXCAVATION

All excavation outside the lines and grades shown, and which is not in conformance with the plans and specifications as determined by the Testing Laboratory, together with the removal and disposal of the associated material shall be at the CONTRACTOR's expense. The unauthorized excavation shall be filled and compacted as specified by the Testing Laboratory, with backfill in accordance with this Section by the CONTRACTOR at his expense.

3.05 PLACEMENT OF FILL, BACKFILL, AND SELECT BACKFILL

A. General

1. All select backfill, backfill and fill required for structures and pavements are required to be provided to the finished grades shown and as described herein shall be furnished, placed and compacted by the CONTRACTOR.

2. Backfill excavations as promptly as work permits, but not until completion of the following:

a. Observation by the Engineer of construction below finish grade.

b. Observation, testing and recording of locations of underground piping and ductwork.

c. Removal of concrete formwork.

d. Removal of shoring and bracing, and backfilling of voids with satisfactory materials.

e. Removal of trash and debris.

f. Backfill against foundation walls, only after review by the Engineer. Do not damage waterproofing when placing backfill.

3. Fill containing organic materials or other unacceptable material shall be removed and replaced with acceptable fill material.

B. Placement of Fill Materials, Backfill, and Select Backfill.

1. Placement of Fill, Backfill, and Select Backfill shall be in accordance with the Owner and Comal County guidelines.

2. Material shall be placed to the grades shown on the Drawings.

3. Backfill around and outside of structures and over select backfill shall be deposited in layers not to exceed eight inches (8") in uncompacted thickness and mechanically compacted, using platform type tampers. Compaction of structural backfill by rolling will be permitted provided the desired compaction is obtained and damage to the structure is prevented. Compaction of select backfill and/or backfill by inundation with water will not be permitted. All materials shall be deposited as specified herein and as shown on the Drawings.

4. No material shall be placed when free water is standing on the surface of the area where the material is to be placed. No compaction of material will be permitted with free water on any portion of the material to be compacted. No material shall be placed or compacted in a frozen condition or on top of frozen material. Any material containing organic materials or other unacceptable material previously described shall be removed and replaced with acceptable material prior to compaction.

5. Compaction shall be performed with equipment suitable for the type of material being placed. The contractor shall select equipment which is capable of providing the minimum density required by these Specifications. The gross weight of compacting equipment shall not exceed 7,000 pounds within a distance of ten feet (10') from the wall of any existing structure or completed structure under this contract. Equipment shall be provided that is capable of compacting in restricted areas next to structures and around piping. The effectiveness of the equipment selected by the CONTRACTOR shall be tested at the commencement of compacted material work by construction of a small section of material within the area where material is to be placed. If tests on this section of backfill show that the specified compaction is not obtained, the CONTRACTOR shall increase the amount of coverages, decrease the lift thicknesses or obtain a different type of compactor.

6. Particular care shall be taken to compact structural backfill which will be beneath pipes, roads, or other surface construction or structures. In addition, wherever a trench passes through structure backfill, the structure

backfill shall be placed and compacted to an elevation twelve inches (12") above the top of the pipe before the trench is excavated. Compacted areas, in each case, shall be adequate to support the item to be constructed or placed thereon.

C. Backfill in Pipe Trenches

1. All pipe trenches shall be excavated, prepared, and backfilled in accordance with SAWS Specification Item No. 804 Excavation, Trenching, and Backfilling.

2. Pipeline trenches may be backfilled prior to pressure testing but no structure shall be constructed over any pipeline until it has been tested.

3. The method of compaction and the equipment used shall be appropriate for the material to be compacted and shall not transmit damaging shocks to the pipe.

D. Compaction Density Requirements

1. Compaction, moisture conditioning and testing required for all non-pipeline trench types of fills shall be in accordance with Comal County guidelines.

2. Compaction, moisture conditioning and testing for pipe trench backfilling, and backfilling around the wetwell shall be in accordance with SAWS Specification Item No. 804 Excavation, Trenching, and Backfilling.

3.06 FINAL GRADING AND EMBANKMENTS

A. To the extent available, backfill material from excavations shall be placed in accordance with this Section to final grades with a minimum compacted depth of twelve inches (12").

B. After other outside work has been finished, and backfilling and embankments completed and settled, all areas on the site of the work which are to be graded shall be brought to a subgrade suitable with the indicated elevations, slopes, and grades with suitable excess excavation material. Final grades shall be within 0.1 foot of the finished grades shown on the Drawings.

END OF SECTION

SECTION 02222

CONSTRUCTION BEST MANAGEMENT PRACTICES AND SEDIMENT AND EROSION CONTROL MEASURES

PART 1 - GENERAL

1.01 SUMMARY

A. A TPDES Stormwater Pollution Plan shall be prepared by the CONTRACTOR.

B. CONTRACTOR shall furnish all labor, materials, equipment and incidentals as shown, specified and necessary to complete the work required for compliance with the TPDES Storm Water Regulations and any other related State, County or local requirements.

C. As a condition of the award of the Contract, the CONTRACTOR will be required to sign and submit a Certification as shown below:

"I certify under penalty of law that this document was prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, and accurate, and complete. I am aware there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

END OF SECTION

SECTION 02316

EXCAVATION AND BACKFILL FOR STRUCTURES

PART 1 GENERAL

1.01 SCOPE

This Section governs the excavation, backfilling, and compaction of backfill for structures.

1.02 DEFINITIONS

A. Unsuitable Material: Unsuitable soil materials are the following:

1. Materials that are classified as ML, CL-ML, MH, PT, OH, and OL according to ASTM D 2487.

2. Materials that cannot be compacted to the required density due to either gradation, plasticity, or moisture content.

3. Materials that contain large clods, aggregates, stones greater than 4 inches in any dimension, debris, vegetation, waste or any other deleterious materials.

4. Materials that are contaminated with hydrocarbons or other chemical contaminants.

B. Suitable Material: Suitable soil materials are those meeting specification requirements. Unsuitable soils meeting specification requirements for suitable soils after treatment with lime or cement shall be considered suitable, unless otherwise indicated.

C. Select Material: Material as defined in Paragraph 2.02A.

D. Backfill: Select material meeting specified quality requirements, placed and compacted under controlled conditions around structures.

E. Foundation Backfill Materials: Natural soil or manufactured aggregate meeting Class I requirements and geotextile filter fabrics as required, to control drainage and material separation. Foundation backfill material is placed and compacted as backfill where needed to provide stable support for the structure foundation base. Foundation backfill materials may include concrete fill and seal slabs.

F. Foundation Base: For foundation base material, use cement stabilized sand or concrete seal slab. The foundation base provides a smooth, level working surface for the construction of the concrete foundation.

G. Foundation Subgrade: Foundation subgrade is the surface of the natural soil which has been excavated and prepared to support the foundation base where needed.

H. Ground Water Control Systems: Installations external to the excavation such as well points, eductors, or deep wells. Ground water control includes dewatering to lower the ground water, intercepting seepage which would otherwise emerge from the side or bottom of the excavation, and depressurization to prevent failure or heaving of the excavation bottom. Refer to Section entitled, "CONTROL OF GROUND WATER AND SURFACE WATER."

I. Surface Water Control: Diversion and drainage of surface water runoff and rain water away from the excavation. Remove rain water and surface water which accidentally enters the excavation as a part of excavation drainage.

J. Excavation Drainage: Removal of surface and seepage water in the excavation by sump pumping and using French drains surrounding the foundation to intercept the water.

K. Over-Excavation and Backfill: Excavation of subgrade soils with unsatisfactory bearing capacity or composed of otherwise unsuitable materials below the foundation as shown on Construction Plans and backfilled with foundation backfill material.

L. Shoring System: A structure that supports the sides of an excavation to maintain stable soil conditions and prevent cave-ins.

1.03 SUBMITTALS

A. Submit a work plan for excavation and backfill for each structure with complete written description which identifies details of the proposed method of construction and the sequence of operations for construction relative to excavation, dewatering (if required), and backfill activities. The descriptions, with supporting illustrations, shall be sufficiently detailed to demonstrate to the Engineer that the procedures meet the requirements of the Specifications and Construction Plans.

B. Submit excavation safety system plan.

1. The excavation safety system plan shall be in accordance with applicable OSHA requirements for all excavations.

2. The excavation safety system plan shall be in accordance with the requirements of Federal Requirements, 29 CFR, Part 1926, Standards - Excavation, Occupational Safety and Health Administration (OSHA).

C. Submit a ground and surface water control plan in accordance with requirements in this Section entitled, "CONTROL OF GROUND WATER AND SURFACE WATER."

D. Submit backfill material sources and product quality information in accordance with requirements of the section entitled, "BACKFILL MATERIALS".

E. Submit project record documents. Record location of utilities, as installed, referenced to survey benchmarks. Include location of utilities encountered or rerouted. Give horizontal dimensions, elevations, inverts and gradients.

1.04 TESTS

Testing and analysis of backfill materials for soil classification and compaction during construction will be performed by an independent laboratory provided by the Owner.

PART 2 PRODUCTS

2.01 EQUIPMENT

A. Perform excavation with equipment suitable for achieving the requirements of this Specification.

B. Use equipment which will produce the degree of compaction specified. Backfill within 3 feet of walls shall be compacted with hand operated equipment. Do not use equipment weighing more than 10,000 pounds closer to walls than a horizontal distance equal to the depth of the fill at that time. Use hand operated power compaction equipment where use of heavier equipment is impractical or restricted due to weight limitations.

2.02 MATERIAL CLASSIFICATIONS

Select Backfill: Clayey gravel or sand or lean clay with a plasticity index between 7 and 20 or clayey soils treated with the required proportion of lime.

PART 3 EXECUTION

3.01 PREPARATION

A. Conduct an inspection to determine condition of existing structures and other permanent installations.

B. Perform work in accordance with OSHA standards. Employ an excavation safety system as specified in the section entitled, “EXCAVATION SUPPORT AND PROTECTION SYSTEMS FOR STRUCTURES”.

C. Install and operate necessary dewatering and surface water control measures in accordance with requirements of Section entitled, “CONTROL OF GROUND WATER AND SURFACE WATER.”

3.02 PROTECTION

A. Protect trees, shrubs, lawns, existing structures, and other permanent objects within the project area.

B. Protect and support above-grade and below-grade utilities which are to remain.

C. Restore damaged permanent facilities to pre-construction conditions unless replacement or abandonment of facilities are indicated on the Construction Plans.

D. Prevent erosion of excavations and backfill. Do not allow water to pond in excavations.

E. Maintain excavation and backfill areas until start of subsequent work. Repair and re-compact slides, washouts, settlements, or areas with loss of density at no additional cost to the Owner.

3.03 EXCAVATION

A. Perform excavation work so that the underground structure can be installed to depths and alignments shown on Construction Plans. Use caution during excavation work to avoid disturbing surrounding ground and existing facilities and improvements. Keep excavation to the absolute minimum necessary. No additional payment will be made for excess excavation not authorized by Engineer.

B. Upon discovery of unknown utilities, badly deteriorated utilities not designated for removal, or concealed conditions, discontinue work at that location. Notify Engineer and obtain instructions before proceeding in such areas.

C. Immediately notify the agency or company owning any line which is damaged, broken or disturbed. Obtain approval from Engineer and agency for any repairs or relocations, either temporary or permanent.

D. Avoid settlement of surrounding soil due to equipment operations, excavation procedures, vibration, dewatering, or other construction methods.

E. Provide surface drainage during construction to protect work and to avoid nuisance to adjoining property. Where required, provide proper dewatering and piezometric pressure control during construction.

F. Conduct hauling operations so that trucks and other vehicles do not create a dirt nuisance in streets. Verify that truck beds are sufficiently tight and loaded in such a manner that objectionable materials will not spill onto streets. Promptly clear away any dirt, mud, or other materials that spill onto streets or are deposited onto streets by vehicle tires.

G. Maintain permanent benchmarks, monumentation, and other reference points. Unless otherwise directed, replace those which are damaged or destroyed by the Work.

H. Provide sheeting, shoring, and bracing where required to safely complete the Work, to prevent excavation from extending beyond limits indicated on Construction Plans, and to protect the Work and adjacent structures or improvements.

I. Prevent voids from forming outside of sheeting. Immediately fill voids with grout, concrete fill, cement stabilized sand, or other material approved by Engineer.

J. After completion of the structure, remove sheeting, shoring, and bracing unless shown on Construction Plans to remain in place or directed by Engineer in writing that such temporary structures may remain. Remove sheeting, shoring and bracing in such a manner as to maintain safety during backfilling operations and to prevent damage to the Work and adjacent structures or improvements.

K. Immediately fill and compact voids left or caused by removal of sheeting with cement stabilized sand or material approved by Engineer.

3.04 HANDLING EXCAVATED MATERIALS

A. Classify excavated materials. Place material which is suitable for use as backfill in orderly piles at a sufficient distance from excavation to prevent slides or cave-ins.

B. Provide additional backfill material, if adequate quantities of suitable material are not available from excavation and trenching operations at the site.

3.05 DEWATERING

A. Provide ground water control per Section entitled, “CONTROL OF GROUND WATER AND SURFACE WATER.”

B. Keep ground water surface elevation a minimum of 2 feet below the bottom of the foundation base.

C. Maintain ground water control as directed by Section entitled, “CONTROL OF GROUND WATER AND SURFACE WATER” and until the structure is sufficiently complete to provide the required weight to resist hydrostatic uplift with a minimum safety factor of 1.2.

3.06 FOUNDATION EXCAVATION

A. Notify Engineer at least 48 hours prior to planned completion of foundation excavations. Do not place the foundation base until the excavation is accepted by the Engineer.

B. Excavate to elevations shown on Construction Plans, as needed to provide space for the foundation base, forming a level undisturbed surface, free of mud or soft material. Remove pockets of soft or otherwise unstable soils and replace with foundation backfill material or a material as directed by the Engineer. Prior to placing material over it, re-compact the subgrade where indicated on the Construction Plans, scarifying as needed, to 95 percent of the maximum Standard Dry Density according to ASTM D 698. If the specified level of compaction cannot be achieved, moisture condition the subgrade and re-compact until 95 percent is achieved, over-excavate to provide a minimum layer of 24 inches of foundation backfill material, or other means acceptable to the Engineer.

C. Fill unauthorized excessive excavation with foundation backfill material or other material as directed by the Engineer.

D. Protect open excavations from rainfall, runoff, freezing groundwater, or excessive drying so as to maintain foundation subgrade in a satisfactory, undisturbed condition. Keep excavations free of standing water and completely free of water during concrete placement.

E. Soils which become unsuitable due to inadequate dewatering or other causes, after initial excavation to the required subgrade, shall be removed and replaced with foundation backfill material, as directed by Engineer, at no additional cost to the Owner.

F. Place foundation base, where needed, over the subgrade on same day that excavation is completed to final grade. Where base of excavations are left open for longer periods, protect them with a seal slab or cement-stabilized sand.

G. Crushed aggregate, and other free draining Class I materials, shall have a filter fabric separating it from native soils or select material backfill. The fabric shall overlap a minimum of 12-inches beyond where another material stops contact with the soil.

H. Crushed aggregate, and other Class I materials, shall be placed in uniform layers of 8-inch maximum thickness. Compaction shall be by means of at least two passes of a vibratory compactor.

3.07 FOUNDATION BASE

After the subgrade is properly prepared, including the placement of foundation backfill where needed, the foundation base shall be placed. The foundation base shall consist of a 12-inch layer of crushed stone aggregate or cement stabilized sand. Alternately, a seal slab with a minimum thickness of 4 inches may be placed. The foundation base shall extend a minimum of 12 inches beyond the edge of the structure foundation, unless shown otherwise on the Construction Plans.

3.08 BACKFILL

A. Complete backfill to surface of natural ground or to lines and grades shown on Construction Plans. Use existing material that qualifies as select material, unless indicated otherwise. Deposit backfill in uniform layers and compact each layer as specified.

B. Do not place backfill against concrete walls or similar structures until laboratory test breaks indicate that the concrete has reached a minimum of 85 percent of the specified compressive strength. Where walls are supported by slabs or intermediate walls, do not begin backfill operations until the slab or intermediate walls have been placed and concrete has attained sufficient strength.

C. Remove concrete forms before starting backfill and remove shoring and bracing as work progresses.

D. Maintain fill material at no less than 2 percent below nor more than 2 percent above optimum moisture content. Place fill material in uniform 8-inch maximum loose layers. Compaction of fill shall be to at least 95 percent of the maximum Standard Dry Density according to ASTM D 698 under paved areas. Compact to at least 90 percent around structures below unpaved areas.

E. Where backfill is placed against a sloped excavation surface, run compaction equipment across the boundary of the cut slope and backfill to form a compacted slope surface for placement of the next layer of backfill.

F. Place backfill using cement stabilized sand in accordance with Section entitled, “CEMENT STABILIZED SAND.”

3.09 FIELD QUALITY CONTROL

A. Tests will be performed initially on minimum of one different sample of each material type for plasticity characteristics, in accordance with ASTM D 4318, and for gradation characteristics, in accordance with Tex-101-E and Tex-110-E. Additional classification tests will be performed whenever there is a noticeable change in material gradation or plasticity.

B. In-place density tests of compacted subgrade and backfill will be performed according to ASTM D 1556, or ASTM D 2922 and ASTM D 3017, and at the following frequencies and conditions:

1. A minimum of one test for every 100 cubic yards of compacted backfill material.

2. A minimum of three density tests for each full work shift.

3. Density tests will be performed in all placement areas.

4. The number of tests will be increased if inspection determines that soil types or moisture contents are not uniform or if compacting effort is variable and not considered sufficient to attain uniform density.

C. At least one test for moisture-density relationships will be initially performed for each type of backfill material in accordance with ASTM D 698. Additional moisture-density relationship tests will be performed whenever there is a noticeable change in material gradation or plasticity.

D. If tests indicate work does not meet specified compaction requirements, recondition, re-compact, and retest at Contractor's expense.

3.10 DISPOSAL OF EXCESS MATERIAL

Dispose of excess materials in accordance with requirements of Section entitled, “WASTE MATERIAL DISPOSAL.”

- END OF SPECIFICATION –

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SECTION 02500

SITE PAVEMENT

PART 1 - GENERAL

1.01 DESCRIPTION

A. Scope

1. CONTRACTOR shall furnish all labor, materials, equipment and incidentals required to provide hot mix-hot laid bituminous paving, as well as concrete paving for driveways as shown.

a. Lift Station Pavement (HMAC)

b. Concrete Driveway

2. The work includes the following:

a. Flexible Base

b. Asphalt Stabilized Base

c. Surface Treatments

d. Hot Mix Asphaltic Concrete

e. Portland Cement Concrete Pavement

f. Testing As Specified

1.02 RELATED SECTIONS

A. Texas Department of Transportation, Standard Specifications for Construction of Highways, Streets and Bridges.

B. Comal County Construction Specifications

1.03 QUALITY ASSURANCE

A. Testing Services

1. General: Testing of materials and of compaction requirements for compliance with technical requirements of the Specifications shall be the duty of a testing laboratory as provided for by the specifications for this Project.

2. Testing Services: The testing laboratory shall:

   a. Test the CONTRACTOR's proposed materials in the laboratory and field for compliance with the Specifications.

   b. Perform field density tests to assure that the specified compaction of surface and base course materials has been obtained.

   c. Report all test results to the CONTRACTOR and the Engineer.

   d. Perform asphaltic concrete testing in accordance with the Project specifications.

1.04 SUBMITTALS

Provide the following in conformance with applicable requirements contained in Section 01300, Submittals.

A. Product Data: Submit product data for the following materials:

   1. Flexible Base.

   2. Asphalt Stabilized Base.

   3. Cement.

   4. Curing Seal Coat.

   5. Tack Coat.

   6. Hot Mix Asphaltic Concrete.

   7. Aggregates for Surface Treatments.

   8. Reinforcing Steel.

B. Laboratory Test Reports
Submit copies of laboratory test reports for optimum lime content for subgrade stabilization, gradation and Atterberg limits for flexible base, gradation and mix designs for asphalt treated base, and mix designs for Hot Mix Asphaltic Concrete and Portland Cement Concrete.

C. All paving and base course materials shall be tested and approved prior to delivery to the site. Samples of materials proposed for use as pavement and base course should be submitted by the CONTRACTOR to the Testing Laboratory for testing. Samples of materials shall be submitted at least 14 days in advance of its use.

PART 2 - PRODUCTS

2.01 MATERIALS

The source of materials shall be acceptable to the Engineer. Materials shall conform to the following:

A. Flexible Base

1. Base material shall be crushed or uncrushed as necessary to meet the requirements hereinafter specified, and shall consist of durable stone or gravel, crushed and/or screened to the required particle size, with or without other approved fine sized materials. Unless otherwise specified in this section, all flexible base shall conform to TxDOT Item 247 "Flexible Base". The material shall be from approved sources.

a. Testing of flexible base material shall be in accordance with the following standard laboratory test procedures:

Preparation of Soil	
Constants and Sieve Analysis	TxDOT TEX-101-E
Liquid Limit	TxDOT TEX-104-E
Plastic Limit	TxDOT TEX-105-E
Plasticity Index	TxDOT TEX-106-E
Linear Shrinkage	TxDOT TEX-107-E
Sieve Analysis	TxDOT TEX-110-E
West Ball Mill	TxDOT TEX 116-E
Los Angeles Abrasion	ASTM C 131 (Grad. A)

b. Samples for testing the material shall be taken prior to compaction operations.

c. The material shall be well graded and when properly tested shall meet the following requirements of Texas Department of Transportation Specifications for Type A Grade 2 Flexible Base:

Retained on 2½ inch sieve	0%
Retained on 1¾ inch sieve	0-10%
Retained on No. 4 sieve	45-75%
Retained on 40 mesh sieve	60-85%

d. The material passing the 40 mesh sieve shall be known as "Soil Binder" and shall meet the following requirements:

The liquid limit shall not exceed	40
The plasticity index shall not exceed	12
The linear shrinkage shall not exceed	10

(Note: The linear shrinkage shall be calculated from the volumetric shrinkage at the liquid limit.)

e. The crushed stone or crushed gravel shall have an abrasion of no more than 40 when subjected to the Los Angeles Abrasion Test.

B. Water

Water shall be free from substances deleterious to the hardening of the treated base.

C. Asphalt Oils and Emulsions

"RC-2" Liquid Asphalt and "EA-11-M" Emulsion used as a seal shall meet the requirements set forth in Item 300 "Asphalts, Oils and Emulsions" of the Texas Department of Transportation Standard Specifications.

Where Emulsified Asphalts are used, the amount of emulsified asphalt as a percentage by volume of the total mixture shall be within the limits shown on the plans, or shall be of a percentage as directed by the Engineer.

1. Prime Coat:

The asphaltic material for Prime Coat shall meet the requirements for Cut-Back Asphalt, "MC-30," Emulsified Asphalt "EA-11M," or "EA-10S," or other asphalts or emulsions as shown on the plans, or as directed, or reviewed by the Engineer. Asphalts and Emulsions shall conform to the requirements of Item 300, "Asphalts, Oils and Emulsions" of the Standard Specifications of the Texas Department of Transportation.

2. Tack Coat:

The asphaltic material used for Tack Coat shall meet the requirements for "Asphalt Cement", "Cut-Back Asphalt", or "Emulsified Asphalt", in Item No. 300 "Asphalts, Oils and Emulsions" of the Texas Department of Transportation Standard Specifications. The asphaltic material used for Tack Coat shall be that type or grade shown on the plans, or shall be as directed, or reviewed by the Engineer.

3. Asphaltic Materials for Surface Treatments:

The asphaltic material used for surface treatments shall meet the requirements for "Asphaltic Cement" in Item No. 300 "Asphalts, Oils and Emulsions" of the Texas Department of Transportation Standard Specifications. The asphaltic material used shall be AC-10 or equal, or shall be as reviewed by the Engineer.

D. Hot Mix Asphaltic Concrete

1. Materials used in Hot Mix Asphaltic Concrete Pavement shall meet the requirements as set forth in Item 340, "Hot Mix Asphaltic Concrete Pavement" of the Texas Department of Transportation Standard Specifications.

2. Paving Mixture used shall be Type D. This mixture shall conform to the requirements of Paragraph 340.3 of Item 340, "Hot Mix Asphaltic Concrete Pavement" of the Texas Department of Transportation Standard Specifications.

   a. Part (2) of Paragraph 340.3 shall be revised as follows, and no other requirements are waived or changed hereby.

DENSITY, PERCENT			STABILITY, PERCENT
Min.	Max.	Optimum	Not less than 45 nor
95	98	96	more than 60.

E. Forms: Formwork shall conform to the provisions of TxDOT Item 360 "Concrete Pavement". Forms shall be constructed of wood or steel, profiled to suit condition.

F. Concrete Pavement and Driveways

1. Concrete and concrete materials shall conform to the provisions of the TxDOT Standard Specifications Item 360, "Concrete Pavement", unless otherwise stated in this specification.

   a. Coarse aggregate will conform to the gradation requirements of Aggregate Grade No. 2.

   b. Fine aggregates will conform to the gradation requirements of Aggregate Grade No. 1.

   c. Portland Cement shall be Type I.

2. Air content shall be 4% + 1%.

3. Slump shall range from 2 to 5 inches.

G. Steel Expansion Joint Dowels: Dowel bars shall be round smooth steel conforming to ASTM A 36, Grade 60.

H. Concrete Pavement/Driveway Reinforcement

1. Reinforcing steel bars (diameter shown on plans) shall conform to TxDOT Item 440, "Reinforcing Steel", ASTM A 615 Grade 60, deformed bars. All reinforcing steel shall be new billet steel.

2. All welded wire fabric shall conform to TxDOT Item 440, “Reinforcing Steel”.

2.02 CUTTING AND REPLACING PAVEMENTS

All materials used for cutting and replacing pavements shall conform to the requirements of this section.

PART 3 - EXECUTION

3.01 GENERAL

The drives and pavement areas shall be constructed to the lines, and typical section shown on the drawings. Pavement removal and replacement within the project shall be performed in accordance with City of San Antonio guidelines.

3.02 SUBGRADE PREPARATION

A. Preparation of the subgrade including compaction shall be completed for the full width of the pavement areas and access roads, or as shown on plans.

1. The subgrade shall be compacted to at least 95 percent (95%) of maximum density between optimum moisture content and optimum moisture content +2% as determined by ASTM D-698. Subgrades with a plasticity index greater than 20 shall be lime stabilized to a depth of 6" below the top of final subgrade elevation to a plasticity index of 20 or less.

2. Six-inches (6") of flexible base or asphalt stabilized base may be substituted for lime-stabilized subgrade at no additional cost to the Owner.

B. No materials shall be placed on subgrades that are muddy or have water thereon.

3.03 CONSTRUCTION OF HOT MIX ASPHALTIC CONCRETE PAVEMENTS

A. General

1. The pavement areas shall be constructed to the lines, grades, and typical section shown on the Drawings.

2. Conform to all applicable requirements of the Texas Department of Transportation Standard Specifications.

B. Flexible Base Course

1. Equipment:
All equipment necessary to properly perform and complete the work shall be on the project prior to beginning the work, shall be subject to the review of the Engineer, and shall be maintained in a satisfactory condition at all times.

a. Motor graders shall be self-propelled, shall have tandem or four-wheel drive, shall have a blade length of not less than 12 feet, shall have a wheel base length (the distance between front and rear axles) of not less than 16 feet, and shall be in good operating condition and reviewed by the Engineer.

b. Compaction equipment shall be of sufficient weight and adequately loaded to accomplish the required compaction.

c. Water distributors shall be equipped with positive and rapidly working cut-off valves, approved spray bars equipped with bituminous nozzles and a power pump that will insure distribution of water in a uniform and controllable rate of application. Spray bars shall be so constructed that the effective length may be quickly and easily altered.

d. Nothing in this section shall relieve the CONTRACTOR of his responsibility for producing finished work of the quality specified.

2. Construction Methods:

a. General:
It is the intent of this specification to obtain a complete course, or courses, of Flexible Base of uniform moisture and density, with a closely-knit surface free from laminations, cracks, ridges, or loose material, and to the surface requirements hereinafter specified.

b. Placing of Flexible Base Material:
The Flexible Base material shall be placed on the approved subgrade in courses not to exceed six inches (6") compacted depth. It shall be the responsibility of the CONTRACTOR that the required amount of material be delivered and uniformly spread and shaped. All material shall be moved from the place where it is dumped by cutting into windrows. After the material has been cut into windrows, it shall be sprinkled, spread, shaped, and rolled in proper sequence to prevent segregation, and as necessary for required compaction.

c. Compaction and Finishing:
Flexible Base shall be compacted to an apparent dry density of not less than 95 percent of the maximum dry density between optimum moisture content and optimum moisture content + 2%, as determined in accordance with TxDOT Test Method TEX 113-E. Tests for density will be made within 24 hours after compaction operations are completed. If the material fails to meet the density specified, it shall be reworked as necessary to meet the density required. Just prior to the placing of any succeeding course of Flexible Base, surfacing on any previously completed course, the density and moisture of the top three inches (3") of Flexible Base shall be checked and if tests show the density to be more than 2 percent below the specified minimum, or the moisture content to be more than 3 percent above or below the optimum, the course shall be reworked as necessary to obtain the specified compaction and moisture content.

The surface upon completion shall be smooth and in conformity with the typical sections and to the established lines and grades.

Any deviation in excess of 1/4 inch in cross-section and in length of 16 feet measured longitudinally shall be corrected. All irregularities, depressions, or weak spots that develop shall be corrected.

C. Prime Coat

1. When the area and/or base is satisfactory to receive the prime coat, the surface shall be cleaned by sweeping or other acceptable methods. If necessary, the surface shall be lightly sprinkled with water just prior to application of the asphaltic material. The asphaltic material shall be applied on the clean surface by an acceptable type of self-propelled pressure distributor so operated as to distribute the prime coat at a rate not to exceed 0.20 gallon per square yard of surface, evenly and smoothly, under a pressure necessary for proper distribution. During the application of prime coat, care shall be taken to prevent splattering of adjacent pavement, curb and gutters or structures.

2. Prime Coat shall not be applied when the air temperature is below 60° F and falling, but it may be applied when the air temperature is above 50° F and is rising; the air temperature being taken in the shade away from artificial heat.

   Asphaltic material shall not be placed when general weather conditions, in the opinion of the Engineer, are not suitable.

D. Tack Coat

1. Before the tack coat is applied, the surface shall be cleaned thoroughly. The asphaltic material shall be applied on the clean surface by an acceptable type of self-propelled pressure distributor so operated as to distribute the tack coat at a rate not to exceed 0.10 gallon per square yard of surface, evenly and smoothly under a pressure necessary for proper distribution. All contact surfaces of curbs and structures and all joints shall be painted with a thin uniform coat of the asphaltic material used for tack coat. The tack coat shall be rolled with a pneumatic tire roller. During the application of tack coat, care shall be taken to prevent splattering of adjacent pavement, curb and gutters or structures.

E. Hot Mix Asphaltic Concrete

1. Construction methods used in laying Hot Mix Asphaltic Concrete Pavement shall meet the requirements as set forth in Item 340 "Hot Mix Asphaltic Concrete Pavement" of the Texas Department of Transportation Standard Specifications, with the following exception:

   Application of Hot Mix Asphaltic Concrete Pavement shall not begin unless the air temperature is at least fifty degrees Fahrenheit (50° F) in the shade and rising.

F. Construction Joints

1. Construction joints shall be made in such a manner as to ensure a neat junction, thorough compaction, and bond throughout.

2. A transverse joint extending over the full width of the strip being laid and at right angles to its centerline shall be constructed at the end of each day's work and at any other times when the operations of placing the hot mixture are suspended for a period of time which will permit the mixture to chill. The forward end of a freshly laid strip shall be thoroughly compacted by rolling before the mixture has become chilled. When work is resumed, the end shall be cut vertically for the full depth of the layer.

3. When new pavement is to join pavement installed by others or previously laid pavement by the CONTRACTOR, the in-place pavement shall be neatly and carefully edged to allow for overlapping and feathering of the new surface course material. A tack coat of bituminous prime coat material shall be placed at the interface of new and previously laid material.

G. Traffic Maintenance

The pavement shall be opened to traffic when directed by the Engineer. Construction traffic on the pavement shall be held to a minimum and shall be acceptable to the Engineer. Adequate protection methods as reviewed by the Engineer shall be utilized when crossing roadways is required.

H. Field Quality Control

1. CONTRACTOR will employ a testing laboratory to perform field quality control. The testing laboratory will make compaction testing of flexible base. The testing laboratory will test the HMAC for Asphalt Extraction, Gradation, Bitumen Content, Stability and laboratory density. CONTRACTOR shall furnish all necessary assistance required by the testing laboratory. CONTRACTOR shall also furnish all labor, materials and equipment necessary for sampling. CONTRACTOR shall furnish all necessary transportation to the Owner's Testing Laboratory required by the testing.

2. Quality Control Testing During Construction:

   a. The testing laboratory will perform sampling and testing for field quality control during the placement of materials as follows:

      (1) HMAC shall be tested as described in these Specifications, at least once for every 500 tons of materials placed or fraction thereof.

      (2) Density:

(a) Compare density of in-place material against laboratory specimen or certificated on same for bituminous concrete mixture.

(b) Acceptable densities of in-place materials shall conform to applicable State Standard Requirements.

(3) Thickness:
In-place compacted thickness shall average not less than the thickness specified.

(4) Surface Smoothness:

(a) Test finished surface of each bituminous concrete course for smoothness, using a 10-foot straight edge applied parallel to and at right angles to centerline of paved areas.

(b) Check surfaced areas at intervals as directed by Engineer.

(c) Surfaces will not be acceptable if deviations exceed the following:

i) Base Courses: 3/8 inch in 10 feet.

ii) Surface Course: 1/4 inch in 10 feet.

iii) Crowned Surfaces:

a) Test crowned surfaces with a crown template, centered and at right angle to the crown.

b) Surfaces will not be acceptable if varying more than 1/4" from the template.

END OF SECTION

SECTION 02732

SANITARY SEWER LIFT STATION

PART 1 - GENERAL

1.01 SUMMARY

A. CONTRACTOR shall furnish all labor, materials, equipment and incidentals as shown, specified and necessary to complete the sanitary sewer lift station and site work, including force main discharge piping, coordination and installation of three phase power to the site, lift station monitoring and control systems, fencing, grading, subgrade and paving and all other work as shown on the plans and described in these specifications.

B. The principal items of equipment for the lift station shall include (but not limited to) three (3) submersible sewage pumps, wet well, wet well level controls, all necessary gate valves, check valves, air release valves, fittings, pipe supports, and pipe for inflow and discharge lines. Site grading, paving and fencing is also included.

1. The CONTRACTOR shall provide and install pump rails (including all hardware), lifting chains, hatch, conduit, and motor control enclosures.

C. The CONTRACTOR shall be responsible for setting and adjusting all controls of all units for proper operation subject to the review of the Engineer.

D. Operation and Maintenance manuals and complete parts lists shall be furnished to the Owner upon completion of the lift station.

1.02 RELATED SECTIONS

A. Section 01300, Submittals

B. Section 02110, Site Clearing

C. Section 02200, Site Preparation

D. Section 02221, Site Earthwork

E. Section 02500, Site Pavement

F. Section 11510, Submersible Non-Clog Pumps

1.03 REFERENCE STANDARDS

The CONTRACTOR shall comply with applicable provisions and recommendations of the following:

A. Texas Commission on Environmental Quality, Chapter 217.

B. Texas Department of Transportation, Standard Specification for Highways, Streets and Bridges.

C. San Antonio Water System Specifications.

D. American Society for Testing and Materials (ASTM).

1.04 SUBMITTALS

Provide the following in conformance with applicable requirements.

A. Product Data

1. Submittals shall be in accordance with Section 1300, “Submittals” of these specifications.

1.05 QUALITY ASSURANCE

A. Testing - The CONTRACTOR shall coordinate all testing required by this Section with the Engineer prior to commencement of testing.

B. The testing laboratory shall sample and test construction materials in accordance with the project specifications.

1.06 DELIVERY, STORAGE AND HANDLING

A. Deliver, store and handle products in accordance with manufacturer's latest published requirements and specifications.

B. The Engineer reserves the right to extend the delivery and installation period beyond the CONTRACTOR's specified time should it be determined the CONTRACTOR is not directly responsible for the delay.

PART 2 – PRODUCTS

2.01 Wet Well

A. Wet well shall be precast concrete. The interior of the wet well shall be lined with SewperCoat, Refratta HAC 100, or approved equal calcium aluminate material.

B. Proposed substitutes must be equal in composition and manufacturer warranty. Liner product must be installed by a manufacturer certified applicator. Prepare surface by sand blasting and provide smooth trowel finish. Apply spray curing compound. Minimum wet well liner thickness shall be 1”.
Hydraulic structure must pass leakage testing prior to application of any coating or linings, fill with clean water to overflow level. Allow minimum 24-hour saturation

period. Test duration is 1-hour. No allowable leakage. Test each basin or chamber. Any areas of visible moisture shall be repaired and retested.

The first riser and floor of the wet well shall be precast integrally. Where this is not feasible, Adeka P.201 waterstop shall be used to seal the walls to a cast-in-place floor slab. Provide rubber O-ring gaskets at all riser joints.

2.02 HDPE Solid Wall Force Main Pipe.

A. All HDPE force main pipe material as shown in the plans shall consist of fusion-welded HDPE. Pipe shall consist of HDPE solid wall referred as to Drisco 1000, Drisco 8600, Quali Pipe, Poly Pipe, and Plexco Pipe that is in compliance with ASTM F714. All pipe and fittings shall be high density polyethylene pipe and made of virgin material, and shall have a minimum working pressure rating of 160 psi. The pipe shall be manufactured from a High Density High Molecular weight polyethylene compound which conforms to ASTM D 1248 and meets the requirements for Type III, Class C, Grade P-34, Category 5, and has a PPI rating of PE 4710. Solid wall pipe shall be produced with a plain end construction for heat-joining (butt fusion) conforming to ASTM D 2657; no flanged or slip-on joints will be accepted.

2.03 Ductile Iron Pipe

A. Ductile iron pipe shown in the plans shall be commensurate with SAWS Material Specification Item No. 05-12.

B. All Ductile Iron Pipe shall be flanged.

2.04 PVC Pipe

A. PVC pipe shall conform to SAWS Specification Section 848, Sanitary Sewer.

2.05 Valves

A. All gate valves, plug valves, check valves, and air release valves shall be suitable for sanitary sewer environments.

B. Gate Valves: Install a gate valve on the upstream side of each check valve. Gate valves shall be resilient wedge, flanged joints, conforming to the applicable requirements of ANSI/AWWA C509, and shall be handled and installed in accordance with the recommendations set forth in the appendix to ANSI/AWWA C509 and the recommendations of the manufacturer. All interior and exterior ferrous metal surfaces of valves and accessories shall be shop coated for corrosion protection. If the full-closing valve is other than a rising stem gate valve, the valve shall include a position indicator to show its open or closed position. Approved manufacturers are Clow F-6102, Mueller A-2360, Kennedy 4561/4701, and American Flow Control – Series 2500.

C. Check Valves: A flanged, non-slamming check valve shall be installed on the discharge side of each pump and on by-pass quick connector, followed by a full-closing isolation valve on each pump. Check valves shall be swing type with an external lever and minimum pressure rating of 250 psi. Approved check valve manufacturers are Clow Style 106LW, Mueller #2600-6-01, Kennedy IBBM Swing Check Valve, American "50" Line with Weight and Lever.

D. Air/Vacuum Release Valves: shall be mounted on common header and all high points along force mains. Air/Vacuum release valves shall be rated for raw sewage, have a minimum 2" inlet, and be provided with flush ports. Valves shall be sized for intended system hydraulics, with related sizing calculations included in engineering report. Air release valves shall be mounted on isolation valves. The air release pipe shall be a minimum of 1-inch PVC Sch. 80, and it shall be installed in a manner than doesn't represent a tripping hazard, and it shall be solidly fastened; unless embedded in concrete slab, and shall discharge into wet well. Liquid shall not accumulate with air release pipe. Air/Vacuum release valves shall have a stainless steel 316 body.

E. All valves shall be commensurate with SAWS Material Specifications.

2.06 Plug Valves

A. Section includes furnishing and installation of plug valves.

B. Related Sections

1. 01300, Submittals

C. Quality Assurance

1. Referenced Standards:

a. B16.1, Cast Iron Pipe Flanges and Flanged Fittings - Classes 25, 125 and 250.

2. ASTM International (ASTM):

a. A126, Standard Specification for Gray Iron Castings for Valves, Flanges and

b. Pipe Fittings

c. A536, Standard Specification for Ductile Iron Castings.

d. D2240, Standard Test Method for Rubber Property – Durometer Hardness.

3. American Water Works Association (AWWA):

a. C207, Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 IN through 144 IN

b . C517, Standard for Resilient Seated Cast Iron Eccentric Plug Valves

c. C550, Standard for Protective Coatings for Valves and Hydrants

D. Each valve and actuator shall have manufacturer's nameplate in stainless steel showing serial and model numbers, year manufactured and other pertinent data such as pressure rating, etc.

E. Valve supplier shall maintain a complete stock of spare parts in the State of Texas or shall indicate that parts will be delivered upon 48 hours of receipt of request.

F. Warranty
Warrant all equipment free of defects in material and workmanship for two (2) years from date of acceptance unless equipment manufacturer’s standard warranty is greater.

G. Non-Lubricated Eccentric Plug Valves (Manufacturers)

1. Subject to compliance with the Contract Documents, the manufacturers listed below are acceptable.

a. DeZURIK

b. Clow Valve Company

c. Milliken Valve Company

d. Val-Matic Valve & Manufacturing

2. Materials:

a. Body: Cast-iron ASTM A 126, Class B

b. Plug: One-piece construction ductile iron, ASTM A536 65-45-12 or cast iron, ASTM A126 Class B or 316 Stainless Steel.

c. Plug facing: Grease and/or petroleum-resistant resilient Buna-N compound, 70 Type A durometer hardness per ASTM D2240.

d. Shaft bearing bushings: Permanently lubricated TFE or Delrin sleeve type stainless steel.

e. Valve seats: Welded-in overlay of 90 percent nickel, minimum Brinell hardness of 200, (minimum 1/8 IN thick).

f. Stem seal: Nitrile butadiene packing or Buna-N dual U-cups.

3. Design Requirements:

   a. Conform to AWWA C517.

   b. Port area: Equal to or exceed 80 percent of full pipe area.

      1. End connections: ASME B16.1 Class 125 flanges.

   c. Stem seal: Adjustable and replaceable without disassembling valve or bonnet.

   d. Designed for seating drip tight in any flow direction.

   e. Rating: 125 psi working pressure.

   f. Actuator

      1. Actuator gearing in enclosure suitable for running in oil with seals on shaft to prevent entry of dirt or water.

      2. Positive identification on actuator indicating valve position.

      3. Adjustable stop to set closing torque.

   g. Provide ceramic epoxy interior coating for all ferrous surfaces in accordance with AWWA C550.

H. Valve Actuators

1. Valve Actuators – General

   a. Counter clockwise opening as viewed from the top.

   b. Direction of opening and the word OPEN to be cast on valve bonnet.

   c. Size actuator to produce required torque with a maximum pull of 80 LB at the maximum pressure rating of the valve provided and withstand without damage a pull of 200 LB.

   d. Valve shall have 2” square nut for activation.

2. Gearing:

   a. Provide power gearing consisting of heat treated steel helical gears, carburized and hardened alloy steel worm, and alloy bronze worm gear, all grease or oil bath lubricated, designed for 100 percent overload, and effectively sealed against entrance of foreign matter.

b. Provide gearing mechanism constructed to permit field changes of reduction gear ratio.

c. Support rotating shafts with anti-friction bearings.

d. Provide separate drive nut/thrust bearing assembly:

e. Mounted to base of actuator
f. High tensile bronze

g. Quarter turn actuator: Provide 90 degree mounting intervals

h. Provide grease fitting on drive assembly

I. Installation

1. Install valves and actuators in accordance with manufacturer's instructions and recommendations.

2. Install valves and valve operators to provide for ease of access and operation.
3. Install valves with valve stem horizontal, plug seat on inlet side and with plug rotating up into the open position for valves in horizontal lines.

4. Install valve with actuator above pipe or plug centerline.

J. Field Quality Control

1. Inspect the completed installation and note deficiencies.

2. Assist the CONTRACTOR during start-up, adjusting, and site testing of competed installation as required.

3. Instruct OWNER personnel in the operations and maintenance of the equipment.

2.07 Warranty

A. All equipment purchased and installed for the project shall be warranted for a minimum period of two (2) years, or manufacturer's time of warranty; whichever is larger, from the date of substantial completion of the project.

PART 3 - EXECUTION

3.01 INSTALLATION

All work shall conform to these Specifications, TCEQ Chapter 217 and the manufacturer's recommendations.

A. Pipe
All pipe shall be installed in trenches and backfilled in accordance with the requirements of the specifications shown herein.

B. Wet Well Pipe Slab and Electrical Control Panel Slab
All excavation and backfill work associated with the above-mentioned slabs shall be in accordance with the plans and the requirements of the specifications shown herein.

C. Electric Service
The CONTRACTOR is responsible for the coordination and installation of the three-phase electric line to service this lift station as shown on the plans.

D. Functionality Testing. After installation and calibration, the Contractor shall conduct a functionality test of the major equipment, electrical, and control components to verify their compliance with the manufacturer's recommended specification and the contract documents. All alarm conditions shall be simulated.

1. Functional testing shall be performed by the Contractor in the presence of the Owner's Civil and Electrical Inspection personnel, the Design Engineer and the pump manufacturer.

2. The pump manufacturer shall prepare a startup report of the Functional Testing to the Contractor, to be forwarded to the Owner.

3. Potable water shall be used for the testing.

3.02 CLEANING
Upon completion of the work of this Section, dispose of, away from the site, all excess material, all debris, trash, containers, residue, remnants and scraps which result from the work of this section.

END OF SECTION

SECTION 03055

CONCRETE STRUCTURES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Extent of Work: This Section governs for construction of all types of structures involving structural concrete.

B. Related Work (if utilized in this project)

1. Excavation: Per the section entitled, “Excavation and Backfill for Structures”.

2. Concrete: Per the section entitled, “Structural Concrete”.

3. Reinforcing Steel: Per the section entitled, “Reinforcing Steel”.

1.02 QUALITY ASSURANCE

A. Submittals: For samples, mix designs, tests and reports per the section entitled, “Structural Concrete”.

B. Prior to start of work submit the following information when requested:

1. Methods of construction.

2. Plans for forms and false work.

3. Amount and type of equipment.

4. Concrete placing schedule with facilities for handling concrete shrinkage.

5. Tabulation of concrete surfaces indicating types of finish on each surface.

1.03 REFERENCES

A. ASTM C309 – Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.

B. ASTM D545- Standard Test Methods for Preformed Expansion Joint Fillers for Concrete Construction, (Nonextruding and Resilient Types).

C. ASTM D1752- Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.

D. CRD-C572-74- Corps of Engineer Specifications for Polyvinylchloride Waterstop.

PART 2 PRODUCTS

2.01 MATERIALS

A. Concrete: Per the section entitled “Structural Concrete”, class as shown on Plans.

B. Expansion Joint Material: As per ASTM D1752. Furnish test results as to compliance with ASTM D545 if requested.

C. Waterstop: Manufactured from virgin polyvinylchloride plastic compound conforming to U.S. Corps of Engineers Specification No. CRD C572 74 and containing no scrap or reclaimed material. Unless otherwise specified or shown, water stops to conform to size and shape of Durajoint as manufactured by Durajoint Concrete Accessories, Garrettsville, Ohio or equivalent of the type indicated as follows:

1. Expansion Joint: Type 5

2. Construction Joint: Type 3

D. Curing Materials: Unless otherwise designated on Plans, use either of the following:

1. Water Curing: Water to meet requirements for concrete mixing water, and which will not stain or leave unsightly residue.

2. Membrane Curing Compound: Per ASTM C309.

3. Cotton Mats for Curing: A filling material cotton "bat" or "bats" (min. 12 oz. per sq. yd.), covered with unsized cloth (min. 6 oz. per sq. yd.), tufted or stitched to maintain stability, free from tears, and in good general condition

E. Forms and Falsework

1. Timber

a. Seasoned timber of good quality, free from loose or unsound knots, knot holes, twists, shakes, decay and other imperfections which would affect its strength or impair finished surface of concrete.
b. Wedges, when required, to be hardwood.

2. Metal

a. See Paragraph 3.02.D
b. Aluminum not permitted.

F. Nonshrinking Grout: Refer to the section entitled, “Structural Grout”.

G. Polyethelene Film for Permanent Moisture Barrier: Minimum thickness of 0.006-inch (six mils) and high impact strength rating.

H. Concrete Bonding Agent: Any of the following:

1. "Daraweld C" as manufactured by W. R. Grace and Company.

2. "Bond Crete" as manufactured by Dayton Superior.

3. Or equivalent.

I. Paint Type Coating (if used): Refer to the section entitled “Painting”.

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

A. Time Sequence of Construction Operations

1. Do not place superstructure members, forms, falsework or erection equipment on substructure before concrete has cured for four days.

2. Erect forms on footings supported by piling or drilled shafts after concrete has cured for 4 days. Such work may begin on spread footings after concrete has aged at least 2 curing days.

3. Support of tie beam and/or cap forms by falsework placed on previously placed tie beams is permissible, provided curing requirements are completed and tie beams are properly supported to eliminate stresses not provided for in design.

3.02 CONSTRUCTION

A. Forming

1. General Requirements: Design and construct to carry maximum anticipated loads and provide rigidity to prevent settlement or deformation.

2. Design Loads: Use 150 pounds per cubic foot for concrete and live load of 50 pounds per square foot of horizontal surface of form work with 125 percent of allowable stresses used for design of structures.

3. Falsework

a. Make timber sills and grillages large enough to support superimposed load without settlement.
b. Place falsework which cannot be founded on a satisfactory spread footing, on piling or drilled shafts.

c. Cap each falsework bent transversely by a member of proper size, and fasten caps securely to each pile or column in bent and set at proper elevation allowing for a construction camber.
d. Use wedges, if required, in pairs and arrange so as to ensure uniform bearing.
e. Use of wedges to compensate for incorrectly cut bearing surfaces not permitted.

B. Forms

1. General

a. Provide mortar tight forms sufficient in strength to prevent bulging or sagging.

b. If bulging or sagging occurs remove concrete causing such condition and reset forms.

c. Remove metal alignment appliances from forms to a depth of at least ½-inch from concrete surface without undue chipping or spalling, leaving a smooth opening in the concrete surface.

i. Turning off of rods, bolts or ties not permitted.

ii. Cut wire ties back at least ½-inch from face of concrete.

iii. Prior to erection treat facing of forms with oil or other bond breaking coating which will not discolor or otherwise injuriously affect concrete surface.

iv. Wet surface of forms to be in contact with concrete immediately before placing concrete.

C. Timber

1. Timber for facing or sheathing surfaced on at least one side and two edges.

2. Use nominal 2 inch lumber minimum thickness for forms for bottoms of beams.

3. Use lumber of nominal 1 inch minimum thickness elsewhere, generally, and back by sufficient number of studs and wales.

4. Plywood form lining made with waterproof adhesive to be ¼ inch minimum thickness, oiled at mill, and reoiled or lacquered on job before using.

5. Use tempered Masonite Concrete Form Board, 3/16 inch minimum thickness, as alternate form lining.

a. Keep moist at least 12 hours before applying to sheathing by moistening screen side of board and stacking boards screen side to screen side.

b. Use smooth, hard face as concrete contact surface of form.

6. Plywood forms to be minimum ¾ inch thickness made with waterproof adhesive backed by adequate studs and wales, with form lining not required.

7. Molding for chamfer strips or other uses.

    a. Redwood, cypress, or pine.
    b. Use quality which will not split when nailed and will hold true lines.
    c. Mill cut, dressed on all faces.
    d. Fillet sharp corners and edges with triangular chamfer strips, ¾ inch on sides.

D. Metal

1. Lining not required.

2. Thickness of metal forms as required to maintain true shape without warping or bulging.

3. Countersink bolt and rivet heads on facing sides of metal forms.

4. Straight metal panel forms may be used for all structures with straight walls, and for those structures with curved walls only below ground level.

5. Curved metal panels may be used for all structures with curved walls.

E. Joints

1. Expansion Joints

    a. Remove form from formed joints as soon as possible to permit free expansion of concrete.

    b. Anchor expansion joint fillers to concrete on side of joint by means of copper wire not lighter than No. 12 B&S gage or copper nails of approved size.

    c. Ensure complete separation of concrete sections by joint material.

2. Construction Joints

    i. Other than those indicated, joints are not permitted without written authorization.

    ii. Roughen previously placed concrete surface so as to expose aggregate particles.

    iii. Remove loose materials, and wash and scrub surface clean with stiff brooms.

    iv. Keep concrete surface moist for 12 hours prior to placing adjacent concrete.

v. For horizontal joints in walls, slosh surface of concrete with coating of mortar approximately ¼ inch thick immediately prior to placing concrete thereon.

vi. Use regular concrete mix, less coarse aggregate, for mortar.

vii. Apply mortar on previously placed vertical surfaces by brushing, where possible, and work mortar into irregularities of surface.

F. Placing Reinforcement: Per the section entitled “Reinforcing Steel”.

G. Placing Concrete

1. Seal Slabs

a. Use in all excavations for structures requiring reinforcing steel in base slab, except for retaining wall footings, unless shown in Plans.
b. Excavate 2-inches minimum below bottom of structural slab and pour seal slab concrete to structural slab bottom elevation.

c. Provide rough float finish.

d. No direct payment made for seal slab concrete.

2. General Requirements

a. Give advance notice before placing concrete.

b. Place concrete only after forms and reinforcing placement have been checked.

c. Discontinue heavy machinery use and other causes of vibration until concrete has attained an age of at least 18 hours.

d. Mix, place, and finish concrete in daylight hours. If necessary, to continue after daylight hours, light entire working area.

e. Do not place concrete when impending weather conditions, such as rain, sleet, or snow, threaten to impair quality of finished work.

f. If rainfall occurs during concrete placement, provide covering to protect work.

3. Handling and Transportation

a. Use method and equipment to maintain rate of placement as required to prevent cold joints.

b. Place concrete by buckets, chutes, buggies, pipes, or troughs, which prevent separation of concrete ingredients.

c. With prior written approval, use belt conveyers or pumps, and test samples at discharge end.

d. Protect concrete transported by conveyers from sun and wind, to prevent loss of slump and workability.

e. Pipes used to pump concrete to be shaded and/or wrapped with wet burlap to prevent loss of slump and workability.

f. Do not transport concrete through aluminum pipes, tubes, or other aluminum equipment.

g. Use of chutes in excess of 35-feet total length prohibited.

4. Depositing: Contractor to provide thermometer to measure temperature of concrete.

a. Equip chutes with baffles for depositing concrete on steep slopes, or make chutes in short lengths that reverse lateral direction of movement.

b. Provide downpipe at end of chute.

c. Use no slope steeper than one vertical to two horizontal.

d. Discharge concrete from chutes and troughs either vertically down inside of forms or into pockets outside of forms from which it may flow through holes left in forms.

e. Keep chutes, troughs, and pipes clean and free from coatings of hardened concrete.

f. Deposit concrete in continuous horizontal layers maximum 12-inches thick.

g. Depositing large quantities at one point and running or working it along forms not permitted.

h. Limit free fall of concrete to 4-feet, except in walls 10-inches or less in thickness, if segregation can be prevented.

i. Use tremies for placing concrete in walls over 10-inches thick.

j. Remove hardened concrete spatter ahead of plastic concrete.

k. Do not jar forms after concrete has taken initial set or place any strain on projecting reinforcement.

l. Make tremies in sections, or provide in several lengths, so outlet may be adjusted to proper heights during placing operations.

m. Place each layer while preceding layer is still plastic, but do not allow more than one hour to elapse between placement of successive layers.

n. Apply vibrators to concrete immediately after depositing, and move throughout mass, through layer of concrete just placed and several inches into plastic layer below.

o. Consolidate concrete and flush mortar to form surfaces by continuous working with immersion type vibrators.

p. Do not attach vibrators to forms or reinforcement.

q. Provide one standby vibrator for emergency use.

r. If excessive bleeding causes water to form on surface of concrete in tall forms, use stiffer mix.

s. In walls and deep beams, place concrete to a point approximately 1-foot below finished elevation of bottom of slab or beam to be poured monolithically with wall, and allow to settle; but to avoid a cold joint, resume placement of concrete before initial set occurs.

t. Overfill forms and screed off excess concrete after partial stiffening.

u. Placing Concrete in Cold Weather: Minimum temperature of all concrete at time of placement to be not less than 50° F.

    i. Maintain slab temperatures at 50° F or above for period of 72 hours from time of placement and above 40° F for additional 72 hours.

    ii. Maintain temperature of all other structural elements at 40° F or above for period of 72 hours from time of placement.

    iii. Maintain temperature of concrete placed on or in the ground above 40° for a period of 72 hours from time of placement.

    iv. Protect concrete against freezing during curing period in accordance with Portland Cement Association "Design and Control of Concrete Mixtures".

    v. Protect concrete from temperatures below 40° F until it has cured for a minimum of three days at 70° F or five days at 50° F. Remove and replace, at Contractor's expense, all concrete deemed unsatisfactory by Engineer.

    vi. Protection may consist of additional covering, insulated forms, artificial heatings, or other means approved by Engineer.

v. Placing Concrete in Hot Weather: When air temperature is above 90° F, use approved retarding agent in all exposed concrete, and in all cased drilled shafts regardless of temperature.

i. Reinforcing steel, steel beam flanges, and other surfaces in contact with concrete, to be cooled to below 90° F by means of water spray or other approved methods.

ii. Concrete temperature prior to placement not to exceed 85° F, plus a maximum tolerance of 5° F. Concrete above this maximum will be rejected.

iii. Reduce concrete temperature at time of placement to satisfy maximum allowable temperature by one or more of the following:

A) Addition of cold water with a subsequent addition of cement to maintain proper water cement ratio. Tanks or trucks used for storing or transporting water to be insulated or painted white. Mechanical refrigeration may be used to reduce water temperatures.
B) Addition of crushed, shaved, or chipped ice directly into the mixer with a subsequent addition of cement to maintain proper water cement ratio. Continue mixing until ice is completely melted.

C) Other approved methods.

w. Placing concrete in water

i. Only when authorized, use concrete mix with minimum 6.5 sacks cement per cubic yard of concrete.

ii. Forms, cofferdams, or caissons to be sufficiently tight to prevent water current passing through space in which concrete is being deposited.

iii. Pumping water not permitted during placing, nor until concrete with tremie, closed bottom dump bucket, or other approved method, to avoid free fall through water.

iv. Do not disturb concrete after depositing, and maintain horizontal layers at all times.

v. Use watertight tube 10-inches or less in diameter for tremie and constructed, so that bottom can be sealed and opened after it is in place and fully charged with concrete.

vi. Support tremie to allow easy movement horizontally to cover work area and vertically to control concrete flow.

vii. Stop flow by lowering tremie.

viii. Capacity of bottom dump buckets not less than one half cubic yard.

ix. Lower bucket or tremie gradually and carefully to rest upon concrete already placed and raise very slowly during upward travel, intent being to maintain still water at point of discharge and to avoid agitating mixture.

x. Pour concrete continuously until work is completed.

x. Placing Concrete on Ground:

i. Place concrete in footings after depth and character of foundation is observed.

ii. Place footing or base slab concrete upon seal slabs after caissons or cofferdams are free from water and seal surface cleaned.

iii. Locate pumps or bailing equipment in sump outside of forms.

iv. Immediately before placing concrete, moisten subgrade to decrease absorption of moisture, if seal slab or waterproofing not required.

v. With prior authorization, side forms in dry excavation may be omitted.

vi. Place column concrete monolithically unless otherwise provided.

H. Curing Concrete:

1. Keep forms tight against concrete or remove and start curing operations.

2. Length of Curing

a. Cure concrete for six consecutive curing days.

b. Cure high early strength concrete for three consecutive curing days.

3. Definition of Curing Day

a. "Curing day" is any calendar day during in which the temperature, taken in the shade and away from artificial heat, is above 50° F for at least 19 hours (or colder days if satisfactory provisions are made to maintain the temperature at all surfaces of the concrete above 40° F for the entire 24 hour day).

b. Required curing period begins when all concrete therein has attained initial set.

4. Curing Methods

a. Water Curing: Keep all exposed concrete surfaces wet continuously for required curing time.

i. Place wet cotton mats as soon as possible after surface has hardened sufficiently to prevent damage to concrete.

ii. Weight mats down to provide continuous contact with all concrete surfaces.

iii. Use overlapping water sprays or sprinklers that keep all unformed surfaces continuously wet.

iv. Use minimum 2-inches clean, granular material kept wet at all times or minimum 1 inch depth of water.

v. Provide dam or similar procedure to retain water or saturated sand.

b. Membrane Curing

i. Deliver curing compound in original containers showing name of compound, manufacturer, and batch number.

ii. Spray compound, using pressure tank type spraying equipment, and keep thoroughly mixed during application.

iii. Apply in single, uniform coating at rate of coverage recommended by manufacturer, but not less than 1 gallon per 180 square feet of area.

iv. Apply to walls immediately after form removal or after first rubbing, as applicable.

v. Apply on slabs immediately after finishing or after excess moisture has disappeared.

vi. Keep in place and protect against abrasive action for 10 days to obtain curing equivalent to a 6 day moist curing.

vii. Protect against any traffic and apply protective coating no sooner than 24 hours after application of membrane curing compound.

viii. Immediately repair any damage to membrane.

ix. Do not use on surface to receive first rubbing with No. 16 carborundum stone, surfaces to be painted, or to which waterproofing material or liquid floor hardener is to be applied, and surfaces on which additional concrete is to be placed.

x. Use on surfaces which cannot be cured satisfactorily with mats, when so directed.

I. Removal of Forms and Falsework:

1. Remove forms from surface to receive rubbed finish when concrete has attained adequate strength to prevent damage, and remove only as rapidly as rubbing operation progresses.

2. Rewet wood forms or form lining left in place longer than 24 hours as required to keep them moist.

3. Remove forms and falsework from portions of structures that do not require rubbed finish, after the following number of curing days:

a. Forms for falsework under slabs, beams or girders 7 days.
b. Forms for walls, columns and piers 2 days.

4. If cold weather continues below 40° F, form and falsework may be removed at the end of a period of calendar days equal to twice the number of curing days specified.

J. Defective Work

Any defective work discovered after form removal to be repaired or replaced immediately at Contractor's expense.

K. Concrete Surface Finish: For concrete having no special finish indicated, remove ties, fill holes, and remove fins and rough edges. Provide finish as follows:

1. Monolithic Finish

a. Finish slabs, platforms, and steps monolithically between joints.

b. Set screeds prior to concrete placement, and make sufficiently rigid to withstand impact of concrete being placed.

c. Tamp concrete thoroughly to force coarse aggregate away from surface of slab, then float to secure hard surface.

d. Provide wood float finish, except use steel trowel finish for building and pump station floor slabs, and elsewhere as indicated on Plans, unless otherwise directed.

e. "Dusting" floor surfaces with dry material not permitted.

f. Round edges at all expansion joints with suitable jointing or edging tools.

L. Exposed Aggregate Panels

1. Forms for raised panels to be sandblasted may be removed on the day following concrete placement (about 18 hours). Continue curing after sandblasting.

2. Immediately after form removal, sandblast to a depth of from 3/8-inch to 5/8-inch.

3. Protect smooth surfaces adjacent to sandblasted panels during sandblasting.

4. Coarse aggregate for raised panels range from Standard No. 4 to 1½-inch gradation.

5. Exposed aggregate sandblasted surfaces are to receive a coat of Prime A Pell 200 as manufactured by Chemproke Corp., Garland, Texas, or equivalent. Preparatory work, application, and precautions in strict compliance with manufacturer's recommendations.

M. Rub Finished Surfaces

1. General

Rub finish exposed vertical and battered surfaces from 6-inches below ground surface or from 6 inches below normal water level to top, except for small plinths and similar structures which extend less than 12-inches above finished grade.

2. Procedure

a. Start rubbing operations when concrete has attained adequate strength for form removal (about 18 hours after concrete placement). Continue curing afterwards.

b. Do necessary pointing as forms are removed.

c. Remove forms only as rubbing progresses in order to prevent rapid hardening of surface to be rubbed.

d. After pointing has set, wet surface with brush and give first surface rubbing with No. 16 carborundum stone or equal.

e. Rub sufficiently to bring surface to paste and to produce smooth dense surface without irregularities.

f. Do not add cement to form surface paste.

g. Spread or brush material, which has been ground to paste, uniformly over surfaces and allow to take reset.

h. Do not rub chamfered corner in first rubbing.

i. Complete first rubbing within 36 hours after completion of concrete placement.

j. For final acceptance, clean surfaces of structure and give final finish rubbing with No. 30 carborundum stone or equal.

k. After rubbing, strip surfaces with brush and allow mortar on surface to take reset; then wash surface with clean water.

l. Leave structure with clean, neat, and uniform appearing finish.

N. Paint Type and Grout Finishes: When specified on Plans or by Special Provision, the following alternative procedures to rubbing apply.

1. Adhesive Grout Coating:
   a. Perform first rub to eliminate rough surfaces, then give surface a coating of latex base adhesive grout of approximately 1/8 inch thickness.

   b. Apply grout by rubbing with sponge rubber float or similar applicator.

   c. Mix to be one part latex base adhesive, two parts white cement, two parts natural cement, two parts fine masonry sand, and sufficient water to produce desired consistency and color.

2. Paint Type Coating

   a. Perform first rub to eliminate rough surfaces before applying paint type coating as specified in Paragraph 2.01.I.

   b. Furnish sample of coating selected, for approval, before application to concrete surfaces.

O. Patching and Filling Holes

1. Tie and Bolt Holes

   a. Fill holes with cement mortar to which has been added white cement so that patches will not appear darker than adjacent concrete surface.

   b. Use mortar as dry as possible and pack into holes.

   c. Fill holes, entirely through concrete, with non-shrinking grout from inside structure with a pressure gun or other device that will force mortar through to outside face.

   d. Strike off excess mortar flush and finish surface to make filled holes as inconspicuous as possible.

2. Honeycomb and Minor Defects

   a. Patch slight honeycomb and minor defects in concrete with cement mortar mixed one part cement to two parts fine aggregate. Match color of adjacent concrete.

b. Repair area by cutting out unsatisfactory material by chipping or other approved methods and replace with new concrete, securely keyed and bonded to old concrete, and finish so as to make joints as inconspicuous as possible. Use stiff mixture and thoroughly tamp into place.

P. Waterstops

1. Secure complete embedment of waterstop into concrete.

2. Make waterstops continuous by heat sealing at splices as recommended by manufacturer. Miter waterstops at directional changes, and butt weld straight splices.

3. Place concrete around splice only after inspection.

Q. Grouting

1. Headworks

a. Prepare slab to receive grout using bonding agent specified in paragraph 2.01.H in accordance with manufacturer's recommendation.

b. Use grout mixture of one part Portland cement and three parts sand by weight.

c. Surface receiving bonding agent shall be free of dirt, grease, and other foreign substances before placement of bonding agent.

d. Placing Grout

i. Do not deposit large quantities at one point.

ii. Use clarifier mechanism operated by hand only for final screeding.

iii. Do not allow grout to build up in front of mechanism greater than three inches.

2. For Setting New Equipment

a. Use nonshrinking grout as specified in paragraph 2.01.F.
b. Blow out bolt holes.
c. Chip concrete to obtain firm bond.
d. Set grout forms true, level, tight, and well braced
e. Assemble equipment to be grouted before grouting.
f. Clean baseplates and all items to be embedded and set in final position.
g. Shim equipment bases for easy removal of shims.
h. Moisten area to receive grout.
i. Do not mix more grout than can be placed in 20 minutes.
j. Place grout from one end or side only to avoid excessive air entrapment and assure good compaction.

k. Work and rod grout continuously while it is being placed.
l. After grout has attained full strength, remove shims.
m. Replace grout damaged by shim removal with like material.
n. Steel trowel exposed grout, and protect exposed area from drying out rapidly.
o. Do not stress items embedded in grout, and do not operate equipment for 36 hours after grout is placed.

3. Other Grouting

a. For general purposes, use mixture of one part Portland cement and two parts sand by weight.

b. If space to be grouted is one inch or less in thickness and cannot be tamp grouted, use a mixture of one part Portland cement and one part sand by weight.

c. If space to be grouted is large, use original concrete mixture.

d. For grout to be tamped, use stiff mixture produced by prolonged mixing.

e. To obtain stiff grout, mix mortar using amount of water required to thoroughly mix ingredients, then continue mixing without additional water until grout is stiff enough to be compacted by tamping when placed.

f. For grouting blockouts, embedded pipes, and similar items, use nonshrinking grout as per paragraph 2.01.F of this specification.

R. Cleanup

Clean up area and remove excess material, dismantled forms and falsework, and debris during construction; and clean area completely and thoroughly after completion of the work herein described.

END OF SECTION

SECTION 03100

CONCRETE FORMWORK

PART 1 GENERAL

1.01 SCOPE

Design, construction, erection, and removal of structural formwork.

1.02 REFERENCE STANDARDS

ACI 117: Standard Tolerances for Concrete Construction and Materials.
ACI 347R: Recommended Practice for Concrete Formwork.
U.S. Product Standard PS 1 Construction and Industrial Plywood.
U.S. Product Standard PS 20 American Softwood Lumber Standard.

1.03 SUBMITTALS

A. Conform to Section entitled, "SUBMITTALS."

B. Shop Drawings: Show location, member size and loading of shoring. When reshoring is permitted, submit plans showing locations and member size of reshoring.

C. Product Data and Samples

1. Corrugated Fiberboard Carton Forms: Submit certification of compliance with design criteria, description of forms, and one foot long sample.

2. Form coating Materials: Submit trade or brand names of manufacturers and complete description of products.

3. Form ties and related accessories, including taper tie plugs, if taper ties are used. Form gaskets.

D. Detailed Layout for Slip forming: Submit detailed layout of proposed slip-forming, including description of equipment, rate of progress, and other data to show suitability of method. Show provisions for ensuring attainment of required concrete surface finish.

PART 2 PRODUCTS

2.01 MATERIALS

A. Smooth Forms: New plywood, metal, plastic, tempered concrete form hardboard, dressed lumber faced with plywood or fiberboard lining, or metal framed plywood ¬faced panel material, to provide continuous, straight, smooth surfaces. Form material shall be free of raised grain, torn surfaces, worn edges, patches, dents or other defects. Furnish material in

largest practical sizes to minimize number of joints and, when indicated on Construction Plans, conform to joint system indicated. Form material shall have sufficient strength and thickness to withstand pressure of newly placed concrete without bow or deflection.

B. Rough Forms: Plywood, metal, dressed or undressed lumber free of knots, splits or other defects, or other material acceptable to Engineer of sufficient strength and thickness to withstand pressure of newly placed concrete without bow or deflecti

C. Plywood: Conform to U.S. Product Standard, PS 1, Class 1.

D. Lumber: Conform to U.S. Product Standard, PS 20.

E. Edge Forms and Intermediate Screed Strips: Type and strength compatible with the screed equipment and methods used.

F. Plastic Forms: One piece forms for domes, beams and pan joists. Single lengths for columns not exceeding height of 7 feet 6 inches. For columns over 7 feet 6-inches, use 7 foot 6 inch sections and filler sections as needed. To facilitate removal of pan joist forms, taper sides one inch per foot.

G. Metal Pan Joist Forms: Removable type; fabricated of minimum 14 gauge steel; one piece between end closures. Adjustable forms not allowed. Taper sides one inch per foot to facilitate removal.

H. Earth Cuts for Forms:

1. Use earth cuts for forming unexposed sides of grade beams cast monolithically with slabs on grade.

2. Where sides of excavations are stable enough to prevent caving or sloughing, following surfaces may be cast against neat cut excavations:

a. Sides of footings

b. Inside face of perimeter grade beams not monolithic with slab on grade. When inside face is cast against earth, increase beam width indicated on Construction Plans by one (1) inch.

c. Both faces of interior grade beams not monolithic with slab on grade. When grade beam is cast against earth, increase beam width indicated on Construction Plans by two (2) inches.

I. Corrugated Fiberboard Carton Forms

1. Corrugated fiberboard carton forms, when called for, are intended to form a void space beneath pile supported and pier supported slabs and other structural elements as shown.

2. Provide products of a reputable manufacturer regularly engaged in commercial production of double faced corrugated fiberboard carton forms, constructed of waterproof paper and laminated with waterproof adhesive.

3. Fiberboard forms: Capable of supporting required dead load plus construction loads, and designed to lose their strength upon prolonged contact with moisture and soil bacteria.

   a. Seal cuts and ends of each form section by dipping in waterproof wax, unless liners and flutes are completely impregnated with waterproofing.

   b. Size forms as indicated on Construction Plans. Assemble as recommended by manufacturer, either with steel banding at four (4) feet maximum on centers, or, where liners and flutes are impregnated with waterproofing, with adequate stapling.

J. Circular Forms

1. Form round section members with paper or fiber tubes, constructed of laminated plies using water resistant adhesive with wax impregnated exterior for weather and moisture protection. Provide units with sufficient wall thickness to resist loads imposed by wet concrete without deformation. Provide manufacturer's seamless units to minimize spiral gaps and seams.

2. Fiberglass or steel forms may be used for round section members.

K. Shores: Wood or adjustable metal, with bearing plates, with double wedges at lower end.

L. Form Ties

1. Use commercially manufactured ties, hangers and other accessories for embedding in concrete. Do not use wire not commercially fabricated for use as a form accessory.

2. Fabricate ties so ends or end fasteners can be removed without causing spalling of concrete faces. Depth from formed concrete face to the embedded portion: At least one (1) inch, or twice the minimum dimension of tie, whichever is greater.

3. Provide water stop feature for form ties used on liquid containing structures and on concrete walls which will have earth backfill on one side.

4. Removable ties: Taper ties may be used when approved by the Engineer. In the hole left by the removal of the taper tie, insert a preformed neoprene or polyurethane plug sized to seat at the center of the wall.

M. Form Coating: Commercial formulation of form oil or form release agent having proven satisfactory performance. Coating shall not bond with, stain or otherwise adversely affect concrete surfaces, or impair their subsequent treatment, including application of bonding agents, curing compounds, paint, protective liners and membrane waterproofing.

N. Coating for Plastic Forms: Alkali resistant gel coated.

O. Chamfer Strips: Unless otherwise indicated on the Construction Plans, provide 3/4 inch chamfer strips in corners of forms to produce beveled edges.

P. Form Gaskets: Polyethylene rod, closed cell, 1 inch diameter

2.02 DESIGN OF FORMWORK

A. Conform to ACI 117, ACI 347R and City Building Codes, unless more restrictive requirements are specified or shown on Construction Plans. Contractor shall design and engineer concrete formwork, including shoring and bracing. Design formwork to be readily removed without impact, shock or damage to concrete surfaces and adjacent materials.

B. Slip Forming: Permitted on written approval of Engineer. Contractor shall demonstrate suitability of method proposed.

PART 3 EXECUTION

3.01 INSTALLATION

A. Formwork Construction

1. Construct and maintain formwork so that it will maintain correct sizes of members, shape, alignment, elevation and position during concrete placement and until concrete has gained sufficient strength.

2. Construct forms for easy removal without damage to concrete surfaces.

3. Make formwork sufficiently tight to prevent leakage of cement paste during concrete placement. Solidly butt joints and provide backup material at joints as required to prevent leakage and fins.

4. Place chamfer strips in forms to bevel edges and corners permanently exposed to view, except top edges of walls, and slabs which are indicated on Construction Plans to be tooled. Do not bevel edges of formed joints and interior corners unless indicated on Construction Plans. Form beveled edges for vertical and horizontal corners of equipment bases. Unless otherwise indicated on Construction Plans, make bevels 3/4 inch wide.

5. Provide temporary openings at bases of column and wall forms and other points as required for observation and cleaning immediately before concrete is placed.

6. Where runways are required for moving equipment, support runways directly on the formwork or structural members. Do not allow runways or supports to rest on reinforcing steel.

7. Use smooth forms on formed concrete surfaces required to have smooth form finish or rubbed finish as specified in the Section entitled, "CONCRETE FINISHING."

8. Rough forms may be used on formed concrete surfaces indicated to have rough form finish as specified in the Section entitled, "CONCRETE FINISHING."

B. Forms for Surfaces Requiring Smooth Form Finish:

1. Drill forms to suit ties used and to prevent leakage of concrete mortar around tie holes. Uniformly space form ties and align in horizontal and vertical rows. Install taper ties, if used, with the large end on the wet face of the wall.

2. Provide sharp, clean corners at intersecting planes, without visible edges or offsets. Back up joints with extra studs or girts to maintain true, square intersections.

3. Form molding shapes, recesses and projections with smooth finish materials and install in forms with sealed joints to prevent displacement.

4. Form exposed corners of beams to produce square, smooth, solid, unbroken lines.

5. Provide exterior exposed edges with 3/4 inch chamfer or 3/4 inch radius.

6. Arrange facing material in orderly and symmetrical fashion. Keep number of joints to practical minimum. Support facing material adequately to prevent deflection in excess of allowable tolerances.

7. For flush surfaces exposed to view in completed structure, overlap previously placed hardened concrete with form sheathing by approximately 1 inch. Hold forms against hardened concrete to maintain true surfaces, preventing offsets or loss of mortar.

C. Forms for Surfaces Requiring Rubbed Finish: Provide forms as specified in Paragraph 3.01(B) of this Section. Use smooth plywood or fiberboard linings or forms, in as large sheets as practicable, and with smooth, even edges and close joints.

D. Edge Forms and Screed Strips for Slabs: Set edge forms or bulkheads and intermediate screed strips for slabs to obtain required elevations and contours in finished slab surface. Provide and secure supports for types of screeds required.

E. Circular Forms: Set forms in one piece for full height of member.

F. Surfaces to Receive Membrane Waterproofing: Coordinate surface finish, anchors, reglets and similar requirements with membrane waterproofing applicator.

G. Fireproofing Steel Member: Construct forms to provide not less than the concrete thickness necessary, measured from face of steel member, to provide the required fire rating. Forms for concealed surfaces may be unlined.

H. Tolerances:

1. Unless noted otherwise on Construction Plans, construct formwork so concrete surfaces will conform to tolerance limits listed in TABLE 03100 located at the end of this Section.

2. Establish sufficient control points and bench marks as references for tolerance checks. Maintain these references in undisturbed condition until final completion and acceptance of Work.

I. Adjustment of Formwork:

1. Use wedges or jacks to provide positive adjustment of shores and struts. After final inspection and before concrete placement, fasten in position wedges used for final adjustment of forms.

2. Brace forms securely against lateral deflections. Prepare to compensate for settling during concrete placement.

J. Corrugated Fiberboard Carton Forms:

1. Place on smooth firm bed of suitable material to prevent vertical displacement; set tight to prevent horizontal displacement. Exercise care to avoid buckling of forms. Install in accordance with manufacturer's directions and recommendations.

2. Fit carton forms tightly around piles and piers; completely fill the space between subgrade and concrete placement with carton forms to form a void space.

3. Protect carton forms from moisture and maintain in a dry condition until concrete is placed on them. If they become wet before placement of concrete, allow them to dry and carefully inspect for strength before concrete is placed.

4. Before concrete placement, replace damaged or deteriorated forms which are in capable of supporting concrete dead load plus construction live loads.

3.02 PREPARATION OF FORM SURFACES

A. Clean surfaces of forms and embedded materials before placing concrete. Remove accumulated mortar, grout, rust and other foreign matter.

B. Coat forms for exposed or painted concrete surfaces with form oil or form release agent before placing reinforcement. Cover form surfaces with coating material in accordance with manufacturer's printed instructions. Do not allow excess coating material to accumulate in forms or to contact hardened concrete against which fresh concrete will be placed. Remove coating material from reinforcement before placing concrete.

C. Forms for unexposed surfaces, other than retained in place metal forms, may be wet with water immediately before concrete placement in lieu of coating. When possibility of freezing temperatures exists, however, the use of coating is mandatory.

3.03 REMOVAL OF FORMS

A. Time Limits:

1. When repair of surface defects or finishing is required before concrete is aged, forms on vertical surfaces may be removed as soon as concrete has hardened sufficiently to resist damage from removal operations.

2. Formwork for non water retaining walls, sides of beams and other formwork components not supporting weight of concrete may be removed after twelve (12) hours, provided concrete has hardened sufficiently to resist damage from removal operations, andprovided removal offorms will not disturb members supporting weight of concrete.

3. Forms and shoring supporting weight of concrete or construction loads: Leave in place until concrete has reached minimum strength specified for removal of forms and shoring. Do not remove such forms in less than four (4) days.

B. Circular Paper or Spiral Tube Forms: Follow manufacturer's directions for form removal. Take necessary precautions to prevent damage to concrete surface. When removal is done before completion of curing time, replace form, tie in place and seal to retard escape of moisture.

C. Removal Strength:

1. Control Tests: Suitable strength control tests will be required as evidence that concrete has attained specified strength for removal of formwork or shoring supporting weight of concrete in beams, slabs and other structural members. Furnish test cylinders and data to verify strength for early form removal.

a. Field cured Test Cylinders: When field cured test cylinders reach specified removal strength, formwork or shoring may be removed from respective concrete placements.

b. Laboratory cured Test Cylinders: When concrete has been cured as specified for structural concrete for same time period required by laboratory cured cylinders to reach specified strength, formwork or shoring may be removed from respective concrete placements. Determine length of time that concrete has been cured by totaling the days or fractions of days, not necessarily consecutive, during which air temperature surrounding concrete is above 50 degrees F and concrete has been damp or thoroughly sealed against evaporation and loss of moisture.

2. Compressive Strengths: The minimum concrete compressive strength for removal of formwork supporting weight of concrete is seventy five (75) percent of specified minimum 28 day strength for class of concrete involved.

3.04 RESHORING

A. When reshoring is permitted, plan operations in advance and obtain Engineer's approval of such operations. While reshoring is under way, keep live load off new construction. Do not permit concrete in any beam, slab, column or other structural member to be subjected to combined dead and construction loads in excess of loads permitted for developed concrete strength at time of reshoring.

B. Place reshores as soon as practicable after form stripping operations are complete but in no case later than end of day on which stripping occurs. Tighten reshores to carry required loads without over stressing construction. Leave reshores in place until tests representative of concrete being supported have reached specified strength at time of removal of formwork supporting weight of concrete.

C. Floors supporting shores under newly placed concrete: Leave original supporting shores in place, or re shore. Locate reshores directly under shore position above. Extend reshoring over a sufficient number of stories to distribute weight of newly ¬placed concrete, forms and construction live loads in such manner that design superimposed loads of floors supporting shores are not exceeded.

3.05 FORM REUSE

Do not reuse forms that are worn or damaged beyond repair. Thoroughly clean and re coat forms before reuse. For wood and plywood forms to be used for exposed smooth finish, sand or otherwise dress concrete contact surface to original condition or provide form liner facing material. For metal forms, straighten, remove dents and clean to return forms to original condition.

TABLE 03100
TOLERANCES FOR FORMED SURFACES CONCRETE IN BUILDINGS **

VARIATION FROM	VARIATION IN	FOR ANY 10 FOOT LENGTH	FOR ANY 20 FOOT LENGTH OR ANY BAY	MAXIMUM FOR ENTIRE DIMENSION
Plumb or Specified Batter	Lines and Surfaces of Columns, Piers, Walls and Arrises	1/4 inch	-	1 inch
	Exposed Corner Columns, Control Joint Grooves, and Other Conspicuous Lines		1/4 inch	1/2 inch
Level or Specified Grade	Slab Soffits, Ceilings, Beam Soffits, and Arrises (Measured Before Removal of Shores)	1/4 inch	3/8 inch	3/4 inch
	Exposed Lintels, Sills, Parapets, Horizontal Grooves and Other Conspicuous Lines		¼-inch	½-inch
Drawing Dimensions	Position of Linear Building Lines, Columns, Walls, and Partitions		½-inch	1-inch
	Size and Location of Sleeves, Floor Openings and Wall Openings			+/- ¼-inch
	Cross Section of Columns, Beams, Slabs, and Walls			+ ½-inch, - ¼-inch
	Footings in Plan *			+ 2-inch, - ½-inch
	Footing Misplacement or Eccentricity in Direction of Error (The Lesser Of)			2 % of Width or 2-inch
	Footing Thickness Decrease			5 %
	Footing Thickness Increase			No Limit
	Step Rise in Flight of Stairs			+/- 1/8-inch
	Step Tread in Flight of Stairs			+/- ¼-inch
	Consecutive Step Rise			+/- 1/16-inch
	Consecutive Step Tread			+/- 1/8-i

* Footing tolerances apply to concrete dimensions only, not to positioning of vertical reinforcing steel, dowels, or embedded items.

** Includes water and wastewater process structures.

END OF SECTION

SECTION 03211

REINFORCING STEEL

PART 1 GENERAL

1.01 SECTION INCLUDES

Structural concrete reinforcement and grouting of reinforcement dowel bars into hardened concrete.

1.02 REFERENCES

ACI 315 - Details and Detailing of Concrete Reinforcement.
ACI 318 - Building Code Requirements for Structural Concrete and Commentary.
ASTM A36 - Standard Specification for Carbon Structural Steel.
ASTM A82 - Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
ASTM A185 - Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
ASTM A497 - Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete Reinforcement.
ASTM A615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
ASTM A675 - Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties.
ASTM A775/A775M - Standard Specification for Epoxy-Coated Steel Reinforcing Bars.
ASTM C881 - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
AWS D1.4 - Structural Welding Code - Reinforcing Steel.
WRI - Manual of Standard Practice for Welded Wire Fabric.
CRSI MSP-1 - Manual of Standard Practice.

1.03 SUBMITTALS

A. Conform to the section entitled, “SUBMITTAL.”

B. Shop Drawings

1. Submit shop drawings detailing reinforcement fabrication, bar placement location, splices, spacing, bar designation, bar type, length, size, bending, number of bars, bar support type and other pertinent information, including dimensions. Provide sufficient detail for placement of reinforcement without use of Contract Drawings. Information shall correspond directly to data listed on bill of materials.

2. Use of reproductions of Contract Drawings by Contractor, Subcontractor, erector, fabricator or material supplier in preparation of shop drawings (or in lieu of preparation of shop drawings).

3. Detail shop drawings in accordance with ACI 315, Figure 6.

4. Submit shop drawings showing location of proposed additional construction joints as required under Section 03055 - Concrete Structures, and obtain approval of Engineer, prior to submitting reinforcing steel shop drawings.

C. Bill of Materials: Submit with shop drawings.

D. Product Data

1. Mechanical Bar Splices: Submit manufacturer's technical literature, including specifications and installation instructions.

2. Epoxy grout proposed for anchoring reinforcing dowels to hardened concrete: Submit manufacturer's technical literature including recommended installation procedures.

E. Certificates

1. Submit steel manufacturer's certificates of mill tests giving properties of steel proposed for use. List manufacturer's test number, heat number, chemical analysis, yield point, tensile strength and percentage of elongation. Identify proposed location of steel in work.

2. Foreign-manufactured reinforcing bars shall be tested for conformance to ASTM requirements by a certified independent testing laboratory located in United States. Certification from any other source is not acceptable. Submit test reports for review. Do not begin fabrication of reinforcement until material has been approved.

1.04 HANDLING AND STORAGE

Store steel reinforcement above ground on platforms, skids or other supports. Protect reinforcing from mechanical injury, surface deterioration and formation of excessive, loose or flaky rust caused by exposure to weather. Protect epoxy-coated reinforcing from formation of any amount of rust.

1.05 QUALITY ASSURANCE

Notify Resident Project Representative at least 48 hours before concrete placement so that reinforcement may be inspected, and errors corrected, without delaying Work.

PART 2 PRODUCTS

2.01 MATERIAL

A. Reinforcing Bars: Deformed bars conforming to ASTM A615, grade as indicated on Drawings, except column spirals and those shown on Drawings to be smooth bars. Where grade is not shown on Drawings, use Grade 60.

B. Smooth Bars: Where indicated on Drawings, use smooth bars conforming to ASTM A36; ASTM A615, Grade 60; or ASTM A675, Grade 70.

C. Column Spirals: Bars conforming to ASTM A615, Grade 60, or wire conforming to ASTM A82.

D. Epoxy-Coated Deformed Bars, Column Spirals and Smooth Bars: Conform to ASTM A775/A775M.

E. Welded Wire Fabric:

1. Welded Smooth Wire Fabric: Conform to ASTM A185.

2. Welded Deformed Wire Fabric: Conform to ASTM A497.

3. Provide wire size, type and spacing as shown. Where type is not shown on Drawings, use welded smooth wire fabric.

4. Furnish welded wire fabric in flat sheets only.

F. Tie Wire: 16-1/2 gage or heavier annealed steel wire. Use plastic-coated tie wire with epoxy-coated reinforcing steel.

G. Bar Supports: Provide chairs, riser bars, ties and other accessories made of plastic or metal, except as otherwise specified. Use bar supports and accessories of sizes required to provide required concrete cover. Where concrete surfaces are exposed to weather, water or wastewater, provide plastic accessories only; do not use galvanized or plastic-tipped metal in such locations. Provide metal bar supports and accessories rated Class 1 or 2 conforming to CRSI MSP-1 Manual of Standard Practice. Use epoxy-coated bar supports with epoxy-coated reinforcing bars.

H. Slabs on Grade: Provide chairs with sheet metal bases or provide precast concrete bar supports 3 inches wide, 6 inches long, and thick enough to allow required cover. Embed tie wires in 3 inch by 6-inch side.

I. Mechanical Bar Splices

1. Conform to ACI 318; use where indicated on Drawings.

a. Compression splices shall develop ultimate stress of reinforcing bar.

b. Tension splices shall develop 125 percent of minimum yield point stress of reinforcing bar.

2. Regardless of chemical composition of steel, any heat effect shall not adversely affect performance of reinforcing bar.

J. Welded Splices

1. Provide welded splices where shown and where approved by the Engineer. Welded splices of reinforcing steel shall develop a tensile strength exceeding 125 percent of the yield strength of the reinforcing bars connected.

2. Provide materials for welded splices conforming to AWS D1.4.

K. Epoxy Grout: High-strength rigid epoxy adhesive, conforming to ASTM C881, Type IV, manufactured for purpose of anchoring dowels into hardened concrete and the moisture condition, application temperature and orientation of the hole to be filled. Unless otherwise shown, depth of embedment shall be as required to develop the full tensile strength (125 percent of yield strength) of dowel, but not less than 12 diameters.

2.02 FABRICATION

A. Bending: Fabricate bars to shapes indicated on Drawings by cold bending. Bends shall conform to minimum bend diameters specified in ACI 318. Do not straighten or rebend bars. Fabricate epoxy-coated reinforcing steel to required shapes in a manner that will not damage epoxy coating. Repair any damaged epoxy coating with patching material conforming to Item 4.4 of ASTM A775/A775M.

B. Splices

1. Locate splices as indicated on Drawings. Do not locate splices at other locations without approval of Engineer. Use minimum number of splices located at points of minimum stress. Stagger splices in adjacent bars.

2. Length of lap splices: As shown on Drawings.

3. Prepare ends of bars at mechanical splices in accordance with splice manufacturer's requirements.

C. Construction Joints: Unless otherwise shown, continue reinforcing through construction joints.

D. Bar Fabrication Tolerances: Conform to tolerances listed in ACI 315, Figures 4 and 5.

E. Standard Hooks: Conform to the requirements of ACI 318.

F. Marking: Clearly mark bars with waterproof tags showing number of bars, size, mark, length and yield strength. Mark steel with same designation as member in which it occurs.

PART 3 EXECUTION

3.01 PREPARATION

Clean reinforcement of scale, loose or flaky rust and other foreign material, including oil, mud or coating that will reduce bond to concrete.

3.02 INSTALLATION

A. Placement Tolerances: Place reinforcement within tolerances of Table 03211A at the end of this Section. Bend tie wire away from forms to maintain the specified concrete coverage.

B. Interferences: Maintain 2-inch clearance from embedded items. Where reinforcing interferes with location of other reinforcing steel, conduit or embedded items, bars may be moved within specified tolerances or one bar diameter, whichever is greater. Where greater movement of bars is required to avoid interference, notify Engineer. Do not cut reinforcement to install inserts, conduit, mechanical openings or other items without approval of Engineer.

C. Concrete Cover: Provide clear cover measured from reinforcement to face of concrete as listed in Table 03211B at the end of this Section, unless otherwise indicated on Drawings.

D. Placement in Forms: Use spacers, chairs, wire ties and other accessory items necessary to assemble, space and support reinforcing properly. Provide accessories of sufficient number, size and strength to prevent deflection or displacement of reinforcement due to construction loads or concrete placement. Use appropriate accessories to position and support bolts, anchors and other embedded items. Tie reinforcing bars at each intersection, and to accessories. Blocking reinforcement with concrete or masonry is prohibited.

E. Placement for Concrete on Ground: Support bar and wire reinforcement on chairs with sheet metal bases or precast concrete blocks spaced at approximately 3 feet on centers each way. Use minimum of one support for each 9 square feet. Tie supports to reinforcing bars and wires.

F. Vertical Reinforcement in Columns: Offset vertical bars by at least one bar diameter at splices. Provide accurate templates for column dowels to ensure proper placement.

G. Splices

1. Do not splice bars, except at locations indicated on Drawings or reviewed shop drawings, without approval of Engineer.

2. Lap Splices: Unless otherwise shown or noted, Class B, conforming to ACI 318, Section 12.15.1. Tie securely with wire prior to concrete placement, to prevent displacement of splices during concrete placement.

3. Mechanical Bar Splices: Use only where indicated on Drawings or approved by the Engineer. Install in accordance with manufacturer's instructions.

a. Couplers located at a joint face shall be of a type which can be set either flush or recessed from the face as shown. Seal couplers prior to concrete placement to completely eliminate concrete or cement paste from entering.

b. Couplers intended for future connections: Recess 1/2 inch minimum from concrete surface. After concrete is placed, plug coupler and fill recess with sealant to prevent contact with water or other corrosive materials.

c. Unless noted otherwise, match mechanical coupler spacing and capacity to that shown for the adjacent reinforcing.

H. Construction Joints: Place reinforcing continuous through construction joints, unless noted otherwise.

I. Welded Wire Fabric: Install wire fabric in as long lengths as practicable. Unless otherwise indicated on Drawings, lap adjoining pieces at least 6 inches or one full mesh plus 2 inches, whichever is larger. Lace splices with wire. Do not make end laps midway between supporting beams, or directly over beams of continuous structures. Offset end laps in adjacent widths to prevent continuous laps. Conform to WRI - Manual of Standard Practice for Welded Wire Fabric.

J. Field Bending: Shape reinforcing bent during construction operations to conform to Drawings. Bars shall be cold-bent; do not heat bars. Closely inspect reinforcing for breaks. When reinforcing is damaged, replace, Cadweld, or otherwise repair, as directed by Engineer. Do not bend reinforcement after it is embedded in concrete.

K. Epoxy-coated Reinforcing Steel: Install in accordance with paragraph 3.02J, Field Bending, and in a manner that will not damage epoxy coating. Repair damaged epoxy coating with patching material as specified in paragraph 2.02A, Bending.

L. Field Cutting: Cut reinforcing bars by shearing or sawing. Do not cut bars with cutting torch.

M. Welding of reinforcing bars is prohibited, except where shown on Drawings.

3.03 GROUTING OF REINFORCING AND DOWEL BARS

Use epoxy grout for anchoring reinforcing and dowel steel to existing concrete in accordance with epoxy manufacturer's instructions. Drill hole not more than 1/4 inch larger than steel bar diameter (including height of deformations for deformed bars) in existing concrete. Just before installation of steel, blow hole clean of all debris using compressed air. Partially fill hole with epoxy, using enough epoxy so when steel bar is inserted, epoxy grout will completely fill hole around bar. Dip end of steel bar in epoxy and twist bar while inserting into partially-filled hole.

Table 03211A

REINFORCEMENT PLACEMENT TOLERANCES

PLACEMENT	**TOLERANCE IN INCHES**
Clear Distance -	
To formed soffit:	-1/4
To other formed surfaces:	+/- 1/4
Minimum spacing between bars:	-1/4
Clear distance from unformed surface to top reinforcement -	
Members 8 inches deep or less:	+/- 1/4
Members more than 8 inches deep but less than 24 inches deep:	-1/4, +1/2
Members 24 inches deep or greater:	-1/4, +1
Uniform spacing of bars (but the required number of bars shall not be reduced):	+/- 2
Uniform spacing of stirrups and ties (but the required number of stirrups and ties shall not be reduced):	+/- 1
Longitudinal locations of bends and ends of reinforcement -	
General:	+/- 2
Discontinuous ends of members:	+/- 1/2
Length of bar laps:	-1-1/2
Embedded length -	
For bar sizes No. 3 through 11:	-1
For bar sizes No. 14 and 18:	-2

Table 03211B

MINIMUM CONCRETE COVER FOR REINFORCEMENT

SURFACE	MINIMUM COVER IN INCHES
Slabs and Joists -	
Top and bottom bars for dry conditions -	
No. 14 and No. 18 bars:	1-1/2
No. 11 bars and smaller:	1
Formed concrete surfaces exposed to earth, water or weather; over, or in contact with, sewage; and for bottoms bearing on work mat, or slabs supporting earth cover -	
No. 5 bars and smaller:	1-1/2
No. 6 through No. 18 bars:	2
Beams and Columns -	
For dry conditions -	
Stirrups, spirals and ties:	1-1/2
Principal reinforcement:	2
Exposed to earth, water, sewage or weather -	
Stirrups and ties:	2
Principal reinforcement:	2-1/2
Walls -	
For dry conditions -	
No. 11 bars and smaller:	1
No. 14 and No. 18 bars:	1-1/2
Formed concrete surfaces exposed to earth, water, sewage or weather, or in contact with ground -	
Circular tanks with ring tension:	2
All others:	2
Footings and Base Slabs -	
At formed surfaces and bottoms bearing on concrete work mat:	2
At unformed surfaces and bottoms in contact with earth:	3
Over top of piles:	2
Top of footings -- same as slabs	

END OF SECTION

SECTION 03310

STRUCTURAL CONCRETE

PART 1 GENERAL

1.01 SECTION INCLUDES

Cast-in-place normal-weight structural concrete and mass concrete.

1.02 REFERENCES

ACI 301 - Specifications for Structural Concrete for Buildings.
ACI 304.2R - Placing Concrete by Pumping Methods
ACI 305R - Hot Weather Concreting.
ACI 306.1 - Standard Specification for Cold Weather Concreting.
ACI 309R - Guide for Consolidation of Concrete.
ACI 318 - Building Code Requirements for Reinforced Concrete.
ACI 350R - Environmental Engineering Concrete Structures.
ASTM C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
ASTM C33 - Standard Specification for Concrete Aggregates.
ASTM C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
ASTM C42 - Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
ASTM C88 - Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
ASTM C94 - Standard Specification for Ready-Mixed Concrete.
ASTM C127 - Standard Test Method for Density, Relative Density (Specific Gravity) and Absorption of Coarse Aggregate.
ASTM C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
ASTM C136 - Standard Test Method for Sieve Analyses of Fine and Coarse Aggregates.Q.ASTM
C143 - Standard Test Method for Slump of Hydraulic Cement Concrete.
ASTM C150 - Standard Specification for Portland Cement.
ASTM C157 – Standard Test Method for Length Change of Hardened Hydraulic Cement Mortar and Concrete.
ASTM C172 - Standard Practice for Sampling Freshly Mixed Concrete.
ASTM C173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
ASTM C192 – Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory.
ASTM C231 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
ASTM C330 - Standard Specification for Lightweight Aggregates for Structural Concrete.
ASTM C494 - Standard Specification for Chemical Admixtures for Concrete.

ASTM C 535 - Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

ASTM C567 - Standard Test Method for Determining Density of Structural Lightweight Concrete.

ASTM C1064 - Standard Test Method for Temperature of Freshly Mixed Hydraulic Cement Concrete.

Concrete Plant Manufacturer's Bureau (CPMB), Plant Mixer Manufacturers Division: Concrete Plant Mixer Standards.

National Ready-Mixed Concrete Association (NRMCA): Certification of Ready-Mixed Concrete Production Facilities (checklist with instructions).

John Wiley and Sons, Interscience Publishers Division, "Encyclopedia of Industrial Chemical Analysis," Vol. 15, Page 230 (alkalinity test procedure)

1.03 DEFINITIONS

A. Mass Concrete: Concrete sections 4 feet or more in least dimension.

B. Hot Weather: Any combination of high air temperature, low relative humidity and wind velocity tending to impair quality of fresh or hardened concrete or otherwise resulting in abnormal properties.

C. Cold Weather: Period when, for more than 2 successive days, mean daily temperature is below 40 degrees F.

1.04 SUBMITTALS

A. Conform to the section entitled, "Submittals."

B. Mill Certificates: Required for bulk cement.

C. Design Mixes:

1. Submit test data on proposed design mixes for each type of concrete in the Work, including each class, and variations in type, source or quantity of material. Include type, brand and amount of cementitious materials; type, brand and amount of each admixture; slump; air content; aggregate sources, gradations, specific gravity and absorption; total water (including moisture in aggregate); water/cement ratio; compressive strength test results for 7 and 28 days; and shrinkage tests for Class A and D concrete at 21 or 28 days of drying.

2. Submit abrasion loss and soundness test results for limestone aggregate.

3. Testing of aggregates, including sieve analysis, shall be performed by a certified independent testing laboratory. Tests shall have been performed no earlier than 3 months before Notice to Proceed.

4. Provide standard deviation data for plant producing concrete. Data shall include copies of laboratory test results and standard deviation calculated in accordance with ACI 318,

Item 5.3.1. Laboratory tests shall have been performed within past 12 months. When standard deviation data is not available, comply with ACI 318, Table 5.3.2.2.

5. Review and acceptance of mix design does not relieve Contractor of responsibility to provide concrete of quality and strength required by these Specifications.

D. Admixtures: Submit manufacturer's technical information, including following:

1. Air-Entraining Admixture: Give requirements to control air content under all conditions, including temperature variations and presence of other admixtures.

2. Chemical Admixtures: Give requirements for quantities and types to be used under various temperatures and job conditions to produce uniform, workable concrete mix. Submit evidence of compatibility with other admixtures and cementitious materials proposed for use in design mix.

E. High-range Water Reducer (Superplasticizer): When approved for use by Engineer, submit manufacturer's technical information and instructions for use of superplasticizer. Superplasticizer will not be added at ready-mix plant. When superplasticizer will be added at job site, submit proposed plan for measuring and adding superplasticizer to concrete mix at job site, and establish dosing area on site with holding tanks and metering devices. Identify portions of Work on which superplasticizer is proposed for use.

F. Hot and Cold Weather Concreting: Submit, when applicable, proposed plans for hot and cold weather concreting. Review and acceptance of proposed procedure will not relieve Contractor of responsibility for quality of finished product.

G. Project Record Drawings: Accurately record actual locations of embedded utilities and components which are concealed from view.

1.05 QUALITY ASSURANCE

A. Provide necessary controls during evaluation of materials, mix designs, production and delivery of concrete, placement and compaction to assure that the Work will be accomplished in accordance with Contract Documents. Maintain records of concrete placement. Record dates, locations, quantities, air temperatures, and test samples taken.

B. Code Requirements: Concrete construction for buildings shall conform to ACI 318. Concrete construction for water and wastewater treatment and conveying structures shall conform to ACI 318 with modifications by ACI 350R, Item 2.6. Where this Specification conflicts with ACI 318 or ACI 350R, this Specification governs.

C. Testing and Other Quality Control Services:

1. Concrete testing required in this section, except concrete mix design, limestone aggregate test data, and testing of deficient concrete, will be performed by an

independent commercial testing laboratory employed and paid by the Owner in accordance with the section entitled, “Testing Laboratory Services.”

2. Provide material for and cooperate fully with Owner's testing laboratory technician in obtaining samples for required tests.

3. Standard Services: The following testing and quality control services will be provided by Owner in accordance with the section entitled, “Testing Laboratory Services:”
   a. Verification that plant equipment and facilities conform to NRMCA “Certification of Ready-Mix Concrete Production Facilities”.

   b. Testing of proposed materials for compliance with this Specification.

   c. Review of proposed mix design submitted by Contractor.

   d. Obtaining production samples of materials at plants or stockpiles during work progress and testing for compliance with this Specification.

   e. Strength testing of concrete according to following procedures:

      (1) Obtaining samples for field test cylinders from every 50 cubic yards and any portion less than 50 cubic yards for each mix design placed each day, according to ASTM C 172, with each sample obtained from a different batch of concrete on a representative, random basis. Selecting test batches by any means other than random numbers chosen before concrete placement begins is not allowed. In the event that a structure is completed with less than 50 cubic yards, a minimum of two random samples shall be selected for that structure.

      (2) Molding four specimens from each sample according to ASTM C 31, and curing under standard moisture and temperature conditions as specified in Sections 7(a) and (b) of ASTM C 31.

      (3) Testing two specimens at 7 days and two specimens at 28 days according to ASTM C 39, reporting test results averaging strengths of two specimens. However, when one specimen evidences improper sampling, molding or testing, it will be discarded and remaining cylinder considered test result. When high-early-strength concrete is used, specimens will be tested at 3 and 7 days.

   f. Air content: For each strength test, determination of air content of normal weight concrete according to ASTM C 231.

   g. Slump: For each strength test, and whenever consistency of concrete appears to vary, conducting slump test in accordance with ASTM C 143.

h. Temperature: For each strength test, checking concrete temperature in accordance with ASTM C 1064.

i. Lightweight concrete: For each strength test, or more frequently when requested by Engineer, determination of air content by ASTM C 567 and unit weight by ASTM C 567.

j. Monitoring of current and forecasted climatic conditions to determine when rate of evaporation, as determined by Figure 2.1.5 of ACI 305R, will produce loss of 0.2 pounds of water, or more, per square foot per hour. Testing lab representative will advise Contractor to use hot weather precautions when such conditions will exist during concrete placement, and note on concrete test reports when Contractor has been advised that hot weather conditions will exist.

k. Class A and D Concrete Shrinkage Tests: Performance of drying shrinkage tests for trial batches as follows:

(1) Preparation and Testing of Specimens: Compression and drying shrinkage test specimens will be taken in each case from the same concrete sample; shrinkage tests will be considered a part of the normal compression tests for the project. 4-inch by 4-inch by 11-inch prisms with an effective gage length of 10 inches, fabricated, cured, dried and measured in accordance with ASTM C157, modified as follows:

(i) Wet curing: Remove specimens from molds at an age of 23 hours “1 hour after trial batching and immediately immerse in water at 70 degrees F “3 degrees F for at least 30 minutes.

(ii) Measure within 30 minutes after first 30 minutes of immersion to determine original length (not to be confused with “base length”);

(iii) Then submerge in saturated limewater, at 73 degrees F +/- 3 degrees F, for 7 days;

(iv) Then measure at age 7 days to establish “base length” for drying shrinkage calculations (“zero” days drying age)

(v) Calculate expansion (base length expressed as a percentage of original length);

(vi) Immediately store specimens in a temperature- and humidity-controlled room maintained at 73 degrees F, +3 degrees F and 50 percent +/- 4 percent relative humidity, for the remainder of the test.

(vii) Measure to determine shrinkage, expressed as percentage of base length. Compute the drying shrinkage deformation of each

specimen as the difference between the base length (at zero days drying age) and the length after drying at each test age. Compute the average drying shrinkage deformation of the specimens to the nearest 0.0001 inch at each test age. If the drying shrinkage of any specimen departs from the average of that test age by more than 0.0004 inch, disregard the results obtained from that specimen. Report results of shrinkage tests to the nearest 0.001 percent of shrinkage.

(viii) Report shrinkage separately for 7, 14, 21, and 28 days of drying after 7 days of moist curing.

4. Additional Testing and Quality Control Services: The following will be performed by an independent commercial testing laboratory employed and paid by the Owner in accordance with the section entitled, "Testing Laboratory Services," when requested by Engineer.

   a. Checking of batching and mixing operations.

      (1) Review of manufacturer's report of each cement shipment and conducting laboratory tests of cement.

      (2) Molding and testing reserve 7 day cylinders or field cylinders

      (3) Conducting additional field tests for slump, concrete temperature and ambient temperature.

      (4) Alkalinity Tests: For concrete used in sanitary structures, one test for each structure. Perform alkalinity tests on concrete covering reinforcing steel on the inside of the pipe or structure in accordance with "Encyclopedia of Industrial Chemical Analysis," Vol. 15, page 230.

5. Contractor shall provide the following testing and quality control services:

   a. Employ an independent commercial testing laboratory, acceptable to Owner, to prepare and test design mix for each class of concrete for which material source has been changed.

   b. Notify commercial testing laboratory employed by Owner 24 hours prior to placing concrete.

6. Testing of deficient concrete in place:

   a. When averages of three consecutive strength test results fail to equal or exceed specified strength, or when any individual strength test result falls below specified strength by more than 500 psi, strength of concrete shall be considered potentially

deficient and core testing, structural analysis or load testing may be required by Engineer.

b. When concrete in place proves to be deficient, Contractor shall pay costs, including costs due to delays, incurred in providing additional testing and analysis services provided by the Engineer, or the independent commercial testing laboratory selected by the Owner.

c. Replace concrete work judged inadequate by core tests, structural analysis or load tests at no additional cost to the Owner.

d. Core Tests:

(1) Obtain and test cores in accordance with ASTM C 42. Where concrete in structure will be dry under service conditions, air dry cores (temperature 60 to 80 degrees F, relative humidity less than 60 percent) for 7 days before test; test dry. Where concrete in structure will be more than superficially wet under service conditions, test cores after moisture conditioning in accordance with ASTM C 42.

(2) Take at least three representative cores from each member or area of concrete in place that is considered potentially deficient. Location of cores shall be determined by Engineer so as to least impair strength of structure. When, before testing, one or more cores shows evidence of having been damaged during or after removal from structure, replace the damaged cores.

(3) Concrete in area represented by core test will be considered adequate when average strength of cores is equal to at least 85 percent of specified strength, and when no single core is less than 75 percent of specified strength.

(4) Patch core holes in accordance with the section entitled, “Concrete Finishing.”

e. Structural Analysis: When core tests are inconclusive or impractical to obtain, Engineer may perform additional structural analysis at Contractor's expense to confirm safety of structure.

f. Load Tests: When core tests and structural analysis do not confirm safety of structure, load tests may be required, and their results evaluated, in accordance with ACI 318.

g. Testing by impact hammer, sonoscope, probe penetration tests (Windsor probe), or other nondestructive device may be permitted by Engineer to determine relative strengths at various locations in structure, to evaluate concrete strength in place, or for selecting areas to be cored. However, such tests, unless properly calibrated and correlated with other test data, shall not be used as basis for acceptance or rejection of structure's safety.

1.06 STORAGE AND HANDLING OF MATERIALS

A. Cement: Store cement in weather tight buildings, bins or silos to provide protection from dampness and contamination and to minimize warehouse set. When there is any doubt as to expansive potential of shrinkage-compensating cements because of method or length of storage and exposure, laboratory test cement before use.

B. Aggregate: Arrange and use aggregate stockpiles to avoid excessive segregation or contamination with other materials or with other sizes of like aggregates. Build stockpiles in successive horizontal layers not exceeding 3 feet in thickness. Complete each layer before next is started.

C. Fine Aggregate: Before using, allow fine aggregate to drain until uniform moisture content is reached.

D. Admixtures: Store admixtures to avoid contamination, evaporation or damage. For those used in form of suspensions or non-stable solutions, provide suitable agitating equipment to assure uniform distribution of ingredients. Protect liquid admixtures from freezing and other temperature changes which would adversely affect their characteristics.

E. Lightweight Aggregates: Uniformly pre-dampen lightweight aggregates as necessary to prevent excessive variations in moisture content. Allow pre-dampened aggregates to remain in stockpiles, under continuous fog spray, for minimum of 24 hours before use. Provide adequate drainage in stockpile areas to eliminate excess water and accumulation of contaminated fines.

PART 2 PRODUCTS

2.01 MATERIALS

A. Cement:

1. Use same brand of cement used in concrete mix design. Use only one brand of each type in each structure, unless otherwise indicated on Drawings.

2. Portland Cement: ASTM C150, Type I or Type II, gray in color. Use Type III only when specifically authorized by Engineer in writing. Use Type II, including the requirements of Table 2, in construction of liquid-containing structures and cooling towers, unless shown otherwise on Drawings.

B. Admixtures:

1. Do not use calcium chloride, thiocyanate or admixtures containing more than 0.05 percent chloride ions.

2. Air-Entraining Admixtures: ASTM C260, compatible with other admixtures used.

3. Chemical Admixtures: Polymer type, non-staining, chloride-free admixtures conforming to ASTM C494, Type A, C, D or E.

4. High-Range Water Reducer (Superplasticizer): ASTM C494, Type F or G, compatible with and by the same manufacturer as other admixtures.

C. Mixing Water: Use clean, potable water, free from harmful amounts of oils, acids, alkalis or other deleterious substances, meeting requirements of ASTM C94.

D. Aggregates: Use coarse aggregate from only one source, and fine aggregate from only one source, for exposed concrete in any single structure.

1. Coarse Aggregate: Gravel, crushed gravel or crushed limestone conforming to ASTM C33.

2. Fine Aggregate: Natural sand complying with ASTMC33.

3. Limestone aggregate shall conform to ASTM C33 and the following additional requirements: Clean, hard, strong and durable particles free of chemicals and coatings of silt, clay, or other fine materials that may affect hydration and bond of cement paste. Select crushed limestone: High-calcium limestone (minimum 95 percent $CaCO_3$ and maximum 3.5 percent $MgCO_3$) with maximum Los Angeles Abrasion loss of 38 percent, when tested in accordance with ASTM C131 or ASTM C535. Test aggregate for soundness in accordance with ASTM C 88; maximum loss shall not exceed 18 percent after 5 cycles of magnesium sulfate test.

4. Maximum size of coarse aggregate:
   a. Normal weight concrete, except as noted below: 1-1/2 inches.

   b. Formed members 6 inches or less in least dimension: 1/5 least dimension.

   c. Slabs: 1/3 depth of slab.

   d. Drilled shafts: 1/3 clearance between reinforcing steel, but not greater than 3/4 inch.
   e. Concrete fill, seal slabs and bonded concrete topping in clarifiers: 3/8 inch.

5. Coarse aggregate for lightweight concrete: ASTM C330. Grading limits: 3/4 inch to No. 4.

6. Abrasive Aggregate: Conform to requirements of the section entitled, “Concrete Finishing.”

E. Calcium Chloride: Not permitted.

F. Evaporation Retardant: Masterbuilders “Confilm”, Euclid “Eucobar”, or equal.

G. Miscellaneous Materials:

1. Bonding Agent: Two-component modified epoxy resin.

2. Vapor barrier: 6 mil clear polyethylene film of type recommended for below-grade application.

3. Non-shrink grout: premixed compound consisting of non-metallic aggregate, cement and water-reducing and plasticizing agents; capable of developing minimum compressive strength of 2,400 psi in 48 hours and 7,000 psi in 28 days.

2.02 CONCRETE MIX

A. Objective: Select proportions of ingredients to produce concrete having proper place-ability, durability, strength, appearance, and other specified properties.

B. Mix Design: Employ and pay an independent commercial testing laboratory, acceptable to Owner, to prepare and test mix designs for each type of concrete specified. Proportion mix design ingredients by weight. Submit mix designs and test results for approval.

1. During the trial batches, aggregate proportions may be adjusted by the testing laboratory using two coarse aggregate size ranges to obtain the required properties. If one size range produces an acceptable mix, a second size range need not be used. Such adjustments shall be considered refinements to the mix design and shall not be the basis for extra compensation to the Contractor. Concrete shall conform to the requirements of this Section, whether the aggregate proportions are from the Contractor's preliminary mix design, or whether the proportions have been adjusted during the trial batch process. Prepare trial batches using the aggregates, cement and admixtures proposed for the project. Make trial batches large enough to obtain 3 drying shrinkage test specimens and 6 compression test specimens from each batch. Shrinkage testing is required only for Class A and D concrete.

2. Determine compressive strength by testing 6-inch diameter by 12-inch high cylinders, made, cured and tested in accordance with ASTM C192 and ASTM C39. Test 3 compression test cylinders at 7 days and 3 at 28 days. Average compressive strength for the 3 cylinders tested at 28 days for any given trial batch shall be not less than 125 percent of the specified compressive strength.

3. Perform sieve analysis of the combined aggregate for each trial batch according to of ASTM C136. Report percentage passing each sieve.

4. In mix designs for Class A and D concrete, fine aggregate shall not exceed 41 percent of total aggregate by weight.

C. Shrinkage Limitations, Class A and D Concrete

1. Maximum concrete shrinkage for specimens cast in the laboratory from the trial batch: 0.036 percent as measured at 21-day drying age, or 0.042 percent at 28-day drying age. Use for construction only mix designs that meet trial batch shrinkage requirements. Shrinkage limitations apply only to Class A and D concrete.

2. Maximum concrete shrinkage for specimens cast in the field shall not exceed the trial batch maximum shrinkage requirement by more than 25 percent.

3. If the required shrinkage limitation is not met during construction, take any or all of the following actions, at no additional cost to the Owner, for securing the specified shrinkage requirements: Changing the source or aggregates, cement or admixtures; reducing water content; washing of aggregate to reduce fines; increasing the number of construction joints; modifying the curing requirements; or other actions designed to minimize shrinkage or its effects.

D. Selecting Ingredient Proportions for Concrete:

1. Proportion concrete mix according to ACI 301, Chapter 3.

2. Establish concrete mix design by laboratory trial batches prepared by independent testing laboratory, or on basis of previous field experience in accordance with provisions of ACI 318, Item 5.3; however, minimum cement content for each class of concrete shall not be less than specified.

3. Concrete mix design data submitted for review shall have average 28-day compressive strength calculated in accordance with ACI 318, Item 5.3.2.1. When data is not available to determine standard deviation in accordance with ACI 318, Item 5.3.1, average 28-day strength of mix design shall conform to ACI 318, Table 5.3.2.2.

E. Water-Cement Ratios:

1. Maximum allowable water-cement ratios shall be as follows:

   a. Concrete for liquid-containing structures: 0.45.
   b. Concrete subjected to brackish water, salt spray or deicers: 0.40.
   c. All other concrete: 0.55.

2. Superplasticizer may be added to maintain specified maximum water-cement ratios. Include free water in aggregate in water-cement ratio computations.

F. Adjustment of Mix Proportions: After sufficient data becomes available during construction, mix may be adjusted upon approval of Engineer, in accordance with ACI 318, Item 5.5; however, minimum cement content for each class of concrete shall not be less than specified.

G. Entrained Air: Air-entrain all concrete except drilled shafts. Total air content in accordance with ASTM C173: 4 to 6 percent.

H. Consistency, Workability, and Slump:

1. The quantity of water in a batch of concrete shall be just sufficient, with a normal mixing period, to produce concrete which can be worked properly into place without segregation, and which can be compacted by vibratory methods as specified, to give the desired strength, density, impermeability, and smoothness of surface. Change the quantity of water as necessary, with variations in the nature or moisture content of the aggregates, to maintain uniform production of a desired consistency. Determine the consistency of the concrete in successive batches by slump tests in accordance with ASTM C 143. Slumps shall be as follows:

Concrete Type	Minimum Slump	Maximum Slump
Portland Cement Concrete	2”	4”
Concrete to be dosed with superplasticizer	1”	3”
Normal Weight Concrete after dosing with superplasticizer	4”	9”
Lightweight Concrete after dosing with superplasticizer	4”	7”
Drilled Shaft Concrete	4” *	8”

* Minimum slump where drilled shafts are cast in temporary casings: 5 inches.

2. Specified slump shall apply at time when concrete is discharged at job site. Perform slump tests to monitor uniformity and consistency of concrete delivered to job site; however, do not use as basis for mix design. Do not exceed water-cement ratios specified.

I. Admixtures: Proportion admixtures according to manufacturer's recommendations. Use of accelerator is permitted when air temperature is less than 40 degrees F. Use of retarder is permitted when temperature of placed concrete exceeds 65 degrees F.

J. High-Range Water Reducers (Superplasticizers): Use superplasticizer to improve workability of concrete or delay hydration of cement, in accordance with requirements and recommendations of product manufacturer and approved submittals.

K. Concrete Classification and Strength:

1. Strength: Conform to values for class of concrete indicated on Drawings for each portion of Work. Requirements are based on 28-day compressive strength. If high early-strength concrete is allowed, requirements are based on 7-day compressive strength.

2. Classification:

Class (Normal Weight)	Minimum 28-Day Compressive Strength (psi)	Minimum Cement Content Pounds per Cubic Yard
Concrete for Structures Containing Water or Wastewater		
A	4000	564 (6 Sacks)
B	1500	329 (3-1/2 Sacks)
C	3000	470 (5 Sacks)
D	5000	658 (7 Sacks)
H	4500	611 (6-1/2 Sacks)
Class (Normal Weight)	Minimum 28-Day Compressive Strength (psi)	Minimum Cement Content Pounds per Cubic Yard
Concrete for Buildings, Slabs on Grade and Miscellaneous Structures		
AB	4000	Not Applicable
BB	1500	Not Applicable
CB	3000	Not Applicable
DB	5000	Not Applicable
Class (Normal Weight)	Minimum 28-Day Compressive Strength (psi)	Minimum Cement Content Pounds per Cubic Yard
E	3000	Not Applicable
F	4000	Not Applicable
G	5000	Not Applicable

3. Maximum size aggregate for Class H concrete: 3/8 inch. Maximum size aggregate for all other normal-weight concrete: 1-1/2 inches, except as specified in Paragraph 2.01D.4.

4. When required strength is not obtained with minimum cement content as specified, add cement, lower water-cement ratio or provide other aggregates as necessary.

5. In addition to conforming to specified strength, lightweight concrete must be within specified unit weight limits. Maximum air-dry unit weight is 118 pounds per cubic foot; minimum is 110 pounds per cubic foot unless shown otherwise on Drawings. Determine air-dry unit weight in accordance with ASTM C 567. Correlate air-dry unit weight with fresh unit weight of the same concrete as a basis for acceptance during construction.

L. Use of Classes of Concrete:

1. Use classes of concrete as indicated on the Drawings and in other specifications.

2. Liquid-containing structures: If not otherwise indicated, use the following classes for structures containing water or wastewater and for utility applications in the locations described:

a. Class A: All reinforced concrete and where not otherwise defined.

b. Class B: Unreinforced concrete used for plugging pipes, seal slabs, thrust blocks and trench dams, unless indicated otherwise.

c. Class H: Fill and topping. Where concrete fill thickness exceeds 3 inches in the majority of a placement and is not less than 1.5 inches thick, Class A concrete may be used.

3. All other structures: If not otherwise indicated, use the following classes in the locations described:

a. Class AB: All reinforced concrete and where not otherwise defined.

b. Class CB: Duct banks; see the section entitled, “Underground Duct Banks” for additional requirements.

c. Class BB: Unreinforced concrete fill under structures.

2.03 MIXING NORMAL WEIGHT CONCRETE

A. Conform to ACI 301, Chapter 7.

B. Ready-Mixed Concrete:

1. Measure, batch, mix and transport ready-mixed concrete according to ASTM C 94. Plant equipment and facilities shall conform to NRMCA “Certification of Ready Mixed Concrete Production Facilities.”

2. Provide batch tickets with information specified in ASTM C 94. Deliver batch ticket with concrete and give to Owner’s on-site testing laboratory representative.

C. Batch Mixing at Site:

1. Mix concrete in batch mixer conforming to requirements of CPMB “Concrete Plant Mixer Standards”. Use mixer equipped with suitable charging hopper, water storage tank and water measuring device. Batch mixer shall be capable of mixing aggregates, cement and water into uniform mass within specified mixing time, and of discharging mix without segregation. Operate mixer according to rated capacity and recommended revolutions per minute printed on manufacturer's rating plate.

2. Charge batch into mixer so some water will enter before cement and aggregates. Keep water running until one-fourth of specified mixing time has elapsed. Provide controls to prevent discharging until required mixing time has elapsed. When concrete of normal weight is specified, provide controls to prevent addition of water during mixing. Discharge entire batch before mixer is recharged.

3. Mix each batch of 2 cubic yards or less for not less than 1 minute and 30 seconds. Increase minimum mixing time 15 seconds for each additional cubic yard or fraction of cubic yard.

4. Keep mixer clean. Replace pick-up and throw-over blades in drum when they have lost 10 percent of original depth.

D. Admixtures:

1. Charge air-entraining and chemical admixtures into mixer as solution using automatic dispenser or similar metering device. Measure admixture to accuracy within + 3 percent. Do not use admixtures in powdered form.

2. Two or more admixtures may be used in same concrete, provided that admixtures in combination retain full efficiency and have no deleterious effect on concrete or on properties of each other. Inject admixtures separately during batching sequence.

3. Add retarding admixtures as soon as practicable after addition of cement.

E. Temperature Control

1. When ambient temperature falls below 40 degrees F, keep as-mixed temperature above 55 degrees F to maintain concrete above minimum placing temperature.

2. When water or aggregate has been heated, combine water with aggregate in mixer before cement is added. Do not add cement to mixtures of water and aggregate when temperature of mixture is greater than 100 degrees F.

3. In hot weather, maintain temperature of concrete below maximum placing temperature. When necessary, temperature may be lowered by cooling ingredients, cooling mixer drum by fog spray, using chilled water or well-crushed ice in whole or part for added water, or arranging delivery sequence so that time of transport and placement does not generate unacceptable temperatures.

4. Submit hot weather and cold weather concreting plans for approval.

2.04 MIXING LIGHTWEIGHT CONCRETE

A. Determining Absorption of Aggregates: Mixing procedures vary according to total absorption by weight of lightweight aggregates. Determine total absorption by weight before pre-damping in accordance with ASTM C 127.

B. Ten Percent or Less Absorption: Follow same requirements as for mixing normal-weight concrete when preparing concrete made with low-absorptive lightweight aggregates having 10 percent or less total absorption by weight. To be low-absorptive, aggregates must absorb less than 2 percent additional water in first hour after mixing.

C. More Than 10 Percent Absorption: Batch and mix concrete made with lightweight aggregates having more than 10 percent total absorption by weight, as follows:

1. Place approximately 80 percent of mixing water in mixer.

2. If aggregates are pre-dampened, add air-entraining admixture and all aggregates. Mix for minimum of 30 seconds, or 5 to 10 revolutions of truck mixer.\

3. When aggregates have not been pre-dampened, mix aggregates and water for minimum of 1 minute and 30 seconds, or 15 to 30 revolutions of truck mixer. Then add air-entraining admixture and mix for additional 30 seconds.

4. Then, in the following sequence, add specified or permitted admixtures (other than air-entraining agent), all cement, and mixing water previously withheld.

5. Complete mixing using procedures for normal-weight concrete.

2.05 MASS CONCRETE

A. Do not use high early-strength cement (Type III) or accelerating admixtures.

B. Use high-range water-reducing admixture (superplasticizer) to minimize water content and cement content.

C. Specified water-reducing retarding admixture may be required to prevent cold joints when placing large quantities of concrete, to permit re-vibration of concrete, to offset effects of high temperature in concrete or weather, and to reduce maximum temperature or rapid temperature rise.

2.06 EQUIPMENT

A. Select equipment of size and design to ensure continuous flow of concrete at delivery end. Conform to following equipment and operations requirements.

B. Truck mixers, agitators and manner of operation: Conform to ASTM C 94. Use of non-agitating equipment for transporting concrete is not permitted.

C. Belt conveyors: Configure horizontally, or at a slope causing no segregation or loss. Use approved arrangement at discharge end to prevent separation. Discharge long runs without separation into hopper.

D. Chutes: Metal or metal-lined (other than aluminum). Arrange for vertical-to-horizontal slopes not more than 1 to 2 nor less than 1 to 3. Chutes longer than 20 feet or not meeting slope requirements may be used if concrete is discharged into hopper before distribution.

E. Do not use aluminum or aluminum-alloy pipe or chutes for conveying concrete.

PART 3 EXECUTION

3.01 SPECIAL CONSIDERATIONS

A. Concreting Under Water: Not permitted except where shown otherwise on Drawings or approved by Engineer. When shown or permitted, deposit concrete under water by methods acceptable to the Engineer so fresh concrete enters mass of previously-placed concrete from within, causing water to be displaced with minimum disturbance at surface of concrete.

B. Protection from Adverse Weather: Unless adequate protection is provided or Engineer's approval is obtained, do not place concrete during rain, sleet, snow or freezing weather. Do not permit rainwater to increase mixing water or to damage surface finish. If rainfall occurs after placing operations begin, provide adequate covering to protect Work.

C. Existing Concrete: Where matching existing concrete, texture and finish of proposed concrete shall match the existing surface. Costs for texture and finish shall be considered subsidiary to the concrete item.

3.02 PREPARATION OF SURFACES FOR CONCRETING

A. Earth Surfaces

1. Under interior slabs on grade, install vapor barrier. Lap joints at least 6 inches and seal watertight with tape, or sealant applied between overlapping edges and ends. Repair vapor barrier damaged during placement of reinforcing and inserts with vapor barrier material; lap over damaged areas at least 6 inches and seal watertight.

2. Other Earth Surfaces: Thoroughly wet by sprinkling prior to placing concrete, and keep moist by frequent sprinkling up to time of placing concrete thereon. Remove standing water. Surfaces shall be free from standing water, mud and debris at the time of placing concrete.

B. Construction Joints

1. Definition: Concrete surfaces upon or against which concrete is to be placed, where the placement of the concrete has been interrupted so that, in the judgment of the Engineer, new concrete cannot be incorporated integrally with that previously placed.

2. Interruptions: When placing of concrete is to be interrupted long enough for the concrete to take a set, use forms or other means to shape the working face to secure proper union with subsequent work. Make construction joints only where acceptable to the Engineer.

3. Preparation: Give horizontal joint surfaces a compacted, roughened surface for good bond. Except where the Drawings call for joint surfaces to be coated, clean joint surfaces of laitance, loose or defective concrete and foreign material by hydro-blasting or sandblasting (exposing aggregate), roughen surface to expose aggregate to a depth of at least 1/4 inch and wash thoroughly. Remove standing water from the construction joint surface before new concrete is placed.

4. After surfaces have been prepared cover approximately horizontal construction joints with a 3-inch lift of a grout mix consisting of Class A concrete batched without coarse aggregate; place and spread grout uniformly. Place wall concrete on the grout mix immediately thereafter.

C. Set and secure reinforcement, anchor bolts, sleeves, inserts and similar embedded items in the forms where indicated on Contract Drawings, shop drawings and as otherwise required. Obtain Engineer's acceptance before concrete is placed. Accuracy of placement is the sole responsibility of the Contractor.

D. Place no concrete until at least 4 hours after formwork, inserts, embedded items, reinforcement and surface preparation have been completed and accepted by the Resident Project Representative. Clean surfaces of forms and embedded items that have become encrusted with grout or previously-placed concrete before placing adjacent concrete.

E. Casting New Concrete Against Old: Where concrete is to be cast against old concrete (any concrete which is greater than 60 days of age), thoroughly clean and roughen the surface of the old concrete by hydro-blasting or sandblasting (exposing aggregate). Coat joint surface with epoxy bonding agent following manufacturer's written instructions, unless indicated otherwise. Unless noted otherwise, this provision does not apply to vertical wall joints where waterstop is installed.

F. Protection from Water: Place no concrete in any structure until water entering the space to be filled with concrete has been properly cut off or diverted and carried out of the forms, clear of the work. Deposit no concrete underwater. Do not allow still water to rise on any concrete until concrete has attained its initial set. Do not allow water to flow over the surface of any concrete in a manner and at a velocity that will damage the surface finish of the concrete. Pumping, dewatering and other necessary operations for removing ground water, if required, are subject to Resident Project Representative review.

G. Corrosion Protection: Position and support pipe, conduit, dowels and other ferrous items to be embedded in concrete construction prior to placement of concrete so there is at least a 2 inch clearance between them and any part of the concrete reinforcement. Do not secure such items in position by wiring or welding them to the reinforcement.

H. Where practicable, provide for openings for pipes, inserts for pipe hangers and brackets, and setting of anchors during placing of concrete.

I. Accurately set anchor bolts and maintain in position with templates while they are being embedded in concrete.

J. Cleaning: Immediately before concrete is placed, thoroughly clean dirt, grease, grout, mortar, loose scale, rust and other foreign substances from surfaces of metalwork to be in contact with concrete.

3.03 HANDLING, TRANSPORTING AND PLACING CONCRETE

A. Conform to applicable requirements of Chapter 8 of ACI 301 and this Section. Use no aluminum materials in conveying concrete.

B. Rejected Work: Remove concrete found to be defective or non-conforming in materials or workmanship. Replace rejected concrete with concrete meeting requirements of Contract Documents, at no additional cost to the Owner.

C. Unauthorized Placement: Place no concrete except in the presence of the Resident Project Representative. Notify the Resident Project Representative in writing at least 24 hours before placement of concrete.

D. Placement in Wall Forms

1. Do not drop concrete through reinforcing steel.

2. Do not place concrete in any form so as to leave an accumulation of mortar on form surfaces above the concrete.

3. Pump concrete or use hoppers and, if necessary, vertical ducts of canvas, rubber or metal (other than aluminum) for placing concrete in forms so it reaches the place of final deposit without separation. Free fall of concrete shall not exceed 4 feet below the ends of pump hoses, ducts, chutes or buggies. Uniformly distribute concrete during depositing.

4. Do not displace concrete in forms more than 6 feet in horizontal direction from place where it was originally deposited.

5. Deposit in uniform horizontal layers not deeper than 2 feet; take care to avoid inclined layers or inclined construction joints except where required for sloping members.

6. Place each layer while the previous layer is still soft. Rate of placement shall not exceed 5 feet of vertical rise per hour.

7. Provide sufficient illumination in form interior so concrete at places of deposit is visible from the deck or runway.

E. Conveyors and Chutes: Design and arrange ends of chutes, hopper gates and other points of concrete discharge in the conveying, hoisting and placing system so concrete passing from them will not fall separated into whatever receptacle immediately receives it. Conveyors, if used, shall be of a type acceptable to the Resident Project Representative. Do not use chutes longer than 50 feet. Slope chutes so concrete of specified consistency will readily flow. If a conveyor is used, it shall be wiped clean by a device operated in such a manner that none of the mortar adhering to the belt will be wasted. All conveyors and chutes shall be covered.

F. Placement of Slabs: In hot or windy weather, conducive to plastic shrinkage cracks, apply evaporation retardant to slab after screeding in accordance with manufacturer's instructions and recommendations. Do not use evaporation retardant to increase water content of the surface cement paste. Place concrete for sloping slabs uniformly from the bottom of the slab to the top, for the full width of the placement. As work progresses, vibrate and carefully work concrete around slab reinforcement. Screed the slab surface in an up-slope direction.

G. Concrete Temperature: When placed, not more than 90 degrees F nor less than 55 degrees F for sections less than 12 inches thick, nor less than 50 degrees for all other sections. Do not heat concrete ingredients to a temperature higher than that necessary to keep the temperature of the mixed concrete, as placed, from falling below the specified minimum temperature. When concrete temperature is 85 degrees F or above, do not exceed 60 minutes between introduction of cement to the aggregates and discharge. When the weather is such that the concrete temperature would exceed 90 degrees F, employ effective means, such as pre-cooling of aggregates and mixing water, using ice or placing at night, as necessary to maintain concrete temperature, as placed, below 90 degrees F.

H. Cold Weather Placement: Conform to ACI 306.1 - Standard Specification for Cold Weather Concreting, and the following:

1. Remove snow, ice and frost from surfaces, including reinforcement, against which concrete is to be placed. Before beginning concrete placement, thaw the subgrade to a minimum depth of 6 inches. Warm reinforcement and embedded items to above 32 degrees F prior to concrete placement.

2. Maintain concrete temperature above 50 degrees F for at least 3 days after placement.

3.04 PUMPING OF CONCRETE

A. If pumped concrete does not produce satisfactory results, in the judgment of the Resident Project Representative, discontinue pumping operations and proceed with the placing of concrete using conventional methods.

B. Pumping Equipment: Use a 2-cylinder pump designed to operate with only one cylinder if one is not functioning or have a standby pump on site during pumping.

C. The minimum hose (conduit) diameter: Comply with ACI 304.2R.

D. Replace pumping equipment and hoses (conduits) that do not function properly.

E. Do not use aluminum conduits for conveying concrete.

F. Field Control: Take samples for slump, air content and test cylinders at the placement (discharge) end of the line.

3.05 CONCRETE PLACEMENT SEQUENCE

A. Place concrete in a sequence acceptable to the Engineer. To minimize effects of shrinkage, place concrete in units bounded by construction joints shown. Place alternate units so each unit placed has cured at least 7 days for hydraulic structures, or 3 days for other structures, before contiguous unit or units are placed, except do not place corner sections of vertical walls until the 2 adjacent wall panels have cured at least 14 days for hydraulic structures and 7 days for other structures.

B. Level the concrete surface whenever a run of concrete is stopped. To ensure straight and level joints on the exposed surface of walls, tack a wood strip at least 3/4-inch thick to the forms on these surfaces. Carry concrete about 1/2 inch above the underside of the strip. About one hour after concrete is placed, remove the strip, level irregularities in the edge formed by the strip with a trowel and remove laitance.

3.06 TAMPING AND VIBRATING

A. Thoroughly settle and compact concrete throughout the entire depth of the layer being consolidated, into a dense, homogeneous mass; fill corners and angles, thoroughly embed reinforcement, eliminate rock pockets and bring only a slight excess of water to the exposed surface of concrete during placement. Use ACI 309R Group 3 immersion-type high-speed power vibrators (8,000 to 12,000 rpm) in sufficient number and with sufficient (at least one) standby units. Use Group 2 vibrators only when accepted by the Resident Project Representative for specific locations.

B. Use care in placing concrete around waterstops. Carefully work concrete by rodding and vibrating to make sure air and rock pockets have been eliminated. Where flat-strip type waterstops are placed horizontally, work concrete under waterstops by hand, making sure air and rock pockets have been eliminated. Give concrete surrounding the waterstops additional vibration beyond that used for adjacent concrete placement to assure complete embedment of waterstops in concrete.

C. Concrete in Walls: Internally vibrate, ram, stir, or work with suitable appliances, tamping bars, shovels or forked tools until concrete completely fills forms or excavations and closes snugly against all surfaces. Do not place subsequent layers of concrete until previously-placed layers have been so worked. Provide vibrators in sufficient numbers, with standby units as required to accomplish the results specified within 15 minutes after concrete of specified consistency is placed in the forms. Keep vibrating heads from contact with form surfaces. Take care not to vibrate concrete excessively or to work it in any manner that causes segregation of its constituents.

3.07 PLACING MASS CONCRETE

Observe the following additional restrictions when placing mass concrete.

A. Use specified superplasticizer.

B. Maximum temperature of concrete when deposited: 70 degrees F.

C. Place in lifts approximately 18 inches thick. Extend vibrator heads into previously-placed layer.

3.08 REPAIRING SURFACE DEFECTS AND FINISHING

Conform to the section entitled, “Concrete Finishing.”

3.09 CURING

Conform to the section entitled, “Concrete Curing.”

3.10 PROTECTION

A. Protect concrete against damage until final acceptance by the Owner.

B. Protect fresh concrete from damage due to rain, hail, sleet or snow. Provide such protection while the concrete is still plastic and whenever such precipitation is imminent or occurring.

C. Do not backfill around concrete structures or subject them to design loadings until all components of the structure needed to resist the loading are complete and have reached the specified 28-day compressive strength, except as authorized otherwise by the Engineer.

END OF SECTION

SECTION 03350

CONCRETE FINISHING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Repairing surface defects.

B. Finishing concrete surfaces including both formed and unformed surfaces.

C. Sealing concrete surfaces.

D. Installation of concrete fill and installation of concrete topping in bottoms of clarifiers and thickeners.

1.02 RELATED SECTIONS

SECTION 03055 – Concrete Structures
SECTION 03310 – Structural Concrete
SECTION 03390 – Concrete Curing
SECTION 03600 – Structural Grout

1.03 REFERENCES

AASTM C144 – Standard Specification for Aggregate for Masonry Mortar.
ASTM C881 – Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
ASTM C1059 – Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete.
ASTM D4587 – Standard Practice for Fluorescent UV-Condensation of Paint and Related Coatings
ASTM E1155 – Standard Test Method for Determining Floor Flatness and Levelness Using the F Number System.

1.04 SUBMITTALS

A. Conform to Submittals Specification.

B. Submit manufacturer's technical literature on the following products proposed for use. Include manufacturer's installation and application instructions and, where specified, manufacturer's certification of conformance to requirements and suitability for use in the applications indicated.

1. Floor hardener.
2. Sealer.

3. Epoxy floor topping.
4. Epoxy penetrating sealer.
5. Latex bonding agent.
6. Epoxy adhesive.
7. Abrasive aggregate.
8. Evaporation retardant.

PART 2 PRODUCTS

2.01 MATERIALS

A. Sealer/Dustproofer (VOC Compliant): Water-based acrylic sealer; non-yellowing under ultraviolet light after 200-hour test in accordance with ASTM D4587. Conform to local, state and federal solvent emission requirements.

B. Epoxy Floor Topping: Two-component epoxy resin meeting ASTM C881 Type III, resistant to wear, staining and chemical attack, blended with granite, sand, trap rock or quartz aggregate, trowel-applied over concrete floor. Topping thickness, 1/8 inch; color, gray.

C. Abrasive Aggregate for Nonslip Finish: Fused aluminum oxide grit, or crushed emery aggregate containing not less than 40 percent aluminum oxide and not less than 25 percent ferric oxide. Material shall be factory graded, packaged, rustproof and non-glazing, and unaffected by freezing, moisture and cleaning materials.

D. Epoxy Penetrating Sealer: Low-viscosity, two-component epoxy system designed to give maximum penetration into concrete surfaces. Sealer shall completely seal concrete surfaces from penetration of water, oil and chemicals; prevent dusting and deterioration of concrete surfaces caused by heavy traffic; and be capable of adhering to floor surfaces subject to hydrostatic pressure from below. Color, transparent amber or gray; surface, nonslip.

E. Latex Bonding Agent: Non re-dispersible latex base liquid conforming to ASTM C1059. When used in water and wastewater treatment structures, bonding agent shall be suitable for use under continuously submerged conditions. Conformance and suitability certification by manufacturer is required.

F. Bonding Grout: Prepare bonding grout by mixing approximately one part cement to one part fine sand meeting ASTM C 144 but with 100 percent passing No. 30 mesh sieve. Mix with water to consistency of thick cream. At Contractor's option, a commercially-prepared bonding agent used in accordance with manufacturer's recommendations and instructions may be used. When used in water and wastewater treatment structures, bonding agent shall be suitable for use under continuously submerged conditions. Conformance and suitability certification by manufacturer is required. Submit manufacturer's technical information on proposed bonding agent.

G. Patching Mortar

1. Make patching mortar of same materials and of approximately same proportions as concrete, except omit coarse aggregate. Substitute white Portland cement for part of gray Portland cement on exposed concrete in order to match color of surrounding concrete. Determine color by making trial patch. Use minimum amount of mixing water required for handling and placing. Mix patching mortar in advance and allow to stand. Mix frequently with trowel until it has reached stiffest consistency that will permit placing. Do not add water.

2. Proprietary compounds for adhesion or specially formulated cementitious repair mortars may be used in lieu of or in addition to foregoing patching materials provided that properties of bond and compressive strength meet or exceed the foregoing and color of surrounding concrete can be matched where required. Use such compounds according to manufacturer's recommendations. When used in water and wastewater treatment structures, material shall be suitable for use under continuously submerged conditions. Conformance and suitability certification by manufacturer is required.

H. Epoxy Adhesive: Two-component, 100 percent solids, 100 percent reactive compound developing 100 percent of strength of concrete, suitable for use on dry or damp surfaces. Epoxy used to inject cracks and as a binder in epoxy mortar shall meet ASTM C 881, Type VI. Epoxy used as a bonding agent for fresh concrete shall meet ASTM C 881, Type V.

I. Non-shrink Grout: See Section 03600 - Structural Grout.

J. Spray-Applied Coating: Acceptable products are Thoro System Products “Thoroseal Plaster Mix” or equal. Color: Gray.

K. Concrete Topping: Class H concrete with 3/8-inch maximum coarse aggregate size, as specified in the Section 03310 – Structural Concrete.

L. Concrete Fill: Class H concrete with 3/8-inch maximum coarse aggregate size, (Class C where fill thickness exceeds 3 inches throughout a placement), as specified in the Section 03310 – Structural Concrete.

M. Evaporation Retardant: Confilm, manufactured by Master Builders; Eucobar, manufactured by Euclid Chemical Company; or equal.

PART 3 EXECUTION

3.01 AGGREGATE CONCEALMENT

Unless indicated otherwise on Drawings or approved by Engineer, all surfaces to be finished shall be free of exposed aggregate.

3.02 REPAIRING SURFACE DEFECTS

A. Defective Areas: Repair immediately after removal of forms. Remove honeycombed and other defective concrete down to sound concrete but in no case to a depth less than one inch. Make edges of cuts perpendicular to concrete surface. Thoroughly work bonding grout into the surface with a brush as that the entire surface is covered. Alternatively, a proprietary bonding agent may be used. Use bonding agent in accordance with manufacturer's instructions. While bonding coat is still tacky, apply premixed patching mortar. Thoroughly consolidate mortar into place and strike off to leave patch slightly higher than surrounding surface. To permit initial shrinkage, leave undisturbed for at least 1 hour before final finishing. Keep patched area damp for 7 days. Alternatively, a proprietary cementitious repair mortar may be used and placed in accordance with manufacturer's instructions. Do not use metal tools in finishing patches in formed walls which will be exposed.

B. Tie Holes: Patch holes immediately after removal of forms. After cleaning and roughening with a wire brush on a rotary drill, thoroughly dampen tie hole and fill solid with patching mortar. Taper tie holes shall have the plug, specified in Section 03055 –Concrete Structures, driven into the hole to the center of the wall before grouting. Completely fill taper tie holes with patching mortar except that non-shrink grout shall be used for all walls in contact with soil or liquid. On wall faces exposed to view, fill the outer 2 inches of the taper tie hole with patching mortar blended to match adjacent concrete.

C. Cracks: Repair cracks in excess of 0.01 inch by pressure injection of moisture-insensitive epoxy-resin system. Submit proposed material and method of repair for approval prior to making repairs.

D. Structural Repair: When required, make structural repairs after prior approval of Engineer as to method and procedure, using specified epoxy adhesive or approved epoxy mortar.

3.03 FINISHING OF FORMED SURFACES

A. Unfinished Surfaces: Finish is not required on surfaces concealed from view in completed structure by earth, ceilings or similar cover, unless indicated otherwise on Drawings.

B. Rough Form Finish

1. No form facing material is required on rough form finish surfaces.

2. Patch tie holes and defects. Chip off fins exceeding 1/4 inch in height.

3. Rough form finish may be used on concrete surfaces which will be concealed from view by earth in completed structure, except concealed surfaces required to have smooth form finish, as shown on Drawings.

C. Smooth Form Finish

1. Form facing shall produce smooth, hard, uniform texture on concrete. Use plywood or fiberboard linings or forms in as large sheets as practicable, and with smooth, even edges and close joints.

2. Patch tie holes and defects. Rub fins and joint marks with wooden blocks to leave smooth, unmarred finished surface.

3. Provide smooth form finish on the wet face of formed surfaces of water-holding structures, and of other formed surfaces not concealed from view by earth in completed structure, except where otherwise indicated on Drawings. Walls that will be exposed after future construction, at locations indicated on Drawings, shall have smooth form finish. Smooth form finish on exterior face of exterior walls shall extend 2 feet below final top of ground elevation. Exterior face of all perimeter grade beams shall have smooth form finish for full depth of grade beam.

D. Rubbed Finish

1. Use plywood or fiberboard linings or forms in as large sheets as practicable, and with smooth, even edges and close joints.

2. Remove forms as soon as practicable, repair defects, wet surfaces, and rub with No. 16 carborundum stone or similar abrasive. Continue rubbing sufficiently to bring surface paste, remove form marks and fins, and produce smooth, dense surface of uniform color and texture. Do not use cement paste other than that drawn from concrete itself. Spread paste uniformly over surface with brush. Allow paste to reset, then wash surface with clean water.

3. Use rubbed finish at locations indicated on Drawings, except where rubbed finish is indicated for a wall which will be containing a liquid, use spray-applied coating.

E. Spray-applied Coating: At Contractor's option, in lieu of rubbed finish, spray-applied coating may be applied after defects have been repaired and fins removed. Remove form oil, curing compound and other foreign matter that would prevent bonding of coating. Apply coating in uniform texture and color in accordance with coating manufacturer's instructions.

F. Related Unformed Surfaces: Tops of piers, walls, bent caps, and similar unformed surfaces occurring adjacent to formed surfaces shall be struck smooth after concrete is placed. Float unformed surfaces to texture reasonably consistent with that of formed surfaces. Continue final treatment on formed surfaces uniformly across unformed surfaces.

3.04 HOT WEATHER FINISHING

When hot weather conditions exist, as defined by Section 03310 – Structural Concrete" and as judged by the Engineer, apply evaporation retardant to the surfaces of slabs, topping and concrete fill placements immediately after each step in the finishing process has been completed.

3.05 FINISHING SLABS AND SIMILAR FLAT SURFACES TO CLASS A, B, AND C TOLERANCES

A. Apply Class A, B, and C finishes at locations indicated on Drawings.

B. Shaping to Contour: Use strike-off templates or approved compacting-type screeds riding on screed strips or edge forms to bring concrete surface to proper contour. See Section 03055 – Concrete Structures for edge forms and screeds.

C. Consolidation and Leveling: Concrete to be consolidated shall be as stiff as practicable Thoroughly consolidate concrete in slabs and use internal vibration in beams and girders of framed slabs and along bulkheads of slabs on grade. Consolidate and level slabs and floors with vibrating bridge screeds, roller pipe screeds or other approved means. After consolidation and leveling, do not permit manipulation of surfaces prior to finishing operations.

D. Tolerances for Finished Surfaces: Check tolerances by placing straightedge of specified length anywhere on slab. Gap between slab and straightedge shall not exceed tolerance listed for specified class.

Class	Straight Edge Length in Feet	Tolerance in Inches
A	10	1/8
B	10	1/4
C	2	1/4

E. Raked Finish: After concrete has been placed, struck off, consolidated and leveled to Class C tolerance, roughen surface before final set. Roughen with stiff brushes or rakes to depth of approximately ¼-inch. Notify Engineer prior to placing concrete requiring initial raked surface finish so that acceptable raked finish standard may be established for project. Protect raked, base-slab finish from contamination until time of topping. Provide raked finish for following:

1. Surfaces to receive bonded concrete topping or fill.
2. Steep ramps, as noted on Drawings.
3. Additional locations as noted on Drawings.

F. Float Finish

1. After concrete has been placed, struck off, consolidated and leveled, do not work further until ready for floating. Begin floating when water sheen has disappeared, or when mix has stiffened sufficiently to permit proper operation of power-driven float. Consolidate surface with power-driven floats. Use hand floating with wood or cork-faced floats in locations inaccessible to power-driven machine and on small, isolated slabs.

2. After initial floating, re-check tolerance of surface with 10-foot straightedge applied at not less than two different angles. Cut down high spots and fill low spots to Class B tolerance. Immediately re-float slab to a uniform, smooth, granular texture.

3. Provide float finish at locations not otherwise specified and not otherwise indicated on Drawings.

G. Trowel Finish

1. Apply float finish as previously specified. After power floating, use power trowel to produce smooth surface, which is relatively free of defects, but which may still contain some trowel marks. Do additional troweling by hand after surface has hardened sufficiently. Do final troweling when ringing sound is produced as trowel is moved over surface. Thoroughly consolidate surface by hand troweling operations.

2. Produce finished surface free of trowel marks, uniform in texture and appearance and conforming to Class A tolerance. On surfaces intended to support floor coverings, remove defects which might show through covering by grinding.

3. Provide trowel finish for floors which will receive floor covering and additional locations indicated on Drawings.

H. Broom or Belt Finish

1. Apply float finish as previously specified. Immediately after completing floated finish, draw broom or burlap belt across surface to give coarse transverse scored texture.

2. Provide broom or belt finish at locations indicated on Drawings.

3.06 FINISHING SLABS AND SIMILAR FLAT SURFACES TO “F NUMBER SYSTEM” FINISH

A. Shaping to Contour: Use strike-off templates or approved compacting-type screeds riding on screed strips or edge forms to bring concrete surface to proper contour. Edge forms and screeds: Conform to Section 03055 –Concrete Structures.

B. Consolidation and Leveling: Concrete to be consolidated shall be as dry as practicable. Thoroughly consolidate concrete in slabs and use internal vibration in beams and girders of framed slabs and along bulkheads of slabs on grade. Consolidate and level slabs and floors with vibrating bridge screeds, roller pipe screeds or other approved means. After consolidation and leveling, do not manipulate surfaces prior to finishing operations.

C. Tolerances for Finished Surfaces: Independent testing laboratory will check floor flatness and levelness in accordance with paragraph 3.12, Field Quality Control.

D. Float Finish

1. After concrete has been placed, struck off, consolidated and leveled, do not work further until ready for floating. Begin floating when water sheen has disappeared, or when mix has stiffened sufficiently to permit proper operation of power-driven float. Consolidate surface with power-driven floats. Use hand floating with wood or cork-faced floats in locations inaccessible to power-driven machine and on small, isolated slabs.

2. Check tolerance of surface after initial floating with a 10-foot straightedge applied at not less than two different angles. Cut down high spots and fill low spots. Immediately refloat slab to uniform, smooth, granular texture to FF20/FL17 tolerance, unless shown otherwise on Drawings.

3. Provide “F Number System” float finish at locations indicated on Drawings.

E. Trowel Finish

1. Apply float finish as previously specified. After power floating, use power trowel to produce smooth surface, which is relatively free of defects, but which may still contain some trowel marks. Do additional troweling by hand after surface has hardened sufficiently. Do final troweling when ringing sound is produced as trowel is moved over surface. Thoroughly consolidate surface by hand troweling operations.

2. Produce finished surface free of trowel marks, uniform in texture and appearance and conforming to an FF25/FL20 tolerance for slabs on grade and FF25/FL17 for elevated slabs, unless shown otherwise on Drawings. On surfaces intended to support floor coverings, remove defects, which might show through covering, by grinding.

3.07 BONDED CONCRETE TOPPING AND FILL

A. Surface Preparation

1. Protect raked, base-slab finish from contamination until time of topping. Mechanically remove oil, grease, asphalt, paint, clay stains or other contaminants, leaving clean surface.

2. Prior to placement of topping or fill, thoroughly dampen roughened slab surface and leave free of standing water. Immediately before topping or fill is placed, scrub coat of bonding grout into surface. Do not allow grout to set or dry before topping or fill is placed.

B. Concrete Fill

1. Where concrete fill intersects a wall surface at an angle steeper than 45 degrees from vertical, provide a 1.5-inch deep keyway in the wall at the point of intersection; size keyway so that no portion of the concrete fill is less than 1.5 inches thick. Form keyway

in new walls; create by saw cutting the top and bottom lines and chipping in existing walls.

2. Apply wood float finish to surfaces of concrete fill.

3. Provide concrete fill at locations shown on Drawings.

3.08 EPOXY PENETRATING SEALER

A. Surfaces to receive epoxy penetrating sealer: Apply wood float finish. Clean surface and apply sealer in compliance with manufacturer's instructions.

B. Rooms with concrete curbs or bases: Continue application of floor coating on curb or base to its juncture with masonry wall. Rooms with solid concrete walls or wainscots: Apply minimum 2-inch-high coverage of floor coating on vertical surface.

C. Mask walls, doors, frames and similar surface to prevent floor coating contact.

D. When coving floor coating up vertical concrete walls, curbs, bases or wainscots, use masking tape or other suitable material to keep a neat level edge at top of cove.

E. Provide epoxy penetrating sealer at locations indicated on Drawings.

3.09 EPOXY FLOOR TOPPING

A. Surfaces to receive epoxy floor topping: Apply wood float finish unless recommended otherwise by epoxy floor topping manufacturer. Clean surface and apply epoxy floor topping in compliance with manufacturer's recommendations and instructions. Thickness of topping: 1/8 inch.

B. Rooms with concrete curbs or bases: Continue application of floor coating on curb or base to its juncture with masonry wall. Rooms with solid concrete walls or wainscots: apply 2-inch-high coverage of floor coating on vertical surface.

C. Mask walls, doors, frames and similar surfaces to prevent floor coating contact.

D. When coving floor coating up vertical concrete walls, curbs, bases or wainscots, use masking tape or other suitable material to keep a neat level edge at top of cove.

E. Finished surface shall be free of trowel marks and dimples.

F. Provide epoxy floor topping at locations indicated on Drawings.

3.10 SEALER/DUSTPROOFER

Where sealer or sealer/dustproofer is indicated on Drawings, just prior to completion of construction, apply coat of specified clear sealer/dustproofing compound to exposed interior concrete floors in accordance with manufacturer's instructions.

3.11 NONSLIP FINISH

A. Apply float finish as specified. Apply two-thirds of required abrasive aggregate by method that ensures even coverage without segregation and re-float. Apply remainder of abrasive aggregate at right angles to first application, using heavier application of aggregate in areas not sufficiently covered by first application. Re-float after second application of aggregate and complete operations with troweled finish. Perform finishing operations in a manner that will allow the abrasive aggregate to be exposed and not covered with cement paste.

B. Provide nonslip finish at locations indicated on Drawings.

3.12 FIELD QUALITY CONTROL

A. Flatness and levelness of slabs and similar flat surfaces that are indicated on Drawings to receive "F Number System" finish will be checked by independent testing laboratory employed by Owner in accordance with Section 01410 – Testing Laboratory Services.

B. Tolerances for "F Number System" finished surfaces:

1. Floor tolerance shall be determined in accordance with ASTM E1155.

2. Floor flatness and levelness tolerances:

a. F_F defines maximum floor curvature allowed over 24 inches. Computed on the basis of successive 12-inch elevation differentials, FF is commonly referred to as the "flatness F-Number."

b. $F_F = 4.57$
Maximum difference in elevation, in decimal inches,
between successive 12-inch elevation differences.

c. F_L defines relative conformity of floor surface to horizontal plane as measured over 10-foot distance. FL is commonly referred to as "levelness F-number."

d. $F_L = 12.5$
Maximum difference in elevation, in inches,
between two points separated by 10 feet.

3. Achieve specified overall slab tolerance. Minimum local tolerance (1/2 bay, unless otherwise designated by Engineer): 2/3 of specified tolerance.

4. Tolerance for floated finish: FF20/FL17, unless otherwise shown on Drawings.

5. Tolerance for troweled finish: FF25/FL20 for slabs on grade, and FF25/FL17 for elevated slabs, unless otherwise shown on Drawings.

3.13 CURING

Conform to requirements of Section 03390 – Concrete Curing.

END OF SECTION

SECTION 03390

CONCRETE CURING

PART 1 GENERAL

1.01 SCOPE

This Section governs the curing of structural concrete.

1.02 REFERENCES

ACI 308 - Standard Specification for Curing Concrete.
ASTM C171 - Standard Specifications for Sheet Materials for Curing Concrete.
ASTM C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
ASTM D4587 - Conducting Standard Practice for Fluorescent UV-Condensation Exposures of Paint and Related Coatings.

1.03 DEFINITIONS

Mass Concrete: Concrete sections 4 feet or more in least dimension.

1.04 SUBMITTALS

A. Conform to Submittals Specification.

B. Product Data: Submit description of proposed curing method for concrete. When use of membrane-forming compound is proposed, submit manufacturer's technical information including material specifications, installation instructions and recommendations, and evidence that compound is satisfactory for intended application. State locations where curing compound will be used.

C. When membrane-forming compounds are to be used, submit certification by the manufacturer of compliance with specified requirements and compatibility with toppings, coatings, finishes, and adhesives to be applied.

PART 2 PRODUCTS

2.01 MATERIALS

A. Membrane-forming Curing Compound: Conform to ASTM C309, Type 1D, and following requirements.

1. Minimum solids content: 30 percent.

2. Compound shall not permanently discolor concrete. When used for liquid- containing structures, curing compound shall be white-pigmented.

3. When used in areas that are to be coated, or that will receive topping or floor covering, material shall not reduce bond of coating, topping, or floor covering to concrete. Curing compound manufacturer's technical information shall state conditions under which compound will not prevent bond.

4. Conform to local, state and federal solvent emission requirements.

B. Clear Curing and Sealing Compound (VOC Compliant): Conform to ASTM C 309, Type 1, Class B, and the following requirements: 30 percent solids content minimum; non-yellowing under ultraviolet light after 500-hour test in accordance with ASTM D 4587. Sodium silicate compounds are not permitted. Conform to local, state and federal solvent emission requirements.

C. Sheet Material for Curing Concrete: ASTM C171; waterproof paper, polyethylene film or white burlap-polyethylene sheeting.

D. Curing Mats (for use in Curing Method 2): Heavy shag rugs or carpets, or cotton mats quilted at 4 inches on center; 12 ounce per square yard minimum weight when dry.

E. Water for curing: Clean and potable.

PART 3 EXECUTION

3.01 CURING PROCEDURES

A. Comply with ACI 308 and the requirements specified herein. Protect freshly-deposited concrete from premature drying and excessively hot or cold temperatures. Maintain minimal moisture loss and relatively constant temperature during time necessary for hydration of cement and proper hardening of concrete.

B. Unformed Surfaces: For concrete surfaces not in contact with forms, use one of following procedures immediately after completion of placement and finishing.

1. Ponding or continuous sprinkling.

2. Absorptive mat or fabric kept continuously wet.

3. Sand or other covering kept continuously wet.

4. Continuous steam bath (not exceeding 150 degrees F at surface of concrete).

5. Vapor mist bath.

6. Membrane-forming curing compound applied according to manufacturer's recommendations. After the curing compound has dried, wet slab surfaces and cover with waterproof paper, polyethylene film, or white burlap-polyethylene sheeting after the application of the curing compound. Tape sheet seams together and provide sufficient weights to keep the sheeting in place. Wet the slab surface again if the sheeting becomes dislodged and replace the sheeting.

7. Other moisture-retaining coverings as approved by Engineer.

C. Restrictions on Use of Curing Compounds: Unless curing compound manufacturer certifies that curing compound will not prevent bond to cured surface, do not use curing compound on surfaces that will be rubbed or receive additional concrete, mortar, topping, terrazzo or other cementitious finishing materials, on slabs under resilient floors or built-up roofing, or on surfaces to be waterproofed, sealed, hardened or painted.

D. Curing and Sealing Compounds: At locations indicated, cure exposed interior slabs and troweled slabs receiving mastic-applied adhesives with specified clear curing and sealing compound in accordance with manufacturer's recommendations. Do not store materials directly on curing membranes. Use plywood to protect curing membrane from damage. Immediately repair membranes damaged by foot traffic or other operations.

E. Duration of Curing: Continue curing until cumulative number of days or fractions of days during which ambient temperature is above 50 degrees F has totaled 7. Continue curing of water-retaining structures for a total of 14 days. When high-early-strength concrete has been used, continue curing for total of 3 days. Prevent rapid drying at end of curing period.

F. Formed Surfaces: During the curing period keep wet steel forms heated by sun and wood forms in contact with concrete. When forms are to be removed during curing period, employ curing materials or methods immediately. Continue such curing for remainder of curing period.

G. Temperature:

1. Cold Weather. When mean daily temperature of atmosphere is less than 40 degrees F, maintain temperature of concrete between 50 and 70 degrees F for required curing period. When necessary, make arrangements for heating, covering, insulating or housing concrete work in advance of placement to maintain required temperature and moisture conditions. Prevent damage or injury due to concentration of heat. When combustion heaters are necessary in enclosed or protected area where concrete slabs are being placed, vent heaters.

2. Hot Weather. In advance of placement make arrangements for shading, fog spraying, sprinkling, ponding or installation of windbreaks or wet covering of light color. Take such protective measures as quickly as concrete hardening and finishing operations will allow.

3. Temperature Changes. Control so rate of change in temperature of concrete is as uniform as possible. Do not permit temperature change to exceed 5 degrees F in any one hour or 50 degrees F in any 24-hour period.

H. Protection from Mechanical Injury. During curing period, protect concrete from damaging mechanical disturbances, particularly load stresses, heavy shock, and excessive vibration. Protect finished concrete surfaces from damage caused by construction equipment, materials or methods, and by rain or running water. Do not load self-supporting structures in a way that over stresses concrete.

3.02 CURING MASS CONCRETE

Observe the following additional restrictions when curing mass concrete.

A. Minimum curing period: 2 weeks.

B. When ambient air temperature falls below 32 degrees F, protect surface of concrete against freezing.

C. Do not use steam or other curing methods that will add heat to concrete.

D. Keep forms and exposed concrete continuously wet for at least the first 48 hours after placing, and whenever surrounding air temperature is above 90 degrees F during final curing period.

E. During 2-week curing period, provide necessary controls to prevent ambient air temperature immediately adjacent to concrete from falling more than 30 degrees F in 24 hours.

END OF SECTION

SECTION 03600

STRUCTURAL GROUT

PART 1 GENERAL

1.01 SCOPE

This Section governs the application of non-shrink grout used wherever grout is shown in the Documents, unless another type is specifically referenced. Two classes of non-shrink grout (Class I and II) and areas of application are specified.

1.02 REFERENCES

CRD C621 - Corps of Engineers Specification for Non-shrink Grout
ASTM C109 - Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in or 50-mm Cube Specimens)
ASTM C230 - Specifications for Flow Table for use in Tests of Hydraulic Cement
ASTM C1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink)

1.03 SUBMITTALS

A. Conform to Submittals Specification.

B. Quality Control:

1. The Contractor shall submit manufacturer's literature certifying compliance with the specified properties for Class I and II grouts.

2. The Contractor shall submit manufacturer's literature containing instructions and recommendations on the mixing, handling, placement and appropriate uses for each type of grout used in the work.

C. The Contractor shall submit manufacturer's written warranty as specified.

1.04 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 Resident Project Representative to ensure continued compliance with these Specifications. The specimens will be made by the Resident Project Representative or its representative.

2. Compression tests and fabrication of specimens for non-shrink grout will be performed as specified in ASTM C109 at intervals during construction as selected by the Resident

Project Representative. A set of three specimens will be made for testing at 7 days, 28 days, and each additional time period as appropriate.

3. Grout already placed which fails to meet the requirements of these Specifications is subject to removal and replacement no additional cost to the owner.

4. The cost of laboratory tests on grout will be borne by the Owner, but the Contractor shall assist the Resident Project Representative in obtaining specimens for testing. However, 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 materials necessary for fabricating the test specimens.

B. Warranty

1. Provide one-year warranty for work provided under this Section.

2. Manufacturer's warranty shall not contain a disclaimer limiting responsibility to only the purchase price of products or materials furnished.

3. Manufacturer shall warrant participation with Contractor in replacing or repairing grout found to be defective due to faulty materials, as determined by industry standard test methods.

PART 2 PRODUCTS

2.01 APPLICATION

A. The following is a listing of typical applications and the corresponding type of grout which is to be used. Unless indicated otherwise, grouts shall be provided as listed below whether or not called for on the Drawings.

Application:	Type of Grout
Structural member base plates	Non-shrink Class II
Storage tanks and other equipment	Non-shrink Class I
Filling blockout spaces for embedded items such as railing posts, gate guide frames, etc.	Non-shrink Class II (Class I where placement time exceeds 15 minutes)
Under precast concrete elements	Non-shrink Class I
Toppings and concrete fill less than 3 inches thick	Concrete Topping per the section entitled, “STRUCTURAL CONCRETE”
Toppings and concrete fill greater than 3 inches thick	Concrete Fill per the section entitled, “STRUCTURAL CONCRETE”
Any application not listed above, where grout is called for on the Drawings	Non-shrink Class I, unless noted otherwise

2.02 PREPACKAGED GROUTS

A. Basic Requirements for Cementitious Non-Shrink Grout

1. Provide prepackaged non-shrink grout that is inorganic, flowable, non-gas-liberating, non-metallic, and cement-based, requiring only the addition of water.

2. Deliver grout in original packaging with manufacturer's instructions printed on each container.

3. Select the specific formulation for each class of non-shrink grout specified to conform to that recommended by the manufacturer for the particular application.

4. Compressive strength at 28 days: 7000 psi minimum.

5. Do not use a grout for which the non-shrink property is based on a chemically generated gas or gypsum expansion.

B. Class I Non-Shrink Grout

1. Supply Class I Grout conforming to these specifications and to CRD C621 and ASTM C1107 Grade C and B (as modified below) when tested using the amount of water needed to achieve the following properties:
   a. Fluid consistency (20 to 30 seconds) per CRD C 611 at initial testing.
   b. Fluid consistency (45 seconds) per CRD C 611 at 30 minutes after mixing.
   c. At temperatures of 45, 73.4, and 95 degrees F.

2. To satisfy non-shrink requirements, the length change from placement to time of final set shall not have a shrinkage greater than the amount of expansion measured after final set at 3 and 14 days. The expansion at 3 and 14 days shall not exceed the 28-day expansion.

3. Fluid grout shall pass through the flow cone, with a continuous flow, 1 hour after mixing.

4. Demonstrate in tests that grout maintains contact with the baseplate to provide an minimum effective bearing area of 95 percent of the gross contact area after final set.

5. The grout packaging shall list weight, maximum amount of mixing water to be used, maximum usable working time (pot life) at flowable consistency, and temperature restrictions for preparation and placement within which grout will meet specified requirements.

C. Class II Non-Shrink Grout

1. Supply Class II Grout confirming to ASTM C1107 and the following requirements when tested using the amount of water needed to achieve the following properties:
   a. Flowable consistency: 140 percent flow on ASTM C 230, five drops in 30 seconds.
   b. Fluid working time: 15 minutes, minimum.

c. Flowable duration: 30 minutes, minimum.

2. When tested, the grout shall not bleed at maximum allowed water.

2.03 CURING MATERIALS

Curing materials: As specified in the section entitled, “CONCRETE CURING” and as recommended by the manufacturer of prepackaged grouts.

2.04 CONSISTENCY

Mix grouts to the consistency necessary to completely fill the space to be grouted. Dry pack consistency is such that the grout is plastic and moldable but will not flow. Where "dry pack" is called for in the Contract Documents, it shall mean a grout of that consistency; the type of grout to be used shall be as specified herein for the particular application.

PART 3 EXECUTION

3.01 PREPARATION

A. Verify that base concrete or masonry has attained design strength before grout is placed.

B. When cementitious grouts are used on concrete surfaces, saturate the concrete surface with water for 24 hours prior to placement of cement-based grout. Upon completion of saturation period remove excess water prior to grouting.

3.02 GROUTING PROCEDURES

Prepackaged Grouts: Perform mixing, surface preparation, handling, placing, consolidation, curing, and other means of execution for prepackaged grouts according to the written instructions of the manufacturer. Use prepackaged materials in the quantities and proportions as directed by the manufacturer unless there is certified test data verifying that the specified properties are attained by modified mix.

3.03 CONSOLIDATION

Place grout in such a manner, for the consistency necessary for each application, so as to assure that the space to be grouted is completely filled.

END OF SECTION

SECTION 05500

METAL FABRICATIONS

PART 1 GENERAL

1.01 SCOPE

This Section governs the covers the provision and application of bolts, anchors, nuts, sleeves, concrete anchors, scheduled items, and other miscellaneous ferrous metal and sheet metal items not specifically included under other sections of these specifications.

1.02 SUBMITTALS

A. Shop Drawings: Indicate materials, profiles, sizes, connection attachments, reinforcing, anchorage, size and type of fasteners, finish and accessories. Include erection drawings showing locations, elevations, clearances, and details where applicable.

B. Indicate welded connections using standard AWS A2.4 welding symbols. Indicate net weld lengths.

C. Submit manufacturer’s technical literature and test reports showing certified capacities for concrete anchors.

1.03 QUALIFICATIONS

A. Prepare Shop Drawings under direct supervision of a Professional Structural Engineer experienced in design of this work and licensed in the State of Texas.

B. Welders' Certificates: Submit under provisions of Section entitled, “SUBMITTALS,” certifying welders employed on the Work, verifying AWS qualification within the previous 12 months.

1.04 FIELD MEASUREMENTS

Verify that field measurements are as indicated on Construction Plans.

PART 2 PRODUCTS

2.01 MATERIALS

A. Shop-primed Materials:

1. Steel Shapes, Bars and Plates: ASTM A36.
2. Structural Tube: Hot formed square or rectangular tubing, ASTM A501.
3. Cold-rolled Sheets: ASTM A366.
4. Cold-finished Bars: ASTM A108.
5. Pipe: ASTM A53, Schedule 40 if not shown otherwise.

B. Uncoated Ferrous Materials:

1. Stainless Steel: Austenitic Type 302 or 304, No. 4 belt polished, 50-180 grit finish, stainless steel conforming to ASTM A276, A269, A312, A632, as applicable.

2. Cast Iron: ASTM A48, Class 30B.

3. Stainless Steel Bolts and Nuts: Bolts per ASTM F593, Type 316; nuts per ASTM F594, Type 316; UNC coarse threads.

4. Concrete Anchors: Concrete anchors are inserted into holes drilled in hardened concrete and shall be one of the following types:

a. Adhesive Anchors: Concrete anchors which are submerged, in splash zones, in enclosed spaces over liquids, or anchoring vibrating equipment shall be epoxy adhesive anchors. Adhesive anchors may be used at all locations where concrete anchors are required. Epoxy systems shall be Sika/FI System with Sikadur Injection Gel Epoxy, Master Builders Concresive Epoxy Cartridge Dispensing System and Concresive Paste LPL, or equal. Threaded rods shall be ASTM F593, Type 316 studs. Where adhesive anchors, or connected metal, are exposed to direct sunlight, the anchors shall be certified to maintain at least 90 percent of their rated strength (tested at 73 degrees F) when tested at 160 degrees F.

b. Expansion Anchors: Where concrete anchors are indicated and adhesive anchors are not required, wedge type anchors made with ASTM A276, Type 316 Stainless Steel shall be used. Anchors shall be KWIK Bolt III By Hilti, Inc. or approved equal.

C. Galvanized Materials:

1. Non-structural Pipe: ASTM A120.
2. Iron and Steel Hardware: ASTM A153.
3. Steel Shapes, Plates, Bars, and Strips: ASTM A123.
4. Steel Sheets: ASTM A446.
5. Assembled Steel Products: ASTM A386.
6. Delivery of Hot-dipped items: ASTM A525.

D. Aluminum Materials:

1. Standard Structural Shapes: ASTM B308.
2. Structural Pipe and Tube: ASTM B429.
3. Extruded Bars, Rods, Shapes, and Tubes: ASTM B221.
4. Plate and Sheet: ASTM B209. Use alloy 3003-H16 for mill finish and alloy 5005-H16 for anodized finish.

2.02 FABRICATION

A. Fit and shop assemble in largest practical sections, for delivery to site.

B. Fabricate items with joints tightly fitted and secured.

C. Grind exposed joints flush and smooth with adjacent finish surface. Make exposed joints butt tight, flush, and hairline. Ease exposed edges to small uniform radius.

D. Exposed Mechanical Fastenings: Flush countersunk screws or bolts; unobtrusively located; consistent with design of component, except where specifically noted otherwise.

E. Supply components required for anchorage of fabrications. Fabricate anchors and related components of same material and finish as fabrication, except where specifically noted otherwise.

2.03 FINISHES

A. Steel Shop Primer:

1. Prepare surfaces to be primed in accordance with SSPC SP-2 and SP-1. Remove mill scale, loose rust, and other foreign materials.

2. Do not prime surfaces in direct contact with concrete or where field welding is required.

3. Acceptable Primers: Comply with F.S. TT-P-86, Type I or II, TT-P-636C, or SSPC – Paint 4-64T. Proprietary primers of equal performance may be used.

4. Application: Apply with spray only for Workmanship Classes 1 and 2. Apply primer free of runs and other irregularities that may require modification to achieve the specified finish appearance.

B. Galvanization: Galvanize, after completion of welded fabrication, in accordance with ASTM A123, structural steel members. Provide minimum 1.25 oz/sq ft galvanized coating.

C. After primer, paint using Devoe Devflex Exterior Waterborne Acrylic Semi-gloss 4206 (Black). Paint material containers not displaying manufacturer’s product identification will not be acceptable.

2.04 WORKMANSHIP CLASSES (Steel)

A. CLASS 1:

1. Exposed Surfaces: Sandblast surfaces smooth with pits, mill marks, nicks and scratches filled or ground off. Defects shall not show when painted.

2. Welds: Conceal welds where possible. Where exposed, grind welds to small radius with uniform sized cove. When painted, welds shall be undetectable.

3. Bolts: Use only flat head countersunk bolts in exposed locations.

4. Straightness: Distortions visible to the eye will be rejected.

5. Joints: Fit joints to hairline finish.

B. CLASS 2:

1. Exposed Surfaces: Moderate irregularities not visible at 30 feet may remain. Mill marks may remain.

2. Welds: Grind welds to small radius with uniform sized cove.

3. Bolts: Use only flat or oval head, countersunk bolts where exposed to view.

4. Straightness: Minor distortions will be permitted.

5. Joints: Provide maximum gap of 1/16 inch.

C. CLASS 3:

1. Exposed Surfaces: No improvement from mill finish required except preparation of galvanizing or priming.

2. Welds: Grinding not required.

3. Bolts: Exposed bolts permitted.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that field conditions are acceptable and are ready to receive work.

B. Beginning of installation means erector accepts existing conditions.

3.02 PREPARATION

A. Clean and strip primed steel items to bare metal where site welding is required.

B. Supply items required to be cast into concrete or embedded in masonry with setting templates, to appropriate sections.

C. All stainless steel threads to be coated with an anti-seizing compound prior to installing the nuts.

3.03 INSTALLATION

A. Install items plumb and level, accurately fitted, free from distortion or defects and as recommended by product manufacturer. Attach members firmly to abutting materials, parallel to adjoining construction.

B. Allow for erection loads, and for sufficient temporary bracing to maintain true alignment until completion of erection and installation of permanent attachments.

C. Field weld components indicated on shop drawings.

D. Perform field welding in accordance with AWS D1.1.

E. Obtain Engineer approval prior to site cutting or making adjustments not scheduled.

F. Fill and sand screw heads and joints larger than a hairline in Class 1 workmanship items.

G. After erection, prime welds, abrasions, and surfaces not shop primed except surfaces to be in contact with concrete.

3.04 ERECTION TOLERANCES

A. Maximum Variation From Plumb: 1/4 inch per story, non cumulative.

B. Maximum Offset From True Alignment: 1/4 inch.

3.05 SCHEDULE

A. General - The Schedule is a list of principal items only. Refer to Construction Plans details for items not specifically scheduled. Items not listed require the following workmanship classes and finishes.

1. Exposed items in finished areas: Class 1.
2. Exposed items in utility areas: Class 2.
3. Concealed items: Class 3.
4. Items not subject to contact with moisture: Primed finish.
5. Items subject to contact with moisture: Galvanized finish.

B. List of Typical Steel Items (Workmanship and Finish)

1. CLASS 1 Workmanship: (Shop Primer finish) Interior wall ladders to roof hatches.
2. CLASS 2 Workmanship: (Shop Primer finish) Miscellaneous interior exposed angles.
3. CLASS 2 Workmanship: (Galvanized finish)

    a. Miscellaneous exterior exposed angles.
    b. Exterior loose lintels.
    c. Exterior wall ladders to roof.

4. CLASS 3 Workmanship: (Shop Primer finish) Miscellaneous interior concealed angles.
5. CLASS 3 Workmanship: (Galvanized finish) Miscellaneous exterior concealed angles.

C. List of Typical Aluminum Items

Anodized Items: Closure panels and plates, exposed to view.

- END OF SECTION –

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SECTION 05512

STRUCTURAL STEEL

PART 1 GENERAL

1.01 SCOPE

This section in general covers the furnishing, fabrication and erection of steel for structural use, anchoring and metal items not specifically included under other specification sections.

1.02 SUBMITTALS

A. Submit under provisions of Section entitled “SUBMITTALS”.

B. Shop Drawings: Indicate profiles, sizes, connections, attachments, reinforcing, anchorage, size and type of fasteners, and accessories. Include erection drawings, elevations, and details where applicable.

C. Indicate welded connections using standard AWS welding symbols. Indicate net weld lengths.

D. Submit manufacturer's technical literature and test reports showing certified capacities for concrete anchors.

1.03 QUALIFICATIONS

A. Prepare Shop Drawings under direct supervision of a Professional Engineer experienced in design of this work and licensed in the State of Texas.

B. Welder's Certificates: Submit under provisions of Section entitled “SUBMITTALS”, certifying welders employed on the Work and verifying AWS qualifications within the previous 12-months.

1.04 FIELD MEASUREMENTS

Verify that field measurements are as indicated on Construction Plans.

1.05 REFERENCE STANDARDS

AISC Steel Construction Manual
ASTM A36- Standard Specification for Carbon Structural Steel
ASTM A123- Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A307- Standard Specification for Carbon Steel Bolts and Steel, 60000 PSI Tensile Strength
ASTM A992 - Standard Specification for Structural Steel Shapes
ASTM A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

ASTM A325 – Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 KSI Minimum Tensile Strength
AWS A5.1- Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding.
AWS D1.1- Structural Welding Code Steel.

PART 2 PRODUCTS

2.01 MATERIALS

A. General

1. All structural steel plates, pipe support framing, and bearing plates shall conform to ASTM Standard A36 unless otherwise shown on the plans.

2. Structural steel for curb angles, channels, sheet metal, stairs and miscellaneous items shall conform to ASTM Standard A36 unless otherwise shown on the plans.

3. Other structural steel shapes (except tubing) shall conform to ASTM Standard A992 unless otherwise shown on the plans.

4. Structural steel tubing shall conform to ASTM Standard A500 unless otherwise shown on the plans.

5. Unless otherwise noted on the drawings, all steel not completely embedded shall be hot-dip galvanized after fabrication.

B. Standard Bolts and Nuts

Unless otherwise specified, noted on the drawings, or required, bolts and nuts shall conform to the requirements of ASTM Standard A325, latest edition, Grade A, with square head, hex nuts, and standard washers.

C. Anchor Bolts

Anchor bolts shall be galvanized and fabricated from new, ASTM A307 steel, round bar stock, complete with American Standard threads, hex nuts, and washer unless otherwise noted.

D. Pipe Supports

The pipe supports shall be fabricated from steel conforming to ASTM Standard A36, latest edition.

2.02 FABRICATION

A. Fit and shop assemble in largest practical sections, for delivery to site.

B. Fabricate items with joints tightly fitted and secured.

C. Grind exposed joints flush and smooth with adjacent finish surface.

2.03 FINISHES

A. Do not prime surfaces in direct contact with concrete or where field welding is required.

B. Galvanize, after completion of welded fabrication, in accordance with ASTM A123. Provide minimum 1.25 oz/sq. ft. galvanized coating.

2.04 PAINT MATERIALS

A. Provide the manufacturer's best-quality paint material of the type specified or approved by Engineer. Paint material containers not displaying manufacturer's product identification will not be acceptable.

B. Painting Specifications:

a. 1st Coat: Devoe Devshield Rust Penetrating Metal Primer 4130-6130

b. 2nd Coat: Devoe Devflex Exterior Waterborne Acrylic Semi-gloss 4206 (color as directed)

PART 3 EXECUTION

3.01 FABRICATION AND ERECTION

A. General

1. All welding to be performed in the field shall be by welders having current weld certifications in accordance with AWS for that type/class of weld.

2. All shop fabrication, field fabrication and erection shall be in accordance with the latest edition of the AISC Manual and Specifications for fabrication and erection of buildings. All fabrication shall be welded construction, unless otherwise shown or approved by the Engineer.

3. Verify that field conditions are acceptable and are ready to receive work.

B. Welding

1. Welding electrodes and welding procedures shall conform to the latest requirements of the AWS A5.1 and D1.1.

2. Clean and strip steel items bare metal where site welding is required.

3.02 INSTALLATION

A. Install items plumb and level, accurately fitted, free from distortion or defects.

B. Allow for erection loads, and for sufficient temporary bracing to maintain true alignment until completion of erection and installation of permanent attachments.

C. Field weld components indicated on shop drawings.

D. Perform field welding in accordance with AWS D1. 1.

E. Obtain Engineer approval prior to site cutting or making adjustments not scheduled.

F. After erection, prime welds, abrasions, and surfaces not shop primed except surfaces to be in contact with concrete.

3.03 ERECTION TOLERANCES

A. Maximum Variation from Plumb: ¼-inch, non-cumulative.

B. Maximum Offset from true Alignment: ¼-inch.

3.04 PAINTING

A. Starting of painting work will be construed as Applicator’s acceptance of surfaces and conditions within any particular area.

B. Do not paint over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions otherwise detrimental to formation of a durable paint film.

C. Clean surfaces to be painted in accordance with the manufacturer before applying paint or surface treatments. Program cleaning and painting so that contaminants from cleaning process will not fall on wet, newly-painted surfaces.

D. Mix, prepare and store painting materials in accordance with manufacturer's directions.

E. Apply paint in accordance with manufacturer's directions. Use applicators and techniques best suited for substrate and type of material being applied.

F. Do not apply material when surface and ambient temperature are outside the temperature range required by the paint product manufacturer.

G. Do not apply exterior coatings during rain, fog, or snow, or when relative humidity is outside the humidity ranges required by the paint manufacturer.

H. Provide special, temporary ventilation and any other protective measures as required by the paint manufacturer and/or applicable laws and regulations.

I. Protection: Protect work of other trades, whether to be painted or not, against damage by painting and finishing work. Correct any damage by cleaning, repairing, or replacing and repainting as acceptable to Owner. Provide "Wet Paint" signs to protect newly-painted wet finishes.

- END OF SECTION –

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SECTION 11510

SUBMERSIBLE NON-CLOG PUMPS

PART 1 -- GENERAL

1.01 WORK INCLUDED

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

B. This Section covers guide rail-mounted submersible, non-clog centrifugal pumping units and controls. Each pumping unit shall be complete with a close-coupled, submersible, electric motor; a floor-mounted discharge base and elbow; guide rails; access hatch cover; and all other appurtenances specified or otherwise required for proper operation.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 02732 – Sanitary Sewer Lift Station.

B. Division 16 – Electrical.

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Comply with the applicable current provisions of the Codes and Standards as specified

1. National Fire Protection Agency (NFPA 820).

1.04 CONTRACTOR SUBMITTALS

A. Submittals shall be made in accordance with Section 01300 “Submittals.”

B. The submittal shall include complete fabrication, assembly, foundation, and installation drawings, together with detailed specifications, and data covering materials used, parts, devices, and other accessories forming a part of the equipment furnished, including the following information:

1. Pumps:

a. Name of Manufacturer.

b. Type and Model.

c. Rotative speed.

d. Size of suction nozzle.

e. Size of discharge nozzle.

f. Type of bearings.

g. Complete performance curve showing capacity vs. head, NPSH required, efficiency, and kW input.

h. Data on shop painting.

2. Motors:

a. Name of Manufacturer.

b. Type and Model.

c. Type of bearings and lubrication.

d. Rated size of motor, hp.

e. Temperature rating.

f. Full load rotative speed.

g. Net weight.

h. Service factor.

i. Efficiency at full load and pump design point.

j. Full load current.

k. Locked rotor current.

3. Control Panel and Components:

a. Name of Manufacturer.

b. Type and Model.

c. Dimensions and net weight of complete panel.

d. Overcurrent characteristics and details of motor control.

1.05 QUALITY ASSURANCE

A. Factory Tests: All submersible pumps and motors shall be factory tested.

1. Hydrostatic Testing: All pumps shall be hydrostatically tested to a minimum pressure of 1.5 times the shut off head of the pump. Each pump and motor shall be tested as one assembled unit and shall show zero leakage.

2. Submersible Motor Leakage Test: The motor shall be leak tested to the pressure equivalent to 30 feet of water and shall show zero leakage. Test procedures shall be submitted to the engineer for review.

B. Field Tests:

1. General: After installation of the pumping equipment, electrical, instrumentation and control, the contractor shall be responsible to make sure that all the works have been checked, and all equipment has been tested in conformance with the drawings and specifications. Field tests shall be conducted in the presence of the pump manufacturer's representative, engineer and SAWS personnel.

2. The contractor shall notify the engineer at least two weeks prior to the scheduled test.

PART 2 -- PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Power Supply: Power supply to equipment will be 460 volts, 60-Hz, 3-phase.

B. Anchor Bolts: All anchor bolts, nuts, and washers shall be Type 316 stainless steel and shall comply with the anchor bolts and expansion anchors section. Anchor bolts shall be accurately located and centered in pipe sleeves having an inside diameter approximately 2-1/2 times the bolt diameter and with a length approximately 8 times the bolt diameter.

C. Painting: All iron and steel parts which will be in contact with pumped liquid or submerged after installation, including the inside of the impeller casing, the impeller, and the discharge elbow, shall be shop cleaned in accordance with the coating manufacturer's recommendations and painted with an epoxy coating system. The coating shall have a dry film thickness of at least 10 mils and shall consist of a prime (first) coat and one or more finish coats. At least one quart of the finish coat shall be furnished with each pump for field touchup painting.

All other iron and steel surfaces, except stainless steel and machined surfaces, shall be shop painted as specified by the manufacturer.

D. Manufacturer: Xylem (Flygt) model NP 3153 SH 3 – 274 (with 176 mm impeller), no substitutions allowed.

2.02 PERFORMANCE AND DESIGN REQUIREMENTS

A. Pumping units shall be designed for the following operating conditions and requirements:

1. Three (3) submersible sewage pumps (1 Lead, 1 Lag, 1 Standby) shall be furnished. The pumps shall be furnished with stainless steel fasteners and assembly. When operating in parallel, the lead and lag pumps conveying flow to the discharge piping shall have a minimum capacity as shown on the plans. Pumps shall be fastened on stainless steel slide rails, with stainless steel lifting chain attached to the pump for easy removal.

2. The pumps shall be capable of handling raw, unscreened sewage. The design shall be such that the pump unit will be automatically and firmly connected to the discharge connection. The discharge connection shall be permanently installed in the wet well. The pump shall be easily removable for inspection or service, requiring no bolts, nuts or other fastenings to be disconnected.

3. Major pump components (pump casing, impeller, intermediate housing, motor housing) shall be of, at minimum, ASTM A48 Class 35 cast iron with smooth surfaces devoid of blow holes and other irregularities.

4. Mating surfaces between components where watertight integrity is critical shall be machined and fitted with Nitrile Rubber or Viton O-Rings. Because there are critical passages and flame paths, no secondary sealing compounds, elliptical O-rings, greases, or other devices shall be used.

5. The pumps shall be furnished by a manufacturer engaged in the production of the specific type of pump for a minimum of 10 years. The manufacturer shall have furnished similar pumps for a least 5 other installations in Texas performing similar duty. Each installation shall have performed satisfactorily for at least 5 years and shall still be in operation.

6. All manufacturer parts and components shall be engineered for long, continuous and uninterrupted service. Provisions shall be made for easy lubrication, adjustment, or replacement of all parts.

7. Where like items are incorporated into equipment systems (i.e. motors, push buttons, etc.) such items must be identical to achieve standardization for appearance, operation, maintenance, spare parts, and service. Corresponding parts of multiple units shall be interchangeable.

8. All stages of the manufacturing process shall be carefully inspected at the factory by factory inspectors who shall use whatever means necessary to

assure the proper fit of all field connections and compliance with all material and fabrication requirements of the specifications.

9. The pump, pump monitoring, and level control panel shall be factory wired and assembled. Assembly and wiring shall be to the point where the only field interconnections to numbered terminal blocks are required.

10. It is absolutely imperative that parts be available within 60 miles of the project site for immediate repairs should repairs become necessary. Unless it can be demonstrated that parts and service have been available at a service center within 60 miles of the project site through the same financially sound firm on a continuing basis for at least 10 years, the spare parts listed in these specifications must be furnished with the pumps at no additional cost to the Owner.

B. Pump Design

1. Pump volutes shall be single piece gray cast iron, Class 35B, non-concentric design with smooth passages large enough to pass any solids that may enter the impeller. Minimum inlet and discharge size shall be as indicated herein.

C. Motors

1. Lift Station Pumps

a. One (1) motor shall be furnished with each pump. The pump motors shall be vertical, with normal starting torque and low starting current characteristics, suitable for three-phase, sixty cycle, 460 volt, AC electric current. The motors shall be 23 HP, 3,510 RPM and of sufficient horsepower to be non-overloading throughout the performance possible on this installation.

b. Pump motors shall be suitable for continuous operation and inverter duty type (suitable for soft starters and variable frequency drives) at full nameplate load while the motor is completely submerged, partially submerged, or totally non-submerged for submersible pumps.

c. Motors shall be equipped with "Motor Controllers" per manufacturer’s recommendations.

d. The pump motor shall be a NEMA B design, induction type with a squirrel cage rotor, shell type design, housed in an air filled, water-tight chamber.

e. The stator windings shall be insulated with moisture-resistant Class H insulation for 180 degrees C. The motor shall be designed for

continuous duty capable of fifteen (15) evenly spaced starts per hour. Automatic reset, normally closed thermal sensors shall be imbedded in each phase of the motor windings to provide overheating protection.

f. The stator shall be insulated by the trickle impregnation method using Class H monomer-free polyester resin resulting in a winding fill factor of at least 95%.

g. The motor shall be designed for continuous duty while handling pumped media of up to 104 degrees F.

h. The stator shall be heat-shrink fitted into the cast iron stator housing. The use of fastening devices to hold or locate the stator and that penetrate the stator housing are not acceptable.

i. The motor service factor shall be 1.15. The motor shall have a voltage tolerance of +/- 10%.

j. The motor shall be designed for a continuous operation in up to a 104-degree F ambient and shall have a NEMA Class B maximum operating temperature rise of 80 degrees C.

k. Motor shaft shall be one-piece, extending through the pump and motor. Extension couplings shall not be acceptable. Shaft shall be ASTM A276 Type 431 stainless steel. Shaft sleeves shall not be acceptable.

l. The power cable entry seal design shall preclude specific torque requirements to insure a watertight seal and shall allow simple field changing of power and pilot cables without affecting pump or motor warranty. The cable entry assembly shall consist of a seal flange designed and machined to provide precise compressions of cylindrical elastomer grommets flanked by stainless steel washers all having a close tolerance fit against the outside diameter of the cable and the inside diameter of the entry body. Cable sizing shall conform to NEC requirements for portable power use.

m. A separate junction chamber shall be provided inside the pump for connection of power and pilot cables to stator leads. The chamber shall be sealed by a nonmetallic terminal board bolted to a machined surfaced and utilizing an O-ring to obtain a watertight seal. A leak detection device shall be mounted in the chamber to detect moisture increase or if a cable is cut, and it shall be connected to a monitoring device in the control panel to send an alarm and shut the pump down.

n. Power cable shall be multi-conductor externally jacketed with oil resistant chloroprene rubber. Internal tinned copper conductor's insulation shall be ethylene propylene rubber and shall be color coded to identify each power lead.

D. Mechanical Seal

1. Pumps shall be provided with a mechanical seal system consisting of two totally independent seal assemblies operating in an oil chamber between the pump volute and motor chamber for seal lubrication and cooling. The oil shall be a white paraffin based oil meeting the standards of FDA 172.87B.

2. The lower seal shall act as the primary unit to prevent entry of pumped liquid to the oil chamber. The upper seal shall act as a secondary unit to prevent pumped liquid or oil from entering the stator housing. The seal system shall allow continuous pump operation with the motor exterior totally dry.

3. Each seal unit shall consist of a positive driven rotation ring, a stationary ring and an independent spring to maintain interface contact. The upper and lower seals for all pumps shall have tungsten carbide rotation and stationary rings.

E. Bearings

1. The pumps shall be equipped with grease lubricated bearings with a minimum L_{10} bearing system life of 50,000 hours at any point along the pump curve at maximum speed.

2. The upper bearings shall be a single deep groove ball bearing.

3. The lower bearing shall be a two row angular contact bearing to compensate for axial thrust and radial forces. Sleeve or single row lower bearings are not acceptable.

4. The lower bearing housing shall include an independent thermal sensor to monitor the bearing temperature. If a high temperature occurs, the sensor shall activate an alarm and shut the pump down.

F. Pump Protection Devices

1. The pump manufacturer shall provide a pump monitoring system which shall consist of pump protective devices and monitoring unit mounted on a dead front door or back plate of control panel.

2. Pump Protective Devices

a. Three thermal switches in the stator coils.

b. A leakage sensor shall be provided in the stator housing to detect water intrusion.

3. Monitoring and Status Unit

a. The Monitoring and Status unit shall be designed to mount on the back plate or swing out door of the control panel

b. All monitoring devices shall connect to the control and monitoring unit.

G. Accessories

1. General

a. The Pump Manufacturer shall furnish and be responsible for coordinating proper fit and suitability of all station hardware and accessories for the use with the pumps furnished or for any future requirements or revisions as may be indicated on the Drawings or other sections of the Contract Specifications. All items furnished shall be guaranteed, to the Owner, suitable for the intended use and shall be warranted against defective workmanship, materials and excessive corrosion for a period of two years after startup and beneficial use by the Owner.

2. The pump manufacturer shall furnish all station hardware and accessories for use with the pumps furnished or for any future requirements or revisions as may be indicated in the Plans or other sections of the Contract Specifications.

3. All items inside the wet well shall be stainless steel or aluminum as indicated below.

4. To insure compatibility, all access covers in structures containing submersible pumps shall be provided by the supplier of the submersible pumps. See specification for access cover requirements.

5. Guide rail system shall consist of no less than two bars. Each bar shall be Schedule 40 wall thickness pipe to assure future availability for replacement. Guide bar diameter shall be as recommended by the pump manufacturer. Guide bars spanning 20 feet or less between upper and lower supports shall not require intermediate bracing. Guide bar material shall be stainless steel, Type 316.

6. Guide Rail Brackets:

a. Dual rail upper guide rail brackets shall be provided by the pump supplier for each pump. Each bracket shall have two 3/16” hooks

for supporting pump power cables and lifting assemblies. The upper guide rail bracket shall be constructed of 316 stainless steel.

b. Dual rail intermediate guide rail brackets shall be provided by the pump supplier for guide rails which exceed 20 feet in length. Intermediate guide rail brackets shall be located at each 20' increment of guide rail or at mid-point of guide rail span. The intermediate guide rail bracket shall be constructed of 316 stainless steel.

7. Access Covers

a. To ensure compatibility, the supplier of the submersible pumps shall supply all access covers in structures containing submersible pumps with size and quantities as outlined on the drawings.

b. Material shall be 6061-T6 aluminum for bars, angles and extrusions. 1/4" diamond plate shall be 5086 aluminum. Hinges shall be of heavy-duty design. Hinge material shall be grade 316 stainless steel.

c. Access cover shall be 300 ponds/square foot Live Load rated.

d. All access covers shall have a "Safe-Hatch" that is designed to combine covering of the opening, fall through protection per OSHA standard 1910.23 and controlled confined space entry per OSHA standard 1910.146.

e. Doors cannot be closed unless the fall through protection has been put back in place.

f. Grate openings shall be 5" x 5", which will allow for visual inspections, limited maintenance and float adjustment while safety grate is left in place. Grate shall also be designed to be near flush to the top of the frame to reduce potential falls on accidental oversteps.

g. Grates shall be "Safety Orange" in color for a visual awareness of the hazard and shall create physical barrier around the opening, protecting persons around the wet well.

8. Float Cable Racks:

a. Level sensor floats shall be suspended in the wet well from a cable rack bolted to the access opening or cover frame. Each rack shall be provided with six, 3/16" minimum diameter hooks over which the level sensor cables shall be looped. The cable rack shall be 316 stainless steel.

9. Power Cable Supports:

   a. A stainless steel or non-metallic cable grip shall be provided for each pump power and pilot cable. The grip shall have a loop on one end, which will hang from a hook provided on the upper guide bar bracket.

10. Lift Station Hardware:

   a. All nuts, bolts, washers, anchor bolts or any attachment hardware used inside the wet well shall be constructed of 316 stainless steel.

H. Testing

1. A certified factory performance test shall be performed on each pumping unit in accordance with Hydraulic Institute Standards, Level A, latest edition. Tests shall be sufficient to determine the curves of head, input horsepower, and efficiency relative to capacity from shutoff to 150% of design flow. A minimum of six points, including shutoff, shall be taken for each test. At least one point of the six shall be taken as near as possible to each specified condition.

I. Electrical Control Panel:
The Pump Manufacturer shall provide and be responsible for proper electrical protection and control operation. The Pump Supplier shall supply the pump control panel in order to assure unit responsibility for equipment selection, component compatibility, startup and operational checks and future service. Electrical equipment supplied must comply with all requirements of Division 16 Electrical and with the Electrical Drawings.

J. Pump Control, Monitoring and Level Sensing
It is the intent of this specification for the contractor to provide a complete pump control, monitoring and level sensing control system for municipal wastewater application involving two (2) pumps. All components required for a complete operable system shall be included.

K. Warranty
All equipment purchased under this contract shall be warranted for a minimum of two (2) years or manufacturer's time of warranty, whichever is longer from date of substantial completion.

The CONTRACTOR shall also furnish a "trouble shooter" within twenty-four (24) hours from notification to repair any malfunction with any unit purchased under this contract for the duration of that unit's warranty.

L. Pump performance shall be stable and free from cavitation and noise throughout the specified operating head range at minimum suction submergences. The design running clearance between the impeller inlet and the casing wearing ring (if

provided) shall be not less than 0.006-inch or one-half mil per inch of casing wearing ring diameter, whichever is greater.

M. Each pumping unit shall be designed so that reverse rotation at rated head will not cause damage to any component.

2.03 MATERIALS

A. Stator Housing, Oil Chamber Housing, Impeller Casing, Impeller, and Sliding Bracket: Cast iron, ASTM A48.

B. Casing Wearing Ring: Bronze ASTM B62.

C. Bottom Wearing Plate: Cast iron, ASTM A48.

D. All Wetted Assembly Fasteners: Type 316 stainless steel.

E. Discharge Base: Cast iron or fabricated steel.

F. Guide Rails: Type 316 stainless steel.

2.04 PUMP CONSTRUCTION

A. Impeller Casing: The impeller casing shall have well-rounded water passages and smooth internal surfaces free from cracks, porosity, blow holes, or other irregularities. The discharge nozzle shall be flanged and sufficiently rigid to support the guide rail-mounted pumping unit under all operating conditions.

B. Impeller: The impeller shall be a semi-open or enclosed one-piece casting with not more than two nonclog passages. The interior water passages shall have uniform sections, smooth surfaces, and free from cracks and porosity. The impeller shall be dynamically balanced and securely locked to the shaft by means of key and self-locking bolt or nut.

Balance vanes shall be provided on the impeller back shroud. Running clearances between the vanes and adjacent housing surfaces shall be such as to reduce pump discharge pressure at the lower mechanical seal sufficiently to permit the oil in the oil chamber housing to effectively lubricate the lower seal.

C. Wearing Rings: Renewable wearing rings shall be securely fastened to the impeller casing front cover to provide either an axial or radial running clearance. As an alternative, the use of an axially adjustable wearing plate arranged to permit adjustment of the axial running clearance between the impeller and plate will also be acceptable. The wearing plate shall have an outward spiraling groove designed to force stringy solids outward and away from the impeller.

D. Oil Chamber Housing: The oil chamber shall contain a moisture sensor, inspection plug, drain plug, and vent plug.

E. Discharge Base: A discharge base and discharge elbow shall be furnished by the pump manufacturer for each pumping unit. The base shall be sufficiently rigid to firmly support the guide rails, discharge piping, and pumping unit under all operating conditions. The base shall be provided with one or more integral support legs or pads suitable for bolting to the floor of the wet well. The face of the discharge elbow inlet flange shall be perpendicular to the floor and make contact with the face of the pump discharge nozzle flange. The diameter and drilling of the elbow outlet flange shall conform to ANSI B16.1, Class 125.

The pump and motor assembly shall be automatically connected to and supported by the discharge base and guide rails such that the unit can be removed from the wet well and replaced without the need for operating personnel to enter the wet well.

F. Sliding Bracket: Each pumping unit shall be provided with an integral, self-aligning guide rail sliding bracket. The bracket shall be designed to obtain a wedging action between flange faces as final alignment of the pump occurs in the connected position. The bracket shall maintain proper contact and a suitably sealed connection between flange faces under all operating conditions.

G. Lifting Chain: A chain suitable for removing and installing each pump should be selected and provided by the pump manufacturer. The chain shall be Type 316 stainless steel. A suitable chain hook shall be provided at the top of the wet well.

2.05 BALANCE

A. All rotating parts shall be accurately machined and shall be in as nearly perfect rotational balance as practicable. Excessive vibration shall be sufficient cause for rejection of the equipment. The mass of the unit and its distribution shall be such that resonance at normal operating speeds is avoided. In any case, the vibration displacement (peak-to-peak) as measured at any point on the machine shall not exceed 4.0 mils.

B. At any operating speed, the ratio of rotative speed to the critical speed of a unit or components thereof shall be less than 0.8 or more than 1.3.

2.06 CONTROLS

A. Refer to Division 16 – Electrical.

PART 3 -- EXECUTION

3.01 GENERAL

A. Each discharge base shall be leveled, plumbed, aligned, and wedged into position to fit connecting piping. Installation procedures shall be as recommended by the pump manufacturer and the Hydraulic Institute Standards.

END OF SECTION

GUAJOLOTE LIFT STATION
AND FORCE MAIN

BID SET

APRIL 17, 2026

STEVEN MOUSER
P.E. NO. 103671

Grubb Engineering, Inc.
TBPE FIRM NO. 3904

DIVISION 16
ELECTRICAL SPECIFICATIONS

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TECHNICAL SPECIFICATION
DIVISION 16
ELECTRICAL

TABLE OF CONTENTS

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SECTION 16010
BASIC ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.1 RELATED SECTIONS

A. Requirements specified within this section apply to all sections in Division 16, ELECTRICAL. Work specified herein shall be performed as if specified in the individual sections.

1.2 STANDARDS

A. All electrical equipment and controls furnished under the provisions of this Section of the specifications shall conform to the current standards, rules, regulations and specifications of the following authorities:

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

AMERICAN SOCIETY OF TESTING AND MATERIALS (ASTM)

AMERICAN WATERWORKS ASSOCIATION (AWWA)

CPS ENERGY

FACTORY MUTUAL (FM)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

INSULATION CABLE ENGINEERS ASSOCIATION (ICEA)

NATIONAL ASSOCIATION OF CORROSION ENGINEERS (NACE)

NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCATION (NEMA)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

UNDERWRITERS' LABORATORIES, INC. (UL)

B. Reference to standards of any technical society, organization, or both shall be construed to mean the latest standard, code, or specification adopted and published at the date of advertisement.

1.3 DESCRIPTION OF ELECTRICAL WORK

A. General Description:

1. The electrical work to be performed under the provisions of these Contract Documents consists of furnishing all materials, equipment, supplies, and appurtenances; providing all construction plant, equipment and tools; performing all necessary labor and supervision, and the construction, complete including all work appurtenant thereto, at the location indicated. The site of the work is Guajolote Lift Station, Bexar County, Texas.

B. Electrical work provided within this Contract at the proposed site:
1. Contractor is responsible for coordinating with CPS Energy and providing all required service construction in accordance with the requirements and specifications of CPS Energy.
2. Furnish and install line extension, Service Pole, Service Raceway, Service Head, and Service Cable, ready for overhead connection by CPS Energy.
3. Furnish and install CPS provided Meter Enclosure.
4. Contractor is responsible for paying all CPS Energy service installation and connection charges.
5. One (1) 3-pole 200 amp fused main disconnect switch. Shall be mounted at the meter rack. Section 16410, SAFETY SWITCHES-HEAVY DUTY.
6. One (1) 3-pole 200 amp non-fused meter disconnect switch. Shall be mounted at the meter rack. Section 16410, SAFETY SWITCHES-HEAVY DUTY
7. Furnish and install Service Power Rack equipped with:
   a. One (1) Combination 15kVA Transformer/Power Panel Unit. It shall consist of a 15kVA transformer, breakers for the primary and secondary sides of the transformer and power panelboard with external SPD located adjacent to panelboard that adheres to UL1449 4th Edition Standards refer to specification 16451. Section 16463, MINI-POWER CENTERS. Section 16050, BASIC ELECTRICAL MATERIALS AND METHODS.
   b. One (1) 480Vac rated wiring gutter.
   c. Canopy lighting and service rack mounted switch. See contract drawings and section 16050, BASIC ELECTRICAL MATERIALS AND METHODS.
   d. One (1) 3-pole 200A Automatic Transfer Switch Section 16503, AUTOMATIC TRANSFER SWITCH.
   e. One (1) 120 Vac GFCI receptacle.
   f. One (1) Auto Dialer Panel.

g. One Pump Control Panel which shall contain three (3) NEMA Size 2 motor Soft Starters with circuit breaker disconnects and other equipment and circuitry as shown on the contract drawings, Section 16421 SOFT START MOTOR CONTROLLERS.

8. Furnish and install required level control instrumentation: submersible level transmitter, and float switches. Section 16930, INSTRUMENTATION.
9. Furnish and install two (2) pole mounted area lights.
10. Furnish and install one (1) Standby Generator, Section 16600, STANDBY GENERATOR, (Size is an estimate only. Generator Manufacturer to verify size based on test parameters in specification section 16600.) Contractor must provide an analysis showing how the generator was selected.
11. The work shall include all duct banks, conduit, cable, wiring, interconnection, controls, instrumentation, grounding, and lighting as specified herein, as indicated on the Contract Drawings and as necessary to provide a complete functional operating electrical system.
12. The CONTRACTOR is to provide the conduit layout drawings showing proposed routing of exposed conduits, conduits embedded in structural concrete and concrete-encased conduits. Drawings shall show locations of pull and junction boxes and all penetrations on walls and floor slabs. Conduit shall not be installed until approved by Owner and Engineer.
13. Furnish and install grounding systems as shown on the contract drawings and specified in section 16451, GROUNDING.
14. Conduct electrical acceptance testing of all installed components per NETA-ATS and per section 16950 Electrical Testing.
15. Contractor shall alert testing firm after panels and disconnects are installed and after distribution cables are installed and landed but not torqued in order for equipment and cable testing to be completed properly.
16. The contractor shall provide a Power System Study including Arc Flash study, Section 16411, POWER SYSTEM STUDY.
17. Furnish Operations and Maintenance Manuals for the following items of electrical equipment:
    a. Safety Switches – Heavy Duty
    b. Combination 15kVA Transformer/Power Panel Unit
    c. Instrumentation
    d. Auto Dialer Equipment
    e. Auto Dialer Panel
    f. Mini Power Center
    g. Pump Control Panel (Motor Controls)
    h. Generator
    i. Automatic Transfer Switch.

1.4 SUBMITTALS

A. Shop Drawing and Material Specification Submittals: The submittal of Shop Drawings and material specifications in accordance with Division 1 and the General Conditions of the Contract, shall include the following:

1. Outline and control drawings for pump control panel including all relays, meters, instrument transformers, and control devices.
2. Power Panel.
3. Instrumentation.
4. Auto Dialer equipment.
5. Duct materials including conduit fittings and spacers.
6. Mini Power Centers.
7. Panel schematics, wiring diagrams, and panel arrangements.
8. Enclosures, light fixtures, and receptacles.
9. Cable specifications.
10. Automatic Transfer Switch specifications.
11. Generator
12. As required in each section.

B. Operation and Maintenance Manuals.

1.5 FINAL DRAWINGS

Final drawings shall be submitted in accordance with Division 1 and shall include:

1. Overall Interconnect Wiring Diagram:
   a. The diagrams shall be documentation of all field wiring (interconnects) made between all equipment, motors, controllers, panels, etc. by the Contractor.
   b. The diagrams shall identify each terminal point, each cable as it was actually labeled and the size and number of cables actually installed by the Contractor.
2. Final "As-Built" Drawings:
   a. The Contractor shall, prior to final acceptance, provide the Owner with one copy of the Contract Drawings indicating all deviations made, and additional information provided during construction and installation. The drawings shall be documentation of the entire station "as-built" by the Contractor and shall also indicate the following:
      1.) All fuse and breaker sizes.
      2.) Transformer size (kVA) and impedance values (%).
      3.) Numbers for all terminal points indicated on the Contract Drawings.
      4.) Items not furnished under this contract are not applicable.

PART 2 PRODUCTS

2.1 GENERAL

A. All electrical materials used shall conform to the National Electric Code rules and shall be approved by the National Board of Fire Underwriters for the class of service for which they are intended and shall bear the label or approval of the Underwriters Laboratories insofar as such services are available.

PART 3 EXECUTION

3.1 GENERAL

A. Electrical Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned.
   1. Dimensions shown on the Drawings related to equipment are based on one typical manufacturer's equipment. Coordinate the dimensions of the equipment furnished with the space available.
   2. Intent:
      a. The drawings show the principal elements of the electrical system. They are not intended as detailed working drawings for the electrical work but as a complement to the specifications to clarify the principal features of the electrical systems.
      b. It is the intent of this Section that all equipment and devices, furnished and installed under this and other Sections, be properly connected and interconnected with other equipment so as to render the installations complete for successful operation, regardless of whether all the connections and interconnections are specifically mentioned in the specifications or shown on the drawings. Any work that may reasonably be inferred from the specifications or drawings as being required to provide the completed electrical systems shall be supplied whether or not it is specifically called for.
      c. Dielectric couplings shall be installed between dissimilar metals in all cases.

B. Install work in accordance with NECA Standard of Installation, unless otherwise specified.

C. Installation and Operation:
   1. Equipment shall not be installed or operated except by, or with the guidance of, qualified personnel having the knowledge and experience necessary for proper results. When so specified, or when employees of Contractor or his Subcontractors are not qualified, such personnel shall be field representatives of the manufacturer of the equipment or materials being installed.

3.2 LOAD BALANCE-NOT REQUIRED

3.3 CHECKOUT AND STARTUP

A. All equipment installed under this Contract shall be placed into successful operation according to the written instructions of the manufacturer or the instructions of the manufacturer's field representative. All required adjustments, tests, operation checks, and other startup activity shall be provided. All costs for these services by the manufacturer shall be included in the contract amount.

B. Voltage Field Test:
   1. Check voltage at point of termination of power company supply system to project when installation is essentially complete and is in operation.
   2. Check voltage amplitude and balance between phases for loaded and unloaded conditions.
   3. Unbalance Corrections:
      a. Make written request to power company to correct condition if balance (as defined by NEMA) exceeds 1 percent, or if voltage varies throughout the day and from loaded to unloaded condition more than plus or minus 4 percent of nominal.
      b. Obtain a written certification from a responsible power company official that the voltage variations and unbalance are within their normal standards if corrections are not made.

END OF SECTION

SECTION 16050
BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.1 SUBMITTALS

A. Shop Drawings:
   1. Junction and pull boxes used at, or below, grade
   2. Device box relocation
   3. Terminal junction boxes
   4. Panelboards and circuit breaker data
   5. Fuses
   6. Contactors
   7. Transformers
   8. Lighting fixtures and poles
   9. Control cabinet enclosures
   10. Control cabinet wiring and terminal blocks
   11. Control cabinet devices and nameplates

1.2 QUALITY ASSURUNCE

A. UL Compliance: Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

1.3 SPARE PARTS

A. Furnish, tag, and box for shipment and storage and deliver prior to 75 percent Project completion the following spare parts:
   1. Fuses, 0 to 600 Volts: Six (6) of each type and each current rating installed unless otherwise specified.
   2. Lamps for panel lighting: Twelve of each type installed.

PART 2 PRODUCTS

2.1 METERING FACILITIES

A. Furnish materials as required by electric utility for utility's installation of metering equipment, service conductors, and mounting of utility company equipment.

2.2 OUTLET AND DEVICE BOXES

A. Cast Metal: (For use only on electric service pole)
   1. Box: Malleable iron
   2. Cover: Gasketed, weatherproof, malleable iron, with stainless steel screws.
   3. Hubs: Threaded
   4. Lugs: Cast Mounting
   5. Finish: Corrosion resistance zinc electroplate coated
   6. Manufacturers and Products:
      a. Crouse-Hinds; Type FS or FD
      b. Appleton; Type FS and FD

B. Aluminum:
   1. Material: Die-cast aluminum
   2. Hubs: Threaded
   3. Cover: Gasketed, weatherproof, aluminum alloy
   4. Manufacturers:
      a. Thomas & Betts Red Dot

2.3 JUNCTION AND PULL BOXES

A. Outlet Boxes Used as Junction or Pull Box: As specified under Article OUTLET AND DEVICE BOXES.

B. Large Stainless Steel Box: NEMA 250, Type 4X.
   1. Box: 16-gauge, Type 316 stainless steel, with white enamel painted interior mounting panel, and 10 gauge stainless steel flanges.
   2. Cover: Hinged with clamps.
   3. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
   4. Manufacturers:
      a. Hoffman Enclosures Co.
      b. Rittal

2.4 WIRING DEVICES

A. Switches:
   1. NEMA WD1 and FSW-S-896E.
   2. Specification grade, totally enclosed, ac type, with quiet tumbler switches and screw terminals.
   3. Capable of controlling 100 percent tungsten filament and fluorescent lamp loads.
   4. Rating: 20 amps, 120/277 volts
   5. Color: Ivory
   6. Manufacturers:
      a. Bryant
      b. Leviton
      c. Hubbell
      d. Pass and Seymour
      e. Arrow Hart

B. Receptacle, Single and Duplex:
   1. NEMA WD 1 and FS W-C-596.
   2. Specification grade, two-pole, three-wire grounding type with screw type wire terminals suitable for No. 10 AWG.
   3. High strength, thermoplastic base color.
   4. Color: Ivory.
   5. Contact Arrangement: Contact to be made on two sides of each inserted blade without detent.
   6. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps.

7. Manufacturers:
    a. Bryant
    b. Leviton
    c. Hubbell
    d. Pass and Seymour
    e. Sierra
    f. Arrow Hart

C. Receptacle, Ground Fault Circuit Interrupter: Duplex, specification grade, tripping at 5 mA.
1. Color: Ivory.
2. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps, capable of interrupting 5,000 amps without damage.
3. Size: For 2-inch by 4-inch outlet boxes.
4. Feed-Through Model: NEMA WD 1, with No. 12 AWG copper USE/RHH/RHW-XLPE insulated pigtails and provisions for testing.
5. Manufacturers:
    a. Pass and Seymour
    b. Bryant
    c. Leviton
    d. Hubbell
    e. Arrow Hart

2.5 DEVICE PLATES

A. General: Sectional type plates not permitted.

B. Metal:
1. Material: Specification grade, one-piece, 0.040-inch nominal thickness stainless steel.
2. Finish: ASTM A167, Type 302/304, satin
3. Mounting Screw: Oval-head, finish matched to plate

C. Cast Metal:
1. Material: Malleable ferrous metal, with gaskets
2. Screw: Oval-head stainless steel

D. Weatherproof:
1. For Receptacles: Gasketed, cast metal or stainless steel, with individual cap over each receptacle opening except for the receptacles located in enclosures
    a. Type: Shall be extra duty, "in-use" type suitable for wet locations as per NEC Article 406.9. Shall be weatherproof whether or not the attachment plug cap/cover is inserted/closed.
    b. Mounting Screw: Stainless steel.
    c. Cap Spring: Stainless steel.
    d. Manufacturers:
        (i) General Electric

(ii) Bryant
(iii) Hubbell
(iv) Sierra
(v) Pass and Seymour
(vi) Crouse-Hinds
(vii) Bell
(viii) Arrow Hart
(ix) Appleton

2. For Switches: Gasketed, cast metal incorporating external operator for internal switch.
   a. Mounting Screw: Stainless steel
   b. Manufacturers:
      (i) Crouse-Hinds; DS-181 or DS-185
      (ii) Appleton; FSK-1VTS or FSK-1VS

2.6 TERMINAL JUNCTION BOX

A. Cover: Hinged, unless otherwise shown.

B. Terminal Blocks: Provide separate connection point for each conductor entering or leaving box.
   1. Spare Terminal Points: 25 percent.

C. Interior Finish: Paint with white enamel or lacquer.

2.7 TERMINAL BLOCK (0 TO 600 VOLTS)

A. UL 486E and UL 1059.

B. Screw-type for accepting ring-tongue compression lugs.

C. Terminal blocks should be rated for applied voltage.

D. Clear safety cover provided to protect power distribution lugs.

E. Manufacturers:
   1. Buchanan
   2. General Electric

2.8 SUPPORT AND FRAMING CHANNELS

A. Material: Type 316 stainless steel.

B. Type: 1-1/2 inch minimum strut

C. Inserts: Continuous

D. Beam Clamps: Type 316 Stainless Steel.

E. Manufacturers:
   1. B-Line
   2. Unistrut
   3. Kindorf

2.9 CONTROL CABINETS

A. All panels shall be UL508A rated.

B. All enclosures including all mounting hardware shall be NEMA Type 4X, 316 stainless steel, unless otherwise noted. All enclosures shall be provided with top, side, and door sunshield.
   1. Pump control panels shall be free standing and shall be equipped with 12" 316 stainless steel legs kits. Panels shall be bolted to the concrete slab.

C. Enclosures shall be constructed of 14-gauge steel with powder coat over phosphatized surfaces, unless otherwise specified to be stainless steel for corrosion resistance.

D. Enclosures shall have a single swing panel front with continuous hinge, and shall have 3 point latch with provision for padlocking. Hinge pin and panel clamps shall be stainless steel.

E. Enclosures shall have an interior back panel. No screws shall penetrate the enclosure. The interior surfaces shall be white baked enamel finish.

F. Devices and nameplates shall be furnished and installed as indicated in the Contract Drawings.

G. Provide an internal, steel, hinged swing-out panel with white baked enamel finish and mounting devices such a pushbuttons, selector switches, control switches and indicating lights. All devices shall be mounted inside the control cabinets.

H. Devices and nameplates shall be furnished and installed as indicated on the Contract Drawings and elsewhere in the specifications.

I. Design and Assembly: Contractor to submit name and qualifications of design and assemble firm for Owner's approval.

J. Pump control Panel shall have flashing alarm light with horn located on the exterior.
   1. Manufacturer:
      a. Alarm Horn: Edwards, model number: 876-N5
      b. Alarm Light: Edwards, model number: 125STRNR120A

K. Enclosure Manufacturers:
   1. Hoffman Enclosure Co.

2. Rittal
3. Eaton B-Line

2.10 NAMEPLATES

A. Material: Laminated plastic

B. Attachment Screws: Stainless steel

C. Color: Black, engraved to a white core

D. Engraving:
1. Pushbuttons/Selector Switches: Name of drive controlled on one, two, or three lines, as required.
2. Panelboards and Main Distribution Panel: Panelboard designation, service voltage, and phases.

E. Letter Height:
1. Pushbuttons/Selector Switches: 1/8-inch.
2. Panelboards: 1/4-inch.

2.11 LIGHTING

A. Provide lighting fixtures and poles as shown on the CONTRACT DRAWINGS.

B. For LED lighting ensure surge protection is included integral within the driver and shall protect the fixture from the damage for transient voltage and currents as defined in ANSI/IEEE C64.41 2002 for location A.

2.12 PUSHBUTTONS, INDICATING LIGHTS, AND SELECTOR SWITCHES

A. All pushbuttons, indicating lights and selector switches shall be NEMA rated. IEC-only rated equipment is not acceptable. Pushbuttons shall be located on enclosure swing panel or shall be rated corrosion-resistant type.

B. Contact Rating: NEMA ICS 2, Type A600.

C. Selector Switch Operating Lever: Standard.

D. Elapsed Time Meter.
1. Voltage: 120VAC
2. Non-reset type

E. Indicating Lights: Heavy-duty, oiltight, 120V, push-to-test:
1. Motor On – Red
2. Motor Off – Green

F. Pushbutton Color:
1. Red mushroom head without spring return

2. On-Red
3. Off-Green

G. Legend Plate:
1. Material: Aluminum
2. Engraving: 11 character/spaces on one line, 14 character/spaces on each of two lines, as required, indicating specific function
3. Letter Height: 7/65-inch

H. Manufacturers:
1. Heavy-Duty, Oiltight Type:
a. General Electric Type CR 104P.
b. Square D Type K.
c. Eaton Type 10250T.
d. Allen-Bradley Type 800T.
2. Heavy-Duty, Watertight, and Corrosion-Resistant Type:
a. Square D Type SK.
b. General Electric Type CR 104P.
c. Eaton Type E34.

2.13 MOLDED CASE CIRCUIT BREAKERS

A. NEMA AB 1 and UL 489.

B. Thermal-magnetic, quick-make, quick-break, molded case, of the indicating type showing ON/OFF and TRIPPED positions of operating handle.
1. Where breakers are used in conjunction with starters equipped with thermal overloads, breakers shall be magnetic only (motor circuit protector). Breakers shall be adjustable and part of a listed combination motor controller having coordinated motor overload and short-circuit and ground-fault protection.

C. Multipole circuit breakers designed to automatically open all poles when an overload occurs on one pole.

D. Do not substitute single-pole circuit breakers with handle ties for multipole breakers.

E. Means for lock open of the circuit breaker shall be permanently installed.

F. Provide NEMA rated molded case circuit breakers.

G. Circuit breakers shall have minimum of 42ka symmetrical interrupting capacity.

H. Circuit breakers shall be designed for continuous operation at rated current in a 40 degree C ambient temperature.

I. Circuit breakers less than 225 ampere frame rating shall be molded case, 3 Pole, 600 Volt, fixed type, manually operated with stored energy closing mechanism. Circuit breakers shall have inverse time and instantaneous tripping characteristics.

J. Trip performance for molded case circuit breakers must be analyzed prior to approval of submittal.

K. Manufacturers:
1. Square D
2. Siemens
3. Eaton
4. General Electric

2.14 DC POWER SUPPLY

A. 24 Vdc Loop Power for the level transducer shall be provided by a single-output DC Power Supply.

B. Ratings:
1. Input Voltage: 120 Vac, + 10% voltage adjustment
2. Output Voltage: 24 Vdc single output.
3. Output Current: 1.3 amperes, overload protected.
4. Ambient Operating Temperature: -10-60 degrees C.

C. UL Compliance: Power Supply shall conform to UL Standards and have an applied UL listing.

D. Manufacturer: IDEC, Model PS5R-VC24.

2.15 OVERLOAD RELAY

A. NEMA ICS

B. Square D Motor Logic SSOLR or equal.

C. Solid State: Trip current rating will be established by selection of overload relay and shall be adjustable (3 to 1 current range). The overload shall be self-powered, provide phase loss and phase unbalance protection, have a permanent tamper guard, and be ambient insensitive. It will also be available in Trip Class 10 or 20 and have a mechanical test function.

D. Protective features shall include current unbalance and loss-of-phase protection. Þ. Outputs: Unit shall be provided with normally open or normally closed auxiliary contact and be field convertible.

E. Reset: Manual reset

2.16 ELAPSED TIME METER

A. Units: Hours

B. Analog

C. Manufacturer
   1. Eaton
   2. Honeywell
   3. Redington

PART 3 EXECUTION

3.1 GENERAL

A. Install equipment in accordance with NECA 5055.

3.2 OUTLET AND DEVICE BOXES

A. Install suitable for conditions encountered at each outlet or device in the wiring or raceway system, sized to meet NFPA 70 requirements.

B. Install plumb and level.

C. Support boxes independently of conduit by attachment to building structure or structural member.

D. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.

E. Open no more knockouts in sheet steel device boxes than are required; seal unused openings.

F. Box Type (Aluminum Raceway System):
   1. Aluminum (die cast)

G. Box Type (Rigid Galvanized Steel Raceway System*, For use only on electric service pole*):
   1. Exposed Raceways: Cast metal
   2. Concealed Raceways: Cast metal

3.3 JUNCTION AND PULL BOXES

A. Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.

B. Install pull boxes where necessary in raceway system to facilitate conductor installation.

C. Install in conduit runs at least every 150 feet or after the equivalent of three right-angle bends.

D. Use outlet boxes as junction and pull boxes wherever possible and allowed by applicable codes.

E. Installed boxes shall be accessible.

F. Install plumb and level.

G. Support boxes independently of conduit by attachment to building structure or structural member.

H. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.

I. Boxes embedded in concrete or masonry need not be additionally supported.

J. At or Below Grade:
   1. Install boxes for below grade conduits flush with finished grade in locations outside of paved areas, roadways, or walkways.
   2. If adjacent structure is available, box may be mounted on structure surface just above finished grade in accessible but unobtrusive location.
   3. Boxes shall not be installed in paved areas, roadways, or walkways.
   4. Use boxes and covers suitable to support anticipated weights.

K. Flush Mounted:
   1. Install with concealed conduit.
   2. Holes in surrounding surface shall be no larger than required to receive box.
   3. Make edges of boxes flush with final surface.

L. Mounting Hardware:
   1. Electric Service Pole: Galvanized. (For use only on electric service pole)
   2. All other Areas: stainless steel.

M. Type:
   1. NEMA 4X, 316 stainless steel.

3.4 WIRING DEVICES

A. Switches:
   1. Install with switch operation in vertical position.
   2. Install single-pole, switches such that toggle is in up position when switch is on.

B. Receptacles:
   1. Install with grounding slot down in vertical mounting, and with neutral slot up in horizontal mounting.
   2. Weatherproof Receptacles:
      a. Weather proof covers suitable for use in wet locations per NEC 406.9
      b. Type: “in-use”

c. Install in cast metal box.
d. Install such that hinge for protective cover is above receptacle opening.
e. Receptacle shall be Ground Fault Circuit Interrupter type.

3. Ground Fault Interrupter: Install feed-through model at locations where ground fault protection is specified for “downstream” conventional receptacles.
4. Special-Purpose Receptacles: Install in accordance with manufacturer's instructions.

3.5 DEVICE PLATES

A. Securely fasten to wiring device; ensure a tight fit to the box.

B. Flush Mounted: Install with all four edges in continuous contact with finished wall surfaces without use of mats or similar materials. Plaster fillings will not be acceptable.

C. Surface Mounted: Plate shall not extend beyond sides of box unless plates have no sharp corners or edges.

D. Install with alignment tolerance to box of 1/16-inch.

E. Types (Unless Otherwise Shown):
1. Weatherproof.

3.6 TERMINAL JUNCTION BOX

A. Label each block and terminal with permanently attached, nondestructible tag.

B. Do not install on finished outdoor surfaces.

C. Location:
1. NEMA 250, Type 4X, 316 stainless steel.

3.7 LIGHTING AND POWER DISTRIBUTION PANELBOARD

A. Install securely, plumb, in-line and square with walls.

B. Install top of cabinet 6 feet above floor unless otherwise shown.

C. Provide typewritten circuit directory for each panelboard.

3.8 SUPPORT AND FRAMING CHANNEL

A. Furnish zinc-rich primer; paint cut ends prior to installation.

B. Install where required for mounting and supporting electrical equipment and raceway systems.

3.9 CONTROL CABINETS

A. Install securely, plumb, in-line and square with walls or structure.

B. Cabinets shall be mounted using manufacturer furnished mounting brackets so that no screws or bolts penetrate the cabinet.

END OF SECTION

SECTION 16110
RACEWAYS

PART 1 GENERAL

1.1 SUBMITTALS

A. Shop Drawings:

1. Manufaturer's Literature:
    a. Rigid galvanized steel conduit
    b. PVC Schedule 40 conduit
    c. PVC Schedule 80 conduit
    d. Flexible, nonmetallic, liquid-tight conduit
    e. Flexible metal, liquid-tight conduit
    f. Rigid aluminum conduit
    g. PVC-Coated rigid aluminum conduit
        (i) Shall include installer's certificate
    h. Conduit fittings
    i. Wireways
2. Precast Manholes and Handholes:
    a. Dimensional drawings and descriptive literature
    b. Traffic loading calculations
    c. Accessory information

1.2 UL COMPLIANCE

A. Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

PART 2 PRODUCTS

2.1 CONDUIT AND TUBING

A. Rigid Galvanized Steel Conduit (RGS): (For use only on electric service rack)

1. Meet requirements of ANSI C80.1 and UL6.
2. Material: Hot-dip galvanized, with chromated protective layer.
3. Manufacturers:
    a. Allied Tube & Conduit
    b. Cantex
    c. Calpipe Industries: Calconduit

B. PVC Schedule 40 and Schedule 80 Conduit:

1. Meet requirements of NEMA TC 2 and UL 651.
2. UL listed for concrete encasement, underground direct burial, concealed or direct sunlight exposure, and 90° C insulated conductors.
3. Manufacturers:
    a. Allied Tube & Conduit
    b. Cantex
    c. Carlon

C. Flexible, Nonmetallic, Liquid-Tight Conduit:
   1. Material: PVC core with fused flexible PVC jacket.
   2. UL 1660 listed for:
      a. Dry Conditions: 80° insulated conductors.
      b. Wet Conditions: 60° C insulated conductors.
   3. Manufacturers:
      a. Carlon; Carflex or X-Flex
      b. T & B; Xtraflex LTC or EFC
      c. Southwire: Ultratite

D. Flexible Metal, Liquid-Tight Conduit
      a. UL 360 listed for 105° insulated conductors.
      b. Material: Aluminum, with an extruded PVC jacket.

E. Rigid Aluminum Conduit:
   1. Meet requirements of UL 6A and ANSI C80.5.
   2. Type: Rigid aluminum.
   3. PVC-Coated aluminum conduit must be used where encased in concrete and installed in soil.
   4. Manufacturers:
      a. Allied Tube & Conduit
      b. Cantex

F. PVC-Coated Rigid Aluminum Conduit and related fittings:
   1. Meet requirements of UL 6A, ANSI C80.5.
   2. Contractor to include certification in submittals showing that they are certified by the manufacturer to install PVC Coated rigid aluminum.
   3. Urethane-Coated threads
   4. Type: Rigid aluminum, PVC externally coated by conduit manufacturer
   5. Coating shall be continuous and uniform.
      a. Exterior: 40-mil PVC
      b. Interior: 2-mil urethane
   6. Manufacturers:
      a. Thomas & Betts: OCAL
      b. Robroy Industries: Perma-Cote and Plasti-Bond
      c. Calpipe Industries: Calbond

2.2 FITTINGS

A. Rigid Galvanized Steel:
   1. General:
      a. Meet requirements of UL 514B.
      b. Type: Threaded, galvanized. Set screw fittings not permitted.
   2. Bushing:
      a. Material: Malleable iron with integral insulated throat, rated for 150° C.
      b. Manufacturers:
         (i) Thomas & Betts
         (ii) O.Z. Gedney

3. Grounding Bushing:
    a. Material: Malleable iron with integral insulated throat rated for 150 degrees C, with solderless lugs.
    b. Manufacturers:
        (i) Appleton
        (ii) O.Z. Gedney
4. Conduit Hub:
    a. Material: Malleable iron with insulated throat.
    b. Manufacturers:
        (i) O.Z. Gedney
        (ii) T & B
5. Conduit Bodies:
    a. Material: Cast ferrous, sized as required by NFPA 70.
    b. Manufacturers (For Normal Conditions):
        (i) Appleton; Form 35 threaded Unilets
        (ii) Crouse-Hinds; Form 7 or 8 threaded condulets
        (iii) Killark; Series O Electrolets
6. Couplings: As supplied by conduit manufacturer.
7. Drain Seal Manufacturers:
    a. Appleton; Type SF
    b. Crouse-Hinds; Type EYD or EZD
8. Drain/Breather Fitting Manufacturers:
    a. Appleton; Type ECDB
    b. Crouse-Hinds; ECD
9. Expansion Fitting Manufacturers:
    a. Deflection/Expansion Movement:
        (i) Appleton; Type DF
        (ii) Crouse-Hinds; Type XD
    b. Expansion Movement Only:
        (i) Appleton; Type XJ
        (ii) Crouse-Hinds; Type XJ
10. Cable Sealing Fittings:
    a. To form watertight nonslip cord or cable connection to conduit
    b. For Conductors with OD of 1/2-inch or less: Neoprene bushing at connector entry
    c. Manufacturers:
        (i) Crouse-Hinds
        (ii) Appleton

B. PVC Conduit and Tubing:
    1. Meet requirements of NEMA TC-3
    2. Type: PVC, slip-on

C. Flexible, Nonmetallic, Liquid-Tight Conduit: Meet requirements of UL 514B.

1. Type: One-piece fitting body, complete with lock nut, O-ring, threaded ferrule, sealing ring, and compression nut.
2. Manufacturers:
   a. Carlon
   b. Kellems
   c. T & B

D. Aluminum:
1. Material: Rigid aluminum.
2. Meet requirements of UL 6A and ANSI C80.5.
3. Cable Sealing Fittings
   a. To stop gasses, vapors or flames from migrating from one conduit system to another.
   b. Fittings shall be used with a suitable system of sealing compound.
   c. Manufacturer: Crouse-Hinds Chico A, Chico X or Chico A-P or Appleton™ ALESKO.
4. Bushing:
   a. Material: Malleable iron with integral insulated throat, rated for 120° C.
   b. Manufacturers:
      (i) Thomas & Betts
      (ii) O.Z. Gedney
5. Grounding Bushing:
   a. Material: copper-free aluminum with integral insulated throat rated for 120 degrees C, with solderless lugs.
6. Conduit Hub:
   a. Material: Aluminum die cast, insulated throat and gasketed
   b. Manufacturers:
      (i) O.Z. Gedney
      (ii) T & B
      (iii) Appleton
7. Conduit Bodies:
   a. Material: Aluminum, sized as required by NFPA 70.
   b. Manufacturers (For Normal Conditions):
      (i) Appleton; Form 35 threaded Unilets
      (ii) Crouse-Hinds; Form 7 or 8 threaded condulets
      (iii) Killark; Series O Electrolets
8. Couplings: As supplied by conduit manufacturer.
9. Drain Seal Manufacturers:
   a. Appleton; Type SF
   b. Crouse-Hinds; Type EYD or EZD

10. Drain/Breather Fitting Manufacturers:
    a. Appleton; Type ECDB
    b. Crouse-Hinds; ECD
11. Expansion Fitting Manufacturers:
    a. Deflection/Expansion Movement:
        (i) Appleton; Type DF
        (ii) Crouse-Hinds; Type XD
    b. Expansion Movement Only:
        (i) Appleton; Type XJ
        (ii) Crouse-Hinds; Type XJ
12. Cable Sealing Fittings:
    a. To form watertight nonslip cord or cable connection to conduit
    b. For Conductors with OD of 1/2 inch or less: Neoprene bushing at connector entry.
    c. Manufacturers:
        (i) Crouse-Hinds
        (ii) Appleton

E. PVC-Coated Rigid Aluminum:
1. Material: Rigid aluminum.
2. Meet requirements of UL 6A and ANSI C80.5.
3. Urethane-Coated threads
4. Coating shall be continuous and uniform.
    a. Exterior: 40-mil PVC
    b. Interior: 2-mil urethane

F. Watertight Entrance Seal Device:
1. New Construction:
    a. Material: Oversized sleeve, malleable iron body with sealing ring, pressure ring, grommet seal, and pressure clamp.
    b. Manufacturer: O.Z. Gedney; Type FSK or WSK, as required.
2. Cored-Hole Application:
    a. Material: Assembled dual pressure disks, neoprene sealing ring, and membrane clamp.
    b. Manufacturer: O.Z. Gedney; Series CSM.

2.3 ACCESSORIES

A. Duct Bank Spacers:
1. Type: Nonmetallic, interlocking, for multiple conduit sizes.
2. Suitable for all types of conduit.
3. Manufacturer: Underground Device, Inc.
4. Carlon: Snap-Loc

B. Identification Devices:
1. Raceway Tags:
    a. Material: Stainless Steel.

b. Shape: Round.
c. Raceway Designation: Pressure stamped, embossed, or engraved.
d. Tags relying on adhesives or taped-on markers not permitted.

2. Warning Tape:
a. Material: Polyethylene, 4-mil gauge with detectable metallic strip.
b. Color: Red
c. Width: Minimum 6-inch
d. Designation: Warning on tape that electric circuit is located below tape.
e. Manufacturers:
(i) Blackburn, Type RT
(ii) Griffolyn Co.

C. Raceway Coating:
1. Material: Bitumastic or plastic tape coating.
2. Manufacturers:
a. Koppers bitumastic
b. Scotchwrap

D. Wraparound Duct Band:
1. Material: Heat-shrinkable, cross-linked polyolefin, precoated with hot-melt adhesive.
2. Manufacturer: Raychem

PART 3 EXECUTION

3.1 GENERAL

A. Conduit and Tubing sizes shown are based on the use of copper conductors.

B. All installed Work shall comply with NECA 5055.

C. Crushed or deformed raceways not permitted.

D. Maintain raceway entirely free of obstructions and moisture.

E. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.

F. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.

G. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.

H. Group raceways installed in same area.

I. Proximity to Heated Piping: Install raceways minimum 12 inches from parallel runs.

J. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.

K. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes. Do not install raceways within walls.

L. Block Walls: Do not install raceways in same horizontal course with reinforcing steel.

M. Install watertight fittings in outdoor, underground, or wet locations.

N. Paint threads, before assembly of fittings, of galvanized conduit installed in exposed or damp locations with zinc-rich paint or liquid galvanizing compound.

O. All metal conduit to be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.

P. Do not install raceways in concrete equipment pads, foundations, or beams.

Q. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.

R. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.

3.2 CONDUIT APPLICATION

A. Diameter: Minimum 3/4-inch.

B. Exterior Exposed:
   1. Rigid aluminum.
   2. Rigid galvanized steel. (For use only on electric service pole).

C. Underground Raceways: PVC coated rigid aluminum elbows and stub-ups. Refer to Drawings for additional requirements. PVC-coated rigid aluminum conduit must be used where encased in concrete.

3.3 CONNECTIONS

A. For motors, wall or ceiling mounted fans and unit heaters, dry type transformers, electrically operated valves, instrumentation, and other equipment where flexible connection is required to minimize vibration:
   1. Conduit Size 4 Inches or Less: Liquid-tight conduit.
   2. Conduit Size Over 4 Inches: Nonflexible.
   3. Corrosive Areas: Flexible, nonmetallic, liquid or aluminum, liquid-tight.

4. Length: 18-inch minimum, 60-inch maximum, of sufficient length to allow movement or adjustment of equipment.

B. Transitions from PVC Schedule 40, Aluminum and PVC-coated aluminum: Refer to detail in plans.

C. Exterior Light Pole Foundations: PVC Schedule 80 conduit.

3.4 PENETRATIONS

A. Make at right angles, unless otherwise shown.

B. Notching or penetration of structural members, including footings and beams, not permitted.

C. Fire-Rated Walls, Floors, or Ceilings: Fire-stop openings around penetrations to maintain fire-resistance rating.

D. Apply single layer of wraparound duct band to all metallic conduit protruding through concrete floor slabs to a point 2 inches above and 2 inches below concrete surface.

E. Concrete Walls, Floors, or Ceilings (Aboveground): Provide nonshrink grout dry-pack, or use watertight seal device.

F. Entering and Exiting Structures:
   1. **General: Use sealing fittings for all conduit entering the wet well. Suitable sealing compound shall be used as indicated elsewhere in the specifications.**
   2. Existing or Precast Wall (Underground): Core drill wall and install a watertight entrance seal device.
   3. Nonwaterproofed Wall or Floor (Underground, without Concrete Encasement):
      a. Provide Schedule 40 galvanized pipe sleeve, or watertight entrance seal device.
      b. Sleeve shall be flush with finished surfaces.
      c. Fill space between raceway and sleeve with an expandable plastic compound, or oakum and lead joint, on each side.
   4. Handholes:
      a. Metallic Raceways: Provide insulated grounding bushings.
      b. Nonmetallic Raceways: Provide bell ends flush with wall.
      c. Install such that raceways enter as near as possible to one end of wall, unless otherwise shown.

G. Use PVC-coated rigid aluminum conduit when conduit is encased in concrete. Refer to detail in plans.

3.5 SUPPORT

A. Support from structural members only, at intervals not exceeding NFPA 70 requirements, and in any case not exceeding 10 feet. Do not support from piping, pipe supports, or other raceways.

B. Provide and attach wall brackets, strap hangers, or ceiling trapeze as follows:
   1. Wood: Wood screws.
   2. Hollow Masonry Units: Toggle bolts.
   3. Concrete or Brick: Expansion shields, or threaded studs driven in by powder charge, with lock washers and nuts.
   4. Steelwork: Machine screws.

C. Nails or wooden plugs inserted in concrete or masonry for attaching raceway not permitted. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers.

3.6 BENDS

A. Install concealed raceways with a minimum of bends in the shortest practical distance. The number of bends shall be in conformance to NEC guidelines.

B. Make bends and offsets of longest practical radius.

C. Install with symmetrical bends or cast metal fittings.

D. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine. Do not heat metal raceways to facilitate bending.

E. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.

F. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run, and raceways are same size.

G. PVC Conduit:
   1. Bends 25-Degree and Larger: Use PVC-Coated Rigid Aluminum.
   2. Use manufacturer's recommended method for forming smaller bends.
   3. Field manufactured bends are not permitted.

H. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.

3.7 EXPANSION/DEFLECTION FITTINGS

A. Provide on all raceways at all structural expansion joints, and in long tangential runs.

B. Provide expansion/deflection joints for 50° F maximum temperature variation.

C. Install in accordance with manufacturer's instructions.

3.8 PVC CONDUIT

A. Solvent Welding:
   1. Provide manufacturer recommended solvent; apply to all joints.
   2. Install such that joint is watertight.

B. Adapters:
   1. PVC to Metallic Fittings: PVC terminal type.
   2. PVC to Rigid Metal Conduit or Aluminum: PVC female adapter.

C. Belled-End Conduit: Bevel the unbelled end of the joint prior to joining.

3.9 TERMINATION AT ENCLOSURES

A. Cast Metal Enclosure: Provide manufacturer's pre-molded insulating sleeve inside metallic conduit terminating in threaded hubs.

B. Sheet Metal Boxes, Cabinets, and Enclosures:
   1. Rigid Galvanized Conduit: (For use on electric service pole only)
      a. Provide one lock nut each on inside and outside of enclosure.
         (i) Install grounding bushing.
         (ii) Provide bonding jumper from grounding bushing to equipment ground bus or ground pad; if neither ground bus nor pad exists, connect jumper to lag bolt attached to metal enclosure.
      b. Install insulated bushing on ends of conduit where grounding is not required per NEC.
      c. Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs.
   2. Flexible, Nonmetallic Conduit: Provide nonmetallic, liquid-tight strain relief connectors.
   3. Rigid Aluminum Conduit:
      a. Refer to item no. 1.
      b. Provide dielectric couplings between dissimilar metals.
   4. PVC Schedule 40 Conduit: Provide PVC terminal adapter with lock nut.

3.10 INSTALLATION IN CAST-IN-PLACE STRUCTURAL CONCRETE

A. Minimum cover 3 inches.

B. Provide support during placement of concrete to ensure raceways remain in position.

C. Floor Slabs:
   1. Outside diameter of conduit not to exceed one-third of the slab thickness.
   2. Separate conduit by minimum six times conduit outside diameter, except at crossings.

3.11 UNDERGROUND RACEWAYS

A. Grade: Maintain minimum grade of 4 inches in 100 feet, either from one manhole, handhole, or pull box to the next, or from a high point between them, depending on surface contour.

B. Cover: Maintain minimum 2-foot cover above top of conduit, unless otherwise shown.

C. Make routing changes as necessary to avoid obstructions or conflicts.

D. Conduits shall have end bells where terminated at walls and adapters for steel conduit continuations.

E. Union type fittings not permitted.

F. Installation with Other Piping Systems:
   1. Crossings: Maintain minimum 12-inch vertical separation.
   2. Parallel Runs: Maintain minimum 12-inch separation.
   3. Installation over valves or couplings not permitted.

G. Spacers:
   1. Provide preformed, nonmetallic spacers, designed for such purpose, to secure and separate parallel conduit runs in concrete encasement.
   2. Install at intervals not greater than that specified in NFPA 70 for support of the type conduit used, but in no case greater than 5 feet.

H. Support conduit so as to prevent bending or displacement during concrete placement.

I. Backfill:
   1. Backfill with sand pneumatically compacted in 6” lifts.
   2. Do not backfill until inspected by OWNER.

J. Concrete Encasement: Class “A” (3000-PSI) concrete.

K. Cutting and Patching of Asphalt Surfaces:
   1. Refer to Civil Plans.

3.12 MANHOLES AND HANDHOLES

A. Excavate, shore, brace, backfill, and final grade in accordance with applicable provisions of Owners Standard Specifications for Construction.

B. Do not install until final raceway grading has been determined.

C. Install such that raceways enter at nearly right angles and as near as possible to one end of wall, unless otherwise shown.

D. Grounding: As specified in Section 16450, GROUNDING.

E. Identification: Field stamp covers with manhole or handhole number as shown. Stamped numbers to be 1-inch minimum height.

3.13 EMPTY RACEWAYS

A. Provide permanent, removable cap over each end.

B. Provide PVC plug with pull-tab for underground raceways with end bells.

C. Provide nylon pull cord.

D. Identify, as specified in Article IDENTIFICATION DEVICES, with waterproof tags attached to pull cord at each end, and at intermediate pull point.

3.14 IDENTIFICATION DEVICES

A. Raceway Tags:
   1. Identify origin and destination.
   2. Install at each terminus, near midpoint, and at minimum intervals of every 50 feet of exposed Raceway, whether in ceiling space or surface mounted.
   3. Provide noncorrosive wire for attachment.

B. Warning Tape: Install approximately 10 inches above top of conduit in underground raceways. Align parallel to, and above centerline of runs.

3.15 PROTECTION OF INSTALLED WORK

A. Protect products from effects of moisture, corrosion, and physical damage during construction.

B. Provide and maintain manufactured watertight and dust-tight seals over all conduit openings during construction.

C. Touch up painted conduit threads after assembly to cover nicks or scars.

END OF SECTION

SECTION 16120
CONDUCTORS

PART 1 GENERAL

1.1 SUBMITTALS

A. Shop Drawings:
   1. Wire and cable descriptive product information.
   2. Wire and cable accessories descriptive product information.

B. Quality Control Submittals:
   1. Factory Test Report for conductors 600 volts and below.

1.2 UL COMPLIANCE

A. Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

PART 2 PRODUCTS

2.1 CONDUCTORS 600 VOLTS AND BELOW

A. Conform to applicable requirements of NEMA WC 3, WC 5, and WC 7.
B. Conductor Type: Stranded Copper
C. Insulation: Type XHHW-2 90ºC. Allowable conductor ampacity shall be as listed for 75 ºC Temperature rating even for conductor with 90 ºC rated insulation.

2.2 600-VOLT RATED CABLE

A. General:
   1. Type: TC, meeting requirements of UL 1277, including Vertical Tray Flame Test at 20,000 Btu/hr, and NFPA 70, Article 340, or UL 13 Listed Power Limited Circuit Cable meeting requirements of NFPA 70, Article 725.
   2. **Pump motor cables shall meet the requirements of the National Electrical Code for flexible cords in wastewater pumping stations.**
   3. **All cable located inside of wet well shall be provided with watertight seals and separate strain relief appurtenances.**
   4. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
   5. Suitable for installation in open air, in cable trays, or conduit.
   6. Minimum Temperature Rating: 90°C dry locations, 75°C wet locations.
   7. Overall Outer Jacket: PVC, flame-retardant, sunlight-and oil-resistant.

B. Type 3-No. 16 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 55 requirements.
   1. Outer Jacket: 45-mil nominal thickness.
   2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.

3. Dimension: 0.31-inch nominal OD.
4. Conductors:
    a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
    b. 20 AWG, seven-strand tinned copper drain wire.
    c. Insulation: 15-mil nominal PVC.
    d. Jacket: 4-mil nominal nylon.
    e. Color Code: Pair conductors black (positive) and white (negative).
5. Manufacturers:
    a. Okonite Co.
    b. Alpha Wire Corp.
    c. Belden

2.3 GROUNDING CONDUCTORS

A. Equipment:
1. No. 6 AWG and Larger: Stranded Bare Copper, Class B stranding, soft drawn.
2. No. 8 AWG and smaller: Solid Bare Copper, or Stranded copper with green, Type USE/RHH/RHW-XLPE or XHHW-2, insulation.
3. Do not install bare copper conductors in the same conduit with insulated conductors.

B. Direct Buried: Stranded bare copper, class B stranding soft drawn.

2.4 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW

A. Tape:
1. General Purpose, Flame-Retardant: 7-mil, vinyl plastic, Scotch Brand 33, rated for 90°C minimum, meeting requirements of UL 510.
2. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88.
3. Arc and Fireproofing:
    a. 30-mil, elastomer
    b. Manufacturers and Products:
        (i) Scotch; Brand 77, with Scotch Brand 69-glass cloth tapebinder.
        (ii) Plymouth; Plyarc 30, with Plymouth Plyglas glass cloth tapebinder.

B. Identification Devices:
1. Sleeve: Permanent, PVC, yellow or white, with legible machine-printed black markings.
2. Marker Plate: Nylon, with legible designations permanently hot stamped on plate.
3. Grounding Conductor: Permanent green heat-shrink sleeve, 2-inch minimum

4. Manufacturers:
    a. Brady
    b. Thomas & Betts
    c. 3M
    d. Panduit

C. Connectors and Terminations:
1. Nylon, Self-Insulated Crimp Connectors:
    a. Manufacturers and Products:
        (i) Thomas & Betts; Sta-Kon
        (ii) Burndy; Insulink
        (iii) ILSCO
2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator:
    a. Manufacturers and Products:
        (i) Thomas & Betts; Sta-Kon
        (ii) Burndy; Insulink
        (iii) ILSCO
3. Self-Insulated, Freespring Wire Connector (Wire Nuts):
    a. Plated steel, square wire springs.
    b. UL Standard 486C.
    c. Manufacturers and Product:
        (i) Thomas & Betts
        (ii) Ideal; Twister
4. **Pump motor power cable terminal fittings must be corrosion resistant and constructed to prevent moisture from entering the cable, and must be provided with strain relief appurtenances.**

D. Cable Lugs:
1. In accordance with NEMA CC 1.
2. Rated 600 volts of same material as conductor metal.
3. Insulated, Locking-Fork, Compression Lugs:
    a. Suitable for use with 75°C wire at full NFPA 70, 75°C ampacity.
    b. Manufacturers and Products:
        (i) Thomas & Betts; Sta-Kon
        (ii) ILSCO; ILSCONS
4. Uninsulated Crimp Connectors and Terminators:
    a. Suitable for use with 75°C wire at full NFPA 70, 75°C ampacity. Manufacturers and Products:
        (i) Square D; Versitide
        (ii) Thomas & Betts; Color-Keyed
        (iii) ILSCO
5. Uninsulated, Bolted, Two-Way Connectors and Terminators:
    a. Manufacturers and Products:
        (i) Thomas & Betts; Locktite
        (ii) Burndy; Qiklug
        (iii) ILSCO

E. Cable Ties: Nylon, adjustable, self-locking, and reusable.
   1. Manufacturer and Product: Thomas & Betts; TY-RAP.

F. Heat Shrinkable Insulation: Thermally stabilized, crosslinked polyolefin.

   1. Manufacturer and Product: Thomas & Betts; SHRINK-KON.

2.5 PULLING COMPOUND

A. Nontoxic, noncorrosive, noncombustible, nonflammable, wax-based lubricant; UL listed.

B. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.

C. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.

D. Manufacturers and Products:
   1. Ideal Co.; Yellow 77
   2. Polywater, Inc.
   3. Cable Grip Co.

2.6 SOURCE QUALITY CONTROL

A. Conductors 600-Volts and below: Test in accordance with UL 44 and 854 Standards.

PART 3 EXECUTION

3.1 GENERAL

A. Conductor installation to be in accordance with NECA 5055.

B. Conductor and cable sizing shown is based on copper conductors, unless noted otherwise.

C. Do not cable manufacturer's recommendations for maximum pulling tensions and minimum bending radius.

D. Tighten screws and terminal bolts in accordance with UL 486A for copper conductors.

E. Cable Lugs: Provide with correct number of holes, bolt size, and center-to-center spacing as required by equipment terminals.

F. Bundling: Where single conductors and cables in manholes, handholes, vaults, cable trays, and other indicated locations are not wrapped together by some other

means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding 18 inches on center.

G. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.

H. Concrete-Encased Raceway Installation: Prior to installation of conductors, pull through each raceway a mandrel approximately 1/4-inch smaller than raceway inside diameter.

3.2 POWER CONDUCTOR COLOR CODING

A. Conductors 600 Volts and Below:

1. No. 4 AWG and Larger: Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering an area 1-1/2 to 2 inches wide.
2. No. 6 AWG and Smaller: Provide colored conductors.
3. Colors:

System	Conductor	Color
All Systems	Equipment Grounding	Green
240/120 Volts Single-Phase, Three-Wire	Grounded Neutral One Hot Leg Other Hot Leg	White Black Red
480Y/277 Volts Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White or Gray Purple Brown Yellow
NOTE: Phase A, B, C implies direction of positive phase rotation.		

4. 4 Volt DC Positive-Blue.
5. 24 Volt DC returns-White with blue tracer
6. 4-20 TSP Red+/Black-
7. Tracer: Outer covering of white with an identifiable colored strip other than green in accordance with NFPA 70.

3.3 CIRCUIT IDENTIFICATION

A. Circuits appearing in the Circuit Schedules: Identify power, instrumentation, and control conductor circuits, using circuit schedule designations, at each termination and in accessible locations such as manholes, handholes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.

B. Circuits Not Appearing in Circuit Schedules:

1. Assign circuit name based on device or equipment at load end of circuit.
2. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.

C. Method:
   1. Conductors No. 3 AWG and Smaller: Identify with sleeves.
   2. Cables, and Conductors No. 2 AWG and Larger:
      a. Identify with marker plates.
      b. Attach marker plates with nylon tie cord.
   3. Taped-on markers or tags relying on adhesives not permitted.

3.4 CONDUCTORS 600 VOLTS AND BELOW

A. Install 10 AWG or 12 AWG conductors for branch circuit power wiring in lighting and receptacle circuits.

B. Do not splice incoming service conductors and branch power distribution conductors No. 6 AWG and larger unless specifically indicated or approved by OWNER.

C. Connections and Terminations:
   1. Install wire nuts only on solid conductors.
   2. Install nylon self-insulated crimp connectors and terminators for instrumentation, control, and power circuit conductors No. 6 AWG and smaller.
   3. Install uninsulated crimp connectors and terminators for instrumentation, control, and power circuit conductors No. 4 AWG through No. 2/0 AWG.
   4. Install uninsulated, bolted, two-way connectors and terminators for power circuit conductors No. 4/0 AWG and larger.
   5. Install uninsulated bolted, two-way connectors for motor circuit conductors No. 12 and larger.
   6. Tape insulate all uninsulated connections.
   7. Place no more than one conductor in any single-barrel pressure connection.
   8. Install crimp connectors with tools approved by connector manufacturer.
   9. Install terminals and connectors acceptable for type of material used.
   10. Compression Lugs:
      a. Attach with a tool specifically designed for purpose.
      b. Tool shall provide complete, controlled crimp and shall not release until crimp is complete.
      c. Do not use plier type crimpers.

D. Do not use soldered mechanical joints.

E. Splices and Terminations:
   1. Indoors: Use general purpose, flame retardant tape.
   2. Outdoors: Use flame retardant, cold- and weather-resistant tape.

F. Cap spare conductors and conductors with UL listed end caps.

G. Cabinets, Panels, and Motor Control Centers:
   1. Remove surplus wire, bridle and secure.

2. Where conductors pass through openings or over edges in sheet metal, remove burrs, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors.

H. Control and Instrumentation Wiring:
   1. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.
   2. Terminate with methods consistent with terminals provided, and in accordance with terminal manufacturer's instructions.
   3. Locate splices in readily accessible cabinets or junction boxes using terminal strips.
   4. Cable Protection:
      a. Under Infinite Access Floors: May be installed without bundling.
      b. All Other Areas: Install individual wires, pairs, or triads in flex conduit under the floor or grouped into bundles at least 1/2-inch in diameter.
      c. Maintain integrity of shielding of instrumentation cables.
      d. Ensure grounds do not occur because of damage to jacket over the shield.

I. Extra Conductor Length: For conductors to be connected by others, install minimum 6 feet of extra conductor in freestanding panels and minimum 2 feet in other assemblies.

3.5 CONDUCTOR ARC AND FIREPROOFING

A. Wrap conductors of same circuit entering from separate conduit together as a single cable.

B. Follow tape manufacturer's installation instructions.

C. Secure tape at intervals of 5 feet with bands of tapebinder. Each band to consist of a minimum of two wraps directly over each other.

3.6 FIELD QUALITY CONTROL

A. In accordance with Section 16950, ELECTRICAL TESTING.

END OF SECTION

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SECTION 16410
SAFETY SWITCHES – HEAVY DUTY

PART 1 GENERAL

1.1 SCOPE

A. The Contractor shall furnish and install the low-voltage fused and non-fused switches as specified herein and as shown on the contract drawings.

1.2 SUBMITTALS

A. Shop Drawings:
   1. Dimensioned outline drawing
   2. Conduit entry/exit locations
   3. Switch ratings including:
   4. Short-circuit rating
      a. Voltage
      b. Continuous current
   5. Fuse ratings and type
   6. Cable terminal sizes

B. Product Information:
   1. Descriptive bulletins.
   2. Product sheets.

1.3 QUALITY ASSURANCE

A. UL Compliance: Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

1.4 SPARE PARTS

A. Furnish, tag, and box for storage three (3) spare fuses of each type and current rating installed.

PART 2 PRODUCTS

2.1 HEAVY-DUTY SAFETY SWITCHES

A. Construction:
   1. Switchblades and jaws shall be plated copper.
   2. Switches shall have copper current carrying parts.
   3. Switches shall have a handle that is easily padlockable in the OFF position.
   4. Switches shall have defeatable door interlocks that prevent the door from opening when the handle is in the ON position.
   5. Switch assembly and operating handle shall be an integral part of the enclosure base.
   6. Switches rated 100A to 600A shall have reinforced fuse clips.
   7. Switchblades shall be readily visible in the OFF position.

8. Switch operating mechanism shall be non-teasible, positive quick-make/ quick-break type (except 30A plug fuse-type).
9. Fusible switches shall be suitable for service entrance equipment.
10. Switches shall have line terminal shields.
11. Switch shall be supplied with an isolated grounded neutral bar.
12. Switch shall be supplied with a grounding bar.

B. Manufacturers:
1. Square D
2. General Electric
3. Eaton
4. Siemens

C. Enclosures:
1. The enclosure shall be NEMA 4X – 316 stainless steel.
2. The enclosure shall have ON and OFF markings stamped into the cover.
3. The operating handle shall be provided with a dual colored, red/black position indication.

D. Switch Ratings:
1. The UL Listed short circuit current rating of the switch shall be 10,000A rms, symmetrical amperes when used with or protected by Class H or K fuses (30-600 amperes) and 200,000A rms, symmetrical amperes when used with or protected by Class R or Class J fuses (30-600 amperes switches employing appropriate fuse rejection schemes).
2. Service entrance duty rated.

2.2 NAMEPLATES
A. Nameplates shall be front cover mounted, contain a permanent record of switch type, ampere rating, and maximum voltage rating.

PART 3 EXECUTION

3.1 FACTORY TESTING
A. Standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of UL and NEMA standards.

3.2 INSTALLATION
A. The equipment shall be installed per the manufacturer's recommendations and the contract drawings.
B. Contractor is responsible for providing all mounting brackets and structure to provide proper support and working clearances.

END OF SECTION

SECTION 16411
POWER SYSTEM STUDY

PART 1 GENERAL

1.1 DESCRIPTION

A. General: This section specifies that the CONTRACTOR provide short circuit and coordination studies including arc flash hazard study.
   1. Each electrical power system shall be deemed to include the utility company's transformers and the OWNER's power distribution system for this project.
   2. All studies to be performed for each electrical service: Utility and generator.
   3. The short circuit, protective device coordination, and arc flash study reports shall provide an evaluation of the electrical power systems and the model numbers and settings of the protective devices for setting by the CONTRACTOR.

B. Scope:
   1. Short Circuit Study:
      a. Provide complete short circuit study. Normal system operating method, alternate operation, and operations which could result in maximum fault conditions shall be thoroughly addressed in the study. The study shall assume all motors operating at rated voltage. Electrical equipment bus impedance shall be assumed zero. Short circuit momentary duties and interrupting duties shall be calculated on the basis of maximum available fault current at the motor control centers.
   2. Protective Device Coordination Study:
      a. A protective device coordination study shall be performed to determine appropriate relay settings. The study shall include all motor control centers, and panelboard main circuit breakers. Motor Control Centers and Panelboard 480V branch circuit devices must be included. The phase overcurrent and ground-fault protection shall be included as well as settings for all other adjustable protective devices.
   3. Arc Flash Hazard Study:
      a. An arc flash hazard study shall be performed based on the worst-case scenario. The worst case arc flash may not coincide with the worst case (max fault current) short circuit scenario. The system study engineer will need to determine the worst-case arc flash scenario.

         The study shall be performed in accordance with the latest version of IEEE Std. 1584. Labels shall be provided for each covered piece of equipment for installation on the equipment. These labels will provide all necessary information for personnel to select the proper Personnel Protective Equipment (PPE). A one-line diagram shall be provided showing incident energy, flash protection boundary, and pertinent ratings.

b. All panelboards, MCC Sections and Switchgear sections should be provided with Arc Flash Hazard labels even if they are exempt from NFPA 70E requirements.

4. Equipment Evaluation Study:
   a. An equipment evaluation study shall be performed to determine the adequacy of circuit breakers, controllers, surge arresters, busways, switches, and fuses by tabulating and comparing the short circuit ratings of these devices with the available fault currents.

5. Load Analysis Study:
   a. A load flow analysis shall be performed to determine the impact the electrical loads will have on the electrical system. The load flow analysis will ensure that the electrical components are performing within their capacity range.

6. Motor Starting Study:
   a. A motor starting analysis shall be performed to determine the effects that motors have on the electrical system. The motor starting analysis will determine the voltage and power factor: before, during starting and running of motors at each bus.

7. Problem Areas or Inadequacies:
   a. Any problem areas or inadequacies in the equipment shall be promptly brought to the Owner's attention and the ENGINEER's attention prior to the shipment of equipment to the project site.

1.2 REFERENCES

A. This Section contains references to the following documents. They are part of this Section as specified and modified. In case of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.

Reference	Title
IEEE 141-1993	Recommended Practice for Electric Power Distribution for Industrial Plants
IEEE 242-2001	Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
IEEE 399-1980	IEEE Recommended Practice for Power System Analysis (IEEE Brown Book)
IEEE 1584-2018	IEEE Guide For Performing Arc Flash Hazard Calculations

IEEE 3002.2-2018	IEEE Recommended Practice for Conducting Load Flow Studies and Analysis of Industrial and Commercial Power Systems
IEEE 3002.3-2018	IEEE Recommended Practice for Conducting Short-Circuit Studies and Analysis of Industrial and Commercial Power System
IEEE 3002.7-2018	IEEE Recommended Practice for Conducting Motor Starting Studies and Analysis of Industrial and Commercial Power System Analysis

1.3 SCHEDULE

A. Shall follow Owner's Standard submittal requirements.

B. The report shall be provided to the OWNER and ENGINEER 90 days before the equipment is shipped to the Work site.

C. The ENGINEER approved reports shall be sent to the Manufacturer (if deficiencies found) electrical installer 45 days before the equipment is shipped to the Work site.

D. The approved reports shall be incorporated as part of the project O&Ms.

PART 2 PRODUCTS

2.1 REPORTS

A. The product shall be a certified report summarizing the short circuit coordination study, and all the studies mentioned in section 1.1B of this specification. The certified report must have a conclusions or recommendations that may affect the integrity of the electric power distribution system. As a minimum, the report shall include the following:
   1. The equipment manufacturer's information used to prepare the study.
   2. Assumptions made during the study.
   3. One line diagram.
   4. Catalog sheets of each protective device being analyzed that will be installed.
   5. For Electric Utility equipment and protective devices, attach the information provided by Electric Utility .
   6. Short circuit calculations listing short circuit levels at each bus along with the calculations that are mentioned in section section 1.1B of this specification.
   7. Setting for the phase monitor relays are to be provided.
   8. Specifications and coordination study for the Motor, Motor Starter, Relays and Overload relays modeling an overload situation and/or a locked rotor condition.
   9. Coordination study time-current curves including the instrument transformer ratios, model numbers of the protective relays, and the relay settings associated with each breaker.

10. Comparison of short circuit duties of each bus to the interrupting capacity of the equipment protecting that bus.
11. All data that was used as input to the report. This data shall include cable impedances, source impedances, equipment ratings, etc.
12. Submitted report must be sealed by a Licensed Electrical Engineer registered in the State of Texas.

PART 3 EXECUTION

3.1 GENERAL

A. Provide short circuit, coordination, and arc flash hazard studies on the electrical power distribution system, as specified. Each study shall be performed in accordance with IEEE Standards 141, 242, and 1584. Each study shall be performed using actual equipment data for all equipment. Each coordination study shall use the data from the manufacturer of protective devices.

B. Contractor to coordinate with Electric Utility to obtain utility system and protection information. This information shall be incorporated in the studies.

C. Contractor to coordinate with Generator Manufacturer to obtain generator system and protection information. This information shall be incorporated in the studies.

3.2 QUALIFICATIONS

A. Each report shall be performed by an electrical engineering or testing service that is regularly engaged in power system studies. A Professional Electrical Engineer, with proficiency in electrical engineering power studies, shall sign and seal the studies. The Professional Engineer shall be licensed to practice engineering in the State of Texas as an Electrical Engineer, with a minimum 5 years experience in system studies.

3.3 SOFTWARE

A. Final System Study model files shall be submitted electronically on USB drive.
   1. Shall include all supporting databases and objects employed in the study.

3.4 SHORT CIRCUIT STUDIES

A. The CONTRACTOR shall be responsible to obtain and verify all data needed to perform the studies.

B. As a minimum, each short circuit study shall include the following:
   1. One-Line Diagram:
      a. Location and function of each protective device in the system, such as relays, direct acting trips, fuses, etc.
      b. Type designation, current rating, range or adjustment, manufacturer's style and catalog number for all protective devices.
      c. Power, voltage ratings, impedance, primary and secondary connections of all transformers.
      d. Type, manufacturer, and ratio of all instrument transformers energizing each relay.

e. Nameplate ratings of all motors and generators with their subtransient reactances. Transient reactances of synchronous motors and generators and synchronous reactances of all generators.
f. Sources of short circuit currents such as utility ties, generators, synchronous motors, and induction motors.
g. All significant circuit elements such as transformers, cables, breakers, fuses, reactors, etc.
h. Emergency as well as normal switch conditions.
i. The time-current setting of existing adjustable relays and direct acting trips, if applicable.

2. Impedance Diagram:
   a. Available MVA or impedance from the utility company
   b. Local generated capacity impedance
   c. Bus impedance
   d. Transformer and/or reactor impedances
   e. Cable impedances
   f. Equipment impedances
   g. System voltages
   h. Ground scheme (resistance grounding, solid grounding, or no grounding)
3. Calculations:
   a. Determine the paths and situations where short circuit currents are the greatest. Assume bolted faults and calculate the 3-phase and line-to-ground short circuits of each case.
   b. Calculate the maximum and minimum fault currents.

3.5 COORDINATION STUDY

A. As a minimum, the coordination study for the power distribution system shall include the following on 5-cycle, log-log graph paper.
   1. Time-current curves for each protective relay or fuse showing graphically that the settings will provide protection and selectivity within industry standards. Each curve shall be identified, and the tap and time dial settings shall be specified.
   2. Time-current curves for each device shall be positioned to provide for maximum selectivity to minimize system disturbances during fault clearing. Where selectivity cannot be achieved, the ENGINEER shall be notified as to the cause.
   3. Time-current curves and points for cable and equipment damage.
   4. Circuit interrupting device operating and interrupting times.
   5. Indicated maximum fault values on the graph.
   6. Sketch of bus and breaker arrangement.

3.6 ARC FLASH HAZARD STUDY

A. Colored labels shall be provided that meet the requirements of NFPA 70E (2021 Edition) and shall therefore contain at a minimum:
   1. Arc Flash Boundary
   2. Available Incident Energy
   3. Working Distance
   4. Minimum Arc Rating of Clothing
   5. Nominal System Voltage

B. All panelboards, MCC sections, Auto Dialer Panel and other control panels shall be provided with Arc Flash Hazard labels even if they are exempt from NFPA 70E requirements.

END OF SECTION

SECTION 16421
SOFT START MOTOR CONTROLLERS

PART 1 GENERAL

1.1 SCOPE OF WORK

A. This section provides specification requirements for solid state soft start devices packaged as a complete motor control unit or herein identified as soft start controller units for use with NEMA B design AC motors.

B. Soft starters shall only be installed at the facility.

C. The solid state soft start controller unit manufacturer shall furnish, field test, adjust and certify all installed soft start controller units for satisfactory operation.

D. Any exceptions/deviations to this specification shall be indicated in writing and submitted with the quotation.

1.2 SUBMITTALS

A. Submit with the delivery of the Motor Controller an Installation and Maintenance Manual and one (1) copy of the manufacturer's drawings for each unit furnished.

1.3 REGULATORY REQUIREMENTS

A. ANSI/NFPA 70 - National Electrical Code

B. NEMA ISC 1, Industrial Control Systems: General Requirements

C. NEMA ISC 2, Industrial Control Systems: Contactors and Overload Relays, rated not more that 2000 Volts AC or 750 Volts DC

D. NEMA ICS 6, Industrial Control Systems: Enclosures

E. UL 508 – UL Standard for Safety Industrial Control Equipment

F. UL 845 – UL Standard for Safety for Motor Control Centers

1.4 WARRANTY

A. The soft start controller unit shall be warranted to be free from defects in materials and workmanship for a period of twenty-four (24) months from date of official acceptance of the project by the owner.

1.5 QUALITY ASSURANCE

A. The soft start controller unit and all selected catalog options shall be UL listed according to Motor Control Center Equipment Specification UL 845. A UL label shall be attached inside each soft start controller unit as verification.

B. The soft start controller unit shall be designed, constructed and tested in accordance with NEMA & NEC standards.

C. All soft start controllers and factory-supplied options shall be completely tested for successful operation before shipment. Documentation shall be furnished with all submittals.

PART 2 PRODUCTS

2.1 MANUFACTURER

A. Use Benshaw Model: RB2 with MX2 controls, Heavy duty type (500% rated amps for 30 seconds). 125% rated amps continuously, with integrated NEMA rated by-pass contactor. Rated at an ambient temperature of 50°C, without derating. Or equal from below manufacturers:
   1. Square D
   2. Siemens
   3. General Electric
   4. Eaton

B. No “equal” from other manufacturers will be accepted.

2.2 GENERAL DESCRIPTION

A. Starter shall include the following components:
   1. Control panel:
      a. Digital alphanumeric door mounted display panel
      b. Digital control keypad to program controller and select parameters to view
   2. Display functions and codes
      a. Display basic functions to include starter status functions, motor status functions, and fault status functions.
      b. Display running codes
      c. Display error codes
   3. Terminal strips:
      a. Terminal strip for control power input
      b. Terminal output strip for auxiliary relays
      c. Terminal input strip: e.g. Start; Stop (Reset)
   4. Molded case circuit breaker for disconnecting means and emergency shunt trip.
   5. Output Relays:
      a. Three (3) form A programmable output relays, minimum. One relay for Soft Starter trip, one for run status and one for the motor overload. Each relay shall be single pole, double throw type.

b. NEMA B300 rated

B. The soft starter shall utilize an SCR bridge consisting of at least two SCR's per phase.

C. The soft starter shall be controlled by a microprocessor that continuously monitors the current and controls the phasing of the SCR's.

D. The soft starter shall have integrated motor overload protection.

E. A by-pass contactor shall be integral part of the soft starter, and all protective features and control options shall be available even when the by-pass contactor is engaged.

2.3 CONSTRUCTION

A. Units shall be of modular construction so that it is possible to readily interchange units of the same size without modifications to the motor control structure.

B. All conducting parts on the line side of the unit disconnect shall be isolated to prevent accidental contact with those parts.

C. Provisions shall be provided for locking the enclosure with owner's padlock.

D. A by-pass contactor shall be supplied in each soft start controller unit to reduce temperature rise within the unit and enclosure. The by-pass contactor shall be rated to carry the motor full load current during steady state after full voltage has been applied to the motor by the soft start. The by-pass contactor shall be an integral part of the soft starter device.

2.4 MOTOR DATA

A. Program controller for current design to operate the following AC induction motor:
   1. Motor horsepower: As indicated on the contract drawings.
   2. Motor full load ampere: As indicated on the contract drawings.
   3. Motor rpm: As indicated in Division 11 specifications.
   4. Motor voltage: 460V
   5. Motor service factor: 1.15

2.5 ENVIRONMENTAL RATINGS

A. The soft start controller unit shall be housed in the pump control panel.

B. The soft start controller unit shall be designed to operate while mounted in an enclosure with an ambient temperature from 15°F to 122°F (50°C) without derating.

C. The storage temperature range shall be -13°F to 158°F.

D. The maximum relative humidity shall be 95%, non-condensing.

E. The soft start controller unit shall be rated to operate at altitudes less than or equal to 3,300 ft.

2.6 ELECTRICAL RATINGS

A. The soft start controller unit shall be designed to operate from an input voltage between –10% and +10% of nominal voltage rating.

B. The soft start controller unit shall operate at 60Hz with a tolerance of + / - 5%.

C. The soft start controller shall be capable of supplying starting current of 500% of rated full load current, for minimum of 30 seconds.

D. The SCR's shall have a minimum repetitive peak inverse voltage (P.I.V) rating of 1800 Vac. Lower rated SCR's with MOV protection are not acceptable.

2.7 PROTECTION

A. A microprocessor-based thermal protection system shall be included which calculates the temperature-rise of the motor and soft starter and provides:
   1. 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.
   2. A motor overload fault will stop the motor if the windings have exceeded 140% of temperature-rise.
   3. An electronic circuit with a time-constant adjustable to the motor's thermal cooling time-constant ensuring the memorization of the thermal state even if power is removed from the soft starter.

B. The soft starter shall provide line and motor phase loss, phase reversal, application, stall, and jam protection. Underload condition shall not trip the motor for this application, but can generate a local alarm at the soft starter display.

C. The integral protective features shall be active even when the shorting contactor is used to bypass the SCRs during steady state operation. Shunt trip coil to trip disconnect in the event of a soft starter fault condition including a shorted SCR.

D. The integral protective features shall monitor, alarm and trip, the motor based on the motor winding and bearing temperature reading.

2.8 ADJUSTMENTS & CONFIGURATIONS

A. Digital indication shall provide, as a minimum, the following conditions:
   1. Soft starter status – ready, starting/stopping, run
   2. Motor status – current, torque, power factor, elapsed time, power in Kw
   3. Fault status – Motor thermal overload, soft starter thermal fault, loss of line or motor phase, line frequency fault, low line voltage fault, locked rotor fault, motor

underload, maximum start time exceeded, external fault, serial communication fault, line phase reversal fault, motor overcurrent fault.

B. Output relays shall be programmed to provide the following status indications:
   1. One Form A (N.O.) minimum for indication of fault and be failsafe type.
   2. One Form A (N.O.) for motor run indication.
   3. One Form A (N.O.) assignable to one of the following functions: motor thermal alarm, motor current level alarm, and motor underload alarm.

C. Additional inputs and outputs shall be available to provide the following status indications:
   1. Two assignable control inputs for the following functions: soft stop, pump control, kick start, linear ramp, dual motor or remote control

D. Relay and I/O functions listed above must be isolated with respect to common.

E. All programming/configuration devices, display units, and field control wiring terminals shall be accessible on the front of the control module. Circuit boards or electrical power devices shall not be exposed during routine adjustments.

2.9 CONTROL OPTIONS

A. All control circuitry shall be operated at 120 Vac, 60 Hz.

2.10 CONTROL CHARACTERISTICS

A. Starting:
   1. (Full load) Motor current: 40 to 100 % rated starter current
   2. Current limit: 125 % motor full load current
   3. Linear (torque-controlled) acceleration ramp time: adjustable 0 to 60 seconds, preset to 15 seconds.

B. Stopping
   1. Coasting: Power removed from motor with no soft stop
   2. Brake time by ramp: Soft stop, 1 to 60 seconds, adjustable, independent of starting ramp. Preset to 15 seconds decelerating ramp.

PART 3 EXECUTION

3.1 INSPECTION

A. Verify that the location is ready to receive work and the dimensions are as indicated.
B. Do not install the soft start controller unit until the enclosure environment can be maintained within the service conditions required by the manufacturer.

3.2 PROTECTION

A. Before and during the installation, the soft start controller unit shall be protected from site contaminants.

3.3 INSTALLATION

A. Installation shall be in compliance with manufacturer's instructions, drawings and recommendations.

B. The soft start controller unit manufacturer shall provide a factory certified technical representative to supervise the contractor's installation, programming, testing and start-up of the soft start controller unit(s) furnished under this specification.

C. A standard wiring diagram shall be included in the Installation and Maintenance Manual for making the appropriate electrical connections.

3.4 TRAINING

A. A one-half day, on-site training course shall be provided by a representative of the soft start controller unit manufacturer for plant and/or maintenance personnel.

END OF SECTION

SECTION 16451
GROUNDING

PART 1 GENERAL

1.1 SUBMITTALS

A. Shop Drawings:

1. Product Data:

a. Exothermic weld connectors
b. Mechanical connectors
c. Compression connectors
d. Ground Rods
e. Surge Protective Device

1.2 UL COMPLIANCE

A. Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

1.3 GROUNDING SYSTEM

A. The grounding system is a solidly grounded neutral system that is multigrounded. The grounding electrode is the grounding rings formed by the conductors encircling the equipment and/or structures.

PART 2 PRODUCTS

2.1 GROUND RODS

A. Located as shown on the grounding site plan.

B. Material: Copper Bonded.

C. Size: 3/4” x 10’

D. Ground Enhancement Material (GEM) backfill, if required.

E. Manufacturers: Erico, Inc.; ground rods and GEM backfill.

2.2 GROUND CONDUCTORS

A. Conductor size as shown on the grounding site plan.

B. As specified in Section 16120, CONDUCTORS.

2.3 CONNECTORS

A. Exothermic Weld Type:

1. Outdoor Weld: Suitable for exposure to elements or direct burial.
2. Indoor Weld: Utilize low-smoke, low-emission process.
3. Manufacturers:

a. Erico Products, Inc.; Cadweld and Cadweld Exolon

b. Thermoweld

B. Below Grade Compression Type:
1. Irreversible high strength compression.
2. Pure wrought copper extrusion.
3. Barrels prefilled with oxide-inhibiting and antiseizing compound and sealed.
4. Manufacturers:
a. Burndy Corp, hyground compression system

C. Above Grade Compression Type for Equipment Ground Connection:
1. Single indentation for conductors 6 AWG and smaller.
2. Double indentation with extended barrel for conductors 4 AWG and larger.
3. Barrels prefilled with oxide-inhibiting and antiseizing compound and sealed. Specifically listed four ground connections
4. All mechanical hardware, nuts, bolts and washers shall be high strength copper alloy.
5. Manufacturers:
a. Burndy Corp

2.4 SURGE PROTECTIVE DEVICE (MAIN FUSED DISCONNECT SWITCH)

A. IEE Exposure Category C.

B. Install with lead lengths not greater than manufacturer requirements.

C. Manufacturers:
1. Eaton Model SPD 250 480Y 3 Q
2. External mounted
3. Breaker disconnect
4. NEMA 4X 304 Stainless Steel Enclosure

2.5 SURGE PROTECTIVE DEVICE (MINI POWER CENTER)

A. UL 1449 3rd Edition.

B. IEE Exposure Category C.

C. Install with lead lengths not greater than manufacturer requirements.

D. Install on secondary side of transformer.

E. Manufacturers:
1. Eaton Model SPD 200 240S 3 Q
2. External mounted
3. Breaker disconnect
4. NEMA 4X 304 Stainless Steel Enclosure

2.6 SURGE PROTECTIVE DEVICE (PUMP CONTROL PANEL)

A. UL 1449 3rd Edition.

B. IEE Exposure Category C.

C. Install with lead lengths not greater than manufacturer requirements.

D. Manufacturers:
   1. Eaton Model SPD 200 480Y 3 Q
   2. Breaker disconnect
   3. NEMA 1 Enclosure

PART 3 EXECUTION

3.01 GENERAL

A. Grounding shall be in compliance with NEC Article 250, NFPA 70 and ANSI C2.

B. Neutral to ground connections on the load side of the service entrance equipment shall be made only as permitted per the NFPA 70 in order to avoid parallel paths.

C. Ground each separately derived system neutral in accordance with NEC 250-30. All connections will be connected to the grounding grid.

D. Ground elements of the electrical rack as shown on Contract Drawings for dissipation of lightning energy into the earth.

E. Bond together system neutrals, service equipment enclosures, exposed noncurrent-carrying metal parts of electrical equipment, metal raceways, ground conductor in raceways and cables, receptacle ground connections, and metal piping systems.

F. Surge Protective Devices shall be installed in locations as shown on the Contract Drawings.

G. Shielded Instrumentation Cables:

   1. Expose shield minimum 1 inch at termination to field instrument and apply heat shrink tube.

   2. Do not ground instrumentation cable shield at more than one point.

H. Ground grid conductors to be installed not less than 30 inches deep.

I. Contractor must pay close attention to NEC Article 250 to avoid the creation of parallel paths to ground

3.02 WIRE CONNECTIONS

A. Ground Conductors: Install in conduit containing low voltage power conductors and control circuits above 50 volts.

B. Nonmetallic Raceways and Flexible Tubing: Install an equipment-grounding conductor connected at both ends to noncurrent carrying grounding bus.

C. Connect ground conductors to raceway grounding bushings.

D. Extend and connect ground conductors to ground bus in all equipment containing a ground bus.

E. Connect enclosure of equipment containing ground bus to that bus.

F. Bolt connections to equipment ground bus.

G. Bond grounding conductors to metallic enclosures at each end, and to intermediate metallic enclosures.

H. Junction Boxes: Furnish materials and connect to equipment grounding system with grounding clips mounted directly on box, or with 3/8-inch machine screws.

3.03 MOTOR GROUNDING

A. Motor frame shall be connected to the ground grid as indicated on the grounding site plan.

B. Nonmetallic Raceways and Flexible Tubing: Install an equipment-grounding conductor connected at both ends to noncurrent carrying grounding bus.

C. Motors Less Than 10 hp: Furnish compression, spade-type terminal connected to conduit box mounting screw.

D. Motors 10 hp and above: Tap motor frame or equipment housing; furnish compression, one-hole, lug type terminal connected with minimum 5/16-inch brass threaded stud with bolt and washer.

E. Circuits 20 Amps or above: Tap motor frame or equipment housing; install solderless terminal with minimum 5/16-inch diameter bolt.

3.04 GROUND RODS

A. Install ground rod full length with conductor connection at upper end. The ground rod shall be driven into undisturbed earth.

B. If soil conditions prevent driving the ground rod to full length, installation shall by accomplished by augering a 3” diameter or larger hole and backfilling with compacted ground enhancement material.

C. Install top of rod 6 inches below finished grade, unless otherwise shown.

3.05 CONNECTIONS

A. General:

1. Above Grade Connections: Use either exothermic weld, mechanical, or compression-type connectors.

2. Below Grade Connections: Install exothermic weld or compression type connectors.
    a. Remove paint, dirt, or other surface coverings at connection points to allow good metal-to-metal contact.
    b. Notify OWNER prior to backfilling ground connections.

B. Exothermic Weld Type:

1. Wire brush or file contact point to bare metal surface.
2. Use welding cartridges and molds in accordance with manufacturer's recommendations.
3. Do not use badly worn molds.
4. Mold to be completely filled with metal when making welds.
5. After completed welds have cooled, brush slag from weld area and thoroughly clean joint.

C. Compression Type:

1. Install in accordance with connector manufacturer's recommendations.
2. Install connectors of proper size for grounding conductors and ground rods specified.
   Install using connector manufacturer's compression tool having proper sized dies.

D. Mechanical Type:

1. Apply homogeneous blend of colloidal copper and rust and corrosion inhibitor before making connection.
2. Install in accordance with connector manufacturer's recommendations.
3. Do not conceal mechanical connections.

3.06 METAL STRUCTURE GROUNDING

A. Ground metal sheathing and exposed metal vertical structural elements to grounding system.

B. Bond electrical equipment supported by metal platforms to the platforms.

C. Provide electrical contact between metal frames and railings supporting pushbutton stations, receptacles, and instrument cabinets, and raceways carrying circuits to these devices.

3.07 HANDHOLE AND MANHOLE GROUNDING

A. Install one ground electrode inside each where shown on drawing.

B. Ground Electrode Floor Protrusion: 4 to 6 inches above floor.

C. Make connections of grounding conductors fully visible and accessible.

D. Connect all noncurrent-carrying metal parts, and any metallic raceway grounding bushings to ground electrode conductor with No. 6 AWG copper conductor.

3.08 TRANSFORMER GROUNDING

A. Bond neutrals of transformers to grounding grid.

3.07 SURGE PROTECTION EQUIPMENT GROUNDING

A. Connect ground terminals to equipment ground bus.

END OF SECTION

SECTION 16463
MINI-POWER CENTERS

PART 1 GENERAL

1.1 SCOPE

A. The CONTRACTOR shall furnish and install single-phase 60 Hz general purpose individually rack mounted mini-power center of the two-winding type, self-cooled, as specified herein, and as shown on the contract drawings.

1.2 REFERENCES

A. The mini-power center and all components shall be designed, manufactured and tested in accordance with the latest applicable standards of ANSI and NEMA.

1.3 SUBMITTALS

A. The following information shall be included:
1. Dimension drawing and weight.
2. Technical certification sheet.
3. Conduit entry/exit locations.
4. Transformer ratings including:
    a. kVA
    b. Primary and secondary Voltage
    c. Taps
    d. Primary and secondary continuous current
    e. Basic impulse rating
    f. Impedance
    g. Insulation class and temperature rise
    h. Sound level
5. Component ratings including:
    a. Voltage
    b. Continuous current
    c. Interrupting Ratings
6. Cable terminal sizes
7. Product data sheets

1.4 OPERATIONS AND MAINTENANCE MANUALS

A. The following information shall be submitted for record purposes:
1. Final (as-built) drawings and information for items listed in Paragraph 1.04, and shall incorporate all changes made during the manufacturing process
2. Connection diagrams
3. Installation information

1.5 QUALIFICATIONS

A. The manufacturer of the assembly shall be the manufacturer of the secondary distribution equipment.

B. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.

C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.6 UL COMPLIANCE

A. The assembly and all components shall be UL listed and bear the UL label.

1.7 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

1.8 FIELD MEASUREMENTS

A. Measure primary and secondary voltages and make appropriate tap adjustments.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Square D
   1. Mini Power Zone Model number: MPZB15S4OFSS

B. Siemens
   1. Sentron Power Center 1LPC015SS

2.2 RATINGS

A. kVA and voltage ratings shall be as shown on the drawings.

B. Units shall be designed for continuous operation at rated kVA, for 24 hours a day, 365 days a year operation, with normal life expectancy as defined in ANSI C57.96

C. Transformer sound levels shall not exceed NEMA ST-20 levels for self-cooled ratings.

2.3 CONSTRUCTION

A. The mini-power center shall include a primary main breaker, an encapsulated dry-type transformer and a panelboard with secondary main breaker. Reference section 16050, Basic Electrical Materials and Methods for panelboard requirements.

B. Primary main, secondary main and feeder breakers shall be enclosed with a padlockable hinged door.

C. Insulation Systems:
   1. Transformers shall be insulated as follows:

a. 2 kVA and below: 150°C insulation system based upon 80°C rise.
b. 3 to 15 kVA: 185°C insulation system based upon 115°C rise.
c. 15 kVA and above: 220°C insulation system based upon 150°C rise.

2. Required performance shall be obtained without exceeding the above indicated temperature rise in a 40°C maximum ambient.
3. All insulation materials shall be flame-retardant and shall not support combustion as defined in ASTM Standard Test Method D635.

D. Core and Coil Assemblies.

1. Transformer core shall be constructed with high-grade, non-aging, grain-oriented silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Maximum magnetic flux densities shall be substantially below the saturation point. The transformer core volume shall allow efficient transformer operation at 10% above the nominal tap voltage. The core laminations shall be tightly clamped and compressed. Coils shall be wound of electrical grade aluminum with continuous wound construction.
2. The core and coil assembly shall be impregnated with non-hydroscopic, thermosetting varnish and cured to reduce hot spots and seal out moisture. The assembly shall be installed on vibration-absorbing pads. Taps shall be two (2) steps above and two (2) steps below nominal voltage in 2.5% increments.
3. Ventilated transformers with wye-connected secondary shall have the neutral brought out to an XO terminal grounded to the transformer enclosure with a flexible copper ground strap.

2.4 BUS

A. Secondary bus shall be copper.

2.5 WIRING/TERMINATIONS

A. All interconnecting wiring between the primary breaker and transformer, secondary main breaker and transformer and distribution section shall be factory installed.

B. All transformers shall be equipped with a wiring compartment suitable for conduit entry and large enough to allow convenient wiring.

2.6 MAIN DEVICES

A. The mini-power center shall include a primary main breaker with an interrupting rating per power system study results at 277/480 volts; and a secondary main breaker with an interrupting rating of 10kA at 120/240 volts, and a panelboard.

2.7 FEEDER DEVICES

A. The secondary distribution section shall accommodate bolt-on breakers with 10 kA interrupting capacity.

2.8 ENCLOSURE

A. The enclosure shall be made of heavy-gauge steel. The maximum temperature of the enclosure shall not exceed 90°C. The core of the transformer shall be grounded to the enclosure with flexible ground strap.

B. The enclosure shall be NEMA 3R - 304 stainless steel, with lifting eyes.

2.9 NAMEPLATE

A. Diagrammatic nameplate to include all rating data and wiring diagram with connection point identification.

2.10 FINISH

A. Enclosures shall be furnished with manufacturer's standard finish, ANSI 61 light gray color.

PART 3 EXECUTION

3.1 FACTORY TESTING

A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.
   1. Ratio tests at the rated voltage connection and at all tap connections.
   2. Polarity and phase relation tests on the rated voltage connection.
   3. Applied potential tests.
   4. Induced potential test.
   5. No-load and excitation current at rated voltage on the rated voltage connection.

3.2 INSTALLATION

A. The CONTRACTOR shall install all equipment per the manufacturer's recommendations and the contract drawings.

B. Provide flexible conduit for external connections to the transformer enclosure.

3.3 FIELD QUALITY CONTROL

A. In accordance with Section 16950, Electrical Testing.

3.4 FIELD ADJUSTMENTS

A. Adjust taps to deliver appropriate secondary voltage.

END OF SECTION

SECTION 16501
AUTOMATIC TRANSFER SWITCHES

PART 1 GENERAL

1.1 SCOPE

Furnish and install an automatic transfer switch (ATS) with four (4) wire grounded neutral, 200A, 480V and withstand current ratings of 22,000A. Automatic transfer shall consist of an inherently double throw power transfer switch unit and a microprocessor controller, interconnected to provide complete automatic operation. Transfer switch and control panel shall be the product of the same manufacturer. Switch shall be delayed transition type.

1.2 ACCEPTABLE MANUFACTURERS

A. Asco

B. Russelectric

C. Zenith

D. Onan

E. Generac

F. Cummins

G. Kohler

H. Caterpillar

1.3 CODES AND STANDARDS

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

A. UL 1008 - Standard for Automatic Transfer Switches

B. NFPA 70 - National Electrical Code

C. NFPA 110 - Emergency and Standby Power Systems

D. IEEE Standard 446 - IEEE Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications

E. NEMA Standard ICS10-1993 (formerly ICS2-447) - AC Automatic Transfer Switches.

F. NEC Articles 700, 701, 702

1.4 SUBMITTALS

A. Shop Drawings

B. O&M Manuals

PART 2 PRODUCTS

2.1 MECHANICALLY HELD TRANSFER SWITCH

A. The transfer switch unit shall be electrically operated and mechanically held. The electrical operator shall be a single-solenoid mechanism, momentarily energized. Main operators which include overcurrent disconnect devices will not be accepted. The switch shall be mechanically interlocked to ensure only one of two possible positions, normal or emergency.

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

C. All main contacts shall be silver composition. Switches rated 600 amperes and above shall have segmented, blow-on construction for high withstand current capability and be protected by separate arcing contacts.

D. Inspection of all contacts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. A manual operating handle shall be provided for maintenance purposes. The handle shall permit the operator to manually stop the contacts at any point throughout their entire travel to inspect and service the contacts when required.

E. Designs utilizing components of molded-case circuit breakers, contactors, or parts thereof which are not intended for continuous duty, repetitive switching or transfer between two active power sources are not acceptable.

F. Where neutral conductors must be switched, the ATS shall be provided with fully-rated neutral transfer contacts.

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

2.2 MICROPROCESSOR CONTROLLER WITH MEMBRANE INTERFACE PANEL

A. The controller shall direct the operation of the transfer switch. The controller's sensing and logic shall be controlled by a built-in microprocessor for maximum reliability, minimum maintenance, and inherent serial communications capability. The controller shall be connected to the transfer switch by an interconnecting wiring harness. The harness shall include a keyed disconnect plug to enable the controller to be disconnected from the transfer switch for routine maintenance.

B. The controller shall be enclosed with a protective cover and be mounted separate from the transfer switch unit for safety and ease of maintenance. Sensing and control logic shall be provided on printed circuit boards. Interfacing relays shall be industrial grade plug-in type with dust covers.

C. The panel shall be capable of operating over a temperature range of –20° to +60°C.

D. The controller shall meet or exceed the requirements for Electromagnetic Compatibility (EMC) as follows:

1. ANSI C37.90A/IEEE 472 Voltage Surge Test
2. NEMA ICS – 109.21 Impulse Withstand Test
3. IEC801-2 Electrostatic discharge (ESD) immunity
4. IEC 801 – 3 Radiated electromagnetic field immunity
5. IEC 801 – 4 Electrical fast transient (EFT) immunity

2.3 ENCLOSURE

A. The ATS shall be furnished in a NEMA type 4X-316 stainless steel enclosure.

B. Provide strip heater with thermostat for NEMA Type 4X-316 stainless steel enclosure requirements.

C. Enclosures shall be constructed of 16-gauge steel with powder coat over phosphatized surfaces, unless otherwise specified to be stainless steel for corrosion resistance.

D. Enclosures shall have a single swing panel front with continuous hinge, and shall have provision for padlocking. Hinge pin and panel clamps shall be stainless steel. Hinged door shall be 16-guage galvanized steel, unless otherwise specified to be stainless steel. Door shall be vandal-resistant.

E. Enclosures shall have an interior back panel. No screws shall penetrate the enclosure. The interior surfaces shall be white baked enamel finish. All control panels and devices shall be on a plane surface providing accessibility for maintenance without removing components.

F. Provide an internal, steel, hinged swing-out panel with white baked enamel finish for mounting devices such as pushbuttons, selector switches, control switches, and indicating lights. All devices shall be mounted inside the control cabinets.

G. Controller shall be flush-mounted display with LED indicators for switch position and source acceptability. It shall also include test and time delay bypass switches.

2.4 VOLTAGE AND FREQUENCY SENSING

A. The voltage of each phase of the normal source shall be monitored, with pickup adjustable to 95% of nominal and dropout adjustable from 70% to 90% of pickup setting.

B. Single-phase voltage and frequency sensing of the emergency source shall be provided.

2.5 TIME DELAYS

A. An adjustable time delay shall be provided to override momentary normal source outages and delay all transfer and engine starting signals.

B. An adjustable time delay shall be provided on transfer to emergency, adjustable from 0 to 5 minutes for controlled timing of transfer of loads to emergency.

C. A generator stabilization time delay shall be provided after transfer to emergency.

D. An adjustable time delay shall be provided on retransfer to normal, adjustable to 30 minutes. Time delay shall be automatically bypassed if emergency source fails and normal source is acceptable.

E. A 5-minute cooldown time delay shall be provided on shutdown of engine generator.

F. All adjustable time delays shall be field adjustable without the use of special tools.

2.6 ADDITIONAL FEATURES

A. A set of contacts rated 5 amps, 32 VDC shall be provided for a low-voltage engine start signal. The start signal shall prevent dry cranking of the engine by requiring the generator set to reach proper output, and run for the duration of the cool down setting, regardless of whether the normal source restores before the load is transferred.

B. A push-button type test switch shall be provided to simulate a normal source failure.

C. A push-button type switch to bypass the time delay on transfer to emergency, the engine exerciser period on the retransfer to normal time delay whichever delay is active at the time the push-button is activated.

D. Terminals shall be provided for a remote contact which opens to signal the ATS to transfer to emergency and for remote contacts which open to inhibit transfer to emergency and/or retransfer to normal.

E. Auxiliary contacts, rated 10 amps, 250 VAC shall be provided consisting of one contact, closed when the ATS is connected to the normal source and one

contact, closed, when the ATS is connected to the emergency source.

F. Auxiliary contacts, rated 10 amps, 250 VAC shall be provided consisting of one contact, closed when healthy normal service is detected and one contact, closed, when healthy emergency service is detected.

G. Indicating lights shall be provided, one to indicate when the ATS is connected to the normal source (green) and one to indicate when the ATS is connected to the emergency source (red). Also provide indicating lights for both normal and emergency source availability.

H. Terminals shall be provided to indicate actual availability of the normal and emergency sources, as determined by the voltage sensing pickup and dropout settings for each source.

I. Engine Exerciser - An engine generator exercising timer shall be provided, including a selector switch to select exercise with or without load transfer.

J. Inphase Monitor - An Inphase monitor shall be inherently built into the controls. The monitor shall control transfer so that motor load inrush currents do not exceed normal starting currents, and shall not require external control of power sources. The inphase monitor shall be specifically designed for and be the product of the ATS manufacturer.

K. Selective Load Disconnect - A double throw contact shall be provided to operate after a time delay, adjustable to 20 seconds prior to transfer and reset 0 to 20 seconds after transfer. This contact can be used to selectively disconnect specific load(s) when the transfer switch is transferred. Output contacts shall be rated 6 amps at 28 VDC or 120 VAC.

L. Programmable Engine Exerciser - A seven or fourteen day programmable engine exerciser with digital readout display. Shall include one form C contact for availability of normal and emergency sources. Include “with or without” load control switch for exerciser period. The exerciser shall be backed up by a permanent battery.

M. Enclosure Heater - A 125 watt enclosure heater with transformer and thermostat (adjustable from 30° to 140 ° F).

Withstand and Closing Ratings

N. The ATS shall be rated to close on and withstand the available rms symmetrical short circuit current at the ATS terminals with the type of overcurrent protection shown on the plans. WCR ATS ratings as be as follows when used with specific circuit breakers:

ATS Size	Withstand & Closing
30	22,000A
70 - 200	22,000A
230	22,000A
260 – 400	42,000A
600 – 1200	65,000A
1600 – 2000	85,000A
2600 – 3000	100,000A

PART 3 EXECUTION

3.1 TESTS AND CERTIFICATION

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

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

C. The ATS manufacturer shall be certified to ISO 9001: 2000 International Quality Standard and the manufacturer shall have third party certification verifying quality assurance in design/development, production, installation and servicing in accordance with ISO 9001: 2000.

3.2 SERVICE REPRESENTATION

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

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

C.

D. For ease of maintenance, the transfer switch nameplate shall include drawing numbers and serviceable part numbers.

END OF SECTION

SECTION 16600
STANDBY GENERATOR

PART 1 GENERAL

Owner has determined a requirement for a generator unit as part of its emergency management plan. In the event of a nFatural, or man-made, disaster where electric service is lost to the Owner's facililties for an extended period of time, the Owner will strive to maintain operation of the lift station. The task will be accomplished through the use of a standby generator. The generator shall be installed in an electrical configuration as shown on the electrical one-line diagram. At a minimum the generator shall be sized to accommodate the maximum load of the lift station facility as indicated in this specification.

1.1 SUBMITTALS

A. Shop Drawings:
   1. Generator
   2. Descriptive information, including materials and features.
   3. Subtransient Reactance - Nameplate data
   4. Additional rating information
   5. Enclosure type and mounting
   6. Dimension and total weight
   7. Conduit box dimension and usable volume
   8. Bearing type
   9. Bearing life
   10. Space heater voltage and watts
   11. Generator sound power level
   12. Generator sizing calculation report data (To conform to test parameters outlined in Part 3)

B. Testing Submittals Field performance test (as described in 3.01).

1.2 CERTIFICATION

A. Shall be generator set designed manufactured, tested and certified to relevant UL, NFPA and ISO standard.
   1. FCC Part 15 Subpart B
   2. ISO8528
   3. IEC61000
   4. UL508
   5. UL2200
   6. UL142
   7. Designed to compliance to NFPA70, NFPA99 and NFPA 110

1.3 SCOPE

A. This section covers requirement for Standby Generator:
   1. One diesel fueled, engine generator rated an estimated 100kW minimum (must also pass performance test in Part 3), wye-connected for use on a solidly grounded 480Vac system.
   2. A breaker with a rating of 200 A with protective devices and manual/electric control.
   3. An auxiliary load-banking breaker with a rating not less than the maximum operating current of the generator with protective devices and manual or electric control.
   4. Sound attenuated weather-protected enclosure.
      a. Sound levels should not exceed 78dB @ 7 meters (23 ft.).
   5. Engine Generator control and indication panel.
   6. Residential Exhaust Silencer.
   7. UL 142 Listed fuel storage system for minimum 48-hour operation at generator full load output in a dual wall sub-base fuel tank. Tank to be provided with leak alarm system.
   8. Install bollards around generator per IFC 312.2.
   9. Tank shall have overfill protection system with alarm and automatic shutoff.
   10. Vent pipe outlets shall be provided and be 12 feet above finished ground level.

1.4 SERVICE

A. The vendor or manufacturer shall have local service personnel available to service and/or maintain the supplied equipment. Local shall be defined as having personnel located within four hours land travel of the Owner Location.

1.5 CODES, PERMITS AND STANDARDS

A. All work shall be accomplished in accordance with applicable Federal, State, and Municipal safety, transportation and construction codes. Permits and licenses, where required, shall be obtained by the vendor at his expense. All electrical equipment and controls shall conform to current applicable standards of the following:
   1. American National Standards Institute (ANSI)
   2. American Society of Testing and Materials (ASTM)
   3. American Water Works Association (AWWA)
   4. Institute of Electrical and Electronic Engineers (IEEE)
   5. National Electrical Manufacturers Association (NEMA)
   6. National Fire Protection Association (NFPA)

1.6 RECORD DRAWING AND OPERATIONS AND MAINTENANCE MANUALS

A. The vendor shall furnish the Owner Operations and Maintenance Manuals for the completed product. These manuals shall be received by the Owner prior to, and

shall be a condition of, final acceptance of the product. The manuals shall contain:

1. All final manufacturers' "as-built" schematic drawings, internal wiring diagrams, interconnect wiring diagrams, and outline and assembly drawings.
2. Instruction books covering installation, operation, and maintenance of all major equipment, fuel storage treatment, relays, control devices, etc.
3. Test data and performance curves.
4. Complete renewal parts list showing all components identified to original manufacturer and ordering designation.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Cummins Power Generation

B. Generac Power Systems

C. Caterpillar

D. MTU (Rolls-Royce)

E. Kohler

2.2 REQUIREMENTS FOR ENGINE GENERATOR

A. Site Conditions

1. Location……Bexar County, Texas
2. Altitude……..1300 feet above msl
3. Temperature (min)……..15 F deg
4. Temperature (max)……...110 F deg
5. Humidity……50-100%
6. Voltage…….……480Vac
7. Phases…….……....3∅
8. Three Phase Connection……...…4-Wire grounded neutral
9. Frequency…….…….…….60 Hertz
10. Power Rating @ .8 Power Factor…..…….……..…… 100kW
11. Volt-Ampere Rating ……..…....125kVA 125^{0}C rise continuous
12. Type……..…..……Static Regulated Brushless
13. RPM…..……..…….……1800
14. Excitation…..……..…..…….Self Excited
15. Insulation…..…….…..….Class H w/ Tropicalization and Antiabrasion
16. Voltage Regulation……...….Less than ± 1.0%
17. Voltage Regulator……..…..……..……3∅ Sensing w/ Volts/Hertz
18. Voltage Gain……..……..Adjustable
19. Over Speed Capability…….……..……..150%

20. Total Harmonic Distortion……..……..……..Less than 5%

B. Engine
   1. Fuel…….……..…….……Diesel
   2. RPM……...……...1800
   3. Vibration……..…..……Linear Isolation; Engine, Generator and Base
   4. Exhaust Silencer. ……Residential Type Silencer
   5. Batteries…….…..……..HD, Lead Acid the ampere-hour capacity shall be sufficient for starting within the temperature range for the site.
   6. Battery Charger: Current Limiting w/ OL Protection, Voltmeter & Ammeter, It shall have an easily accessible terminal strip where external 120 Vac power may be connected to provide battery charging during engine generator storage.
   7. Alternator Heater and Block Heater: Rated at 240 Volts and controlled by manufacture's standard.

C. Control Panel
   1. Control Voltage…….…….24Vdc
   2. Control Start/Stop……..Automatic Transfer Switch
   3. Front.…….……..Electrical Dead Front
   4. Door.…….…….Lockable hinged Door
   5. Voltmeter……..……3-1/2 inch Dial, 2% Accuracy
   6. Ammeter….……3-1/2 inch Dial, 2% Accuracy
   7. Frequency Meter..……..3-1/2 inch Dial, 45-65 Hz Range
   8. Voltage Adjust…..…….……Manual, Rheostat
   9. Emergency Stop.……....PB w/ Red Mushroom Head, No Spring Return
   10. Cool Down.……..……..…..Automatic w/ Timer
   11. Run Time…….……..Elapsed Time Meter
   12. Coolant…….Coolant Temperature Gauge
   13. Lube Oil.…….Oil Pressure Gauge
   14. Shutdown Protection and LED Indication
   15. Auxillary Contacts:
      a. High Coolant Temperature
      b. Low Oil Pressure
      c. Overcrank
      d. Overspeed
      e. Low Fuel Alarm (Pressure)
      f. Run Indication
      g. Failure Indication
      h. Fuel Leak Alarm

D. Load Connection Provision.

   1. Circuit Breaker NEMA AB 200 Amp, Manual/Electric, w/ Thermal and

Magnetic Trip (must override motor start). The generator circuit breaker must be supplied with a shunt trip.

2. Electrical Protection
   a. Overvoltage
   b. Overcurrent
   c. Reverse Power

2. Terminal Box: NEMA 3R if located outside of weather protective enclosure, NEMA 1 otherwise.
3. Remote emergency stop switch located on exterior of generator meeting all requirements of 2023 NEC Article 445.19. It shall disable all prime mover start control circuits and initiate shutdown mechanism that requires a mechanical reset.

PART 3 FIELD PERFORMANCE TEST AND TRAINING

3.1 Performance Test

A. Field performance as described below will be the basis for final acceptance of the engine generator. The vendor shall supply all materials and labor to perform the testing in the presence of the Owner, or his authorized representative. The engine generator is shown to be an estimated 100 KW but the actual size may differ if the vendor can supply an engine generator capable of successfully passing the tests below . The contractor must provide, with the submittals, a sizing calculation report obtained from the manufacturer that indicates how the generator was sized.

B. Demonstrate that the engine generator will start and run with the following steps:

Step 1: One (1) 15kVA load on the transformer

Step 2: One (1) submersible 23 hp Code J soft start pump motor.

Step 3: One (1) submersible 23 hp Code J soft start pump motor

Step 4: One (1) submersible 23 hp Code J soft start pump motor

The maximum instantaneous voltage dip at the generator terminals shall not exceed 20% of system nominal voltage and frequency dip below 5% of rated frequency at any time. This test with all listed loads connected shall continue for two hours with monitoring to determine compliance with vendor-stated performance. The contractor is responsible for providing a generator that can pass this performance test. Generator can be load bank tested if full load testing of the facility is not feasible.

C. Training of the Owner's personnel and contractors shall be included as an integral part of the test. Additional training on operation of the unit and the function of each of the different control, metering and protection devices shall continue after

the actual load test. The vendor should assume a full day of testing and training and include such in his bid.

B. Warranty: Manufacturer shall include a minimum 2 year/400 hour run-time written warranty.

END OF SECTION

SECTION 16930
INSTRUMENTATION

PART 1 GENERAL

1.1 SCOPE

A. Contractor shall furnish, install, calibrate and test instrumentation for monitoring and control, for the following lift station process functions:

1. Level Controller
2. Submersible Level Transducer with weight
3. Level Float Switches

1.2 SUBMITTALS

A. Shop Drawings:

1. Bill of Materials
2. Catalog Cuts
3. Component Data Sheets

PART 2 PRODUCTS

2.1 GENERAL

A. All devices shall be Factory Mutual (FM) approved.
   1. Explosion Proof for Class I division 1 group B, C, and D.
   2. Dust-Ignition Proof for Class II and Class III, division 1, group E, F and G.
   3. Suitable for Indoor and Outdoor Hazardous locations.
   4. Factory Sealed.

B. Hardware:
   1. All hardware used for outdoor instrument mounting shall be Stainless Steel.

C. Instrument Stand
   1. 2-inch Schedule 80 Double Dipped Galvanized steel pipe.

D. Process Pipping:
   1. All tubing and fitting shall be made of 316 Stainless Steel.

2.2 LEVEL CONTROLLER

A. Level monitoring controller:

1. Local and remote indication

2. Non-contacting level instrument
3. Mounted in pump control panel

B. Ratings:
1. Relays: 4 Form A, 5 Amp, 250 Vac and 2 Form C, 5 Amp, 250 Vac
2. Power Supply: 110-120 Vac
3. Ambient Temperature: -5 to 122° F
4. Outputs: (2) 4-20 mA
5. Inputs: (1) analog, (2) digital
6. Transducer: Refer to 2.3.

C. Manufacturer:
1. Siemens HydroRanger LT 500 ; Model : 7ML6003-1AC20-1AA3

2.3 SUBMERSIBLE LEVEL TRANSDUCER

A. Ratings:
1. Output: 4-20 mA
2. Power supply: 13–30 V DC, two-wire system
3. Capacitive 316 Stainless Steel Sensor
4. Contractor shall add a 10 lb weight of 316 stainless steel bolted to instrument.
5. Range 20 psi (46.2 ft wc)
6. Cable: ETFE

B. Manufacturer: Mercoid Model PBLTX-20-60.

2.4 LEVEL FLOAT SWITCH
A. Shall be suitable for wastewater applications.
B. Shall have non-mercury construction.
C. Float control junction box must be located on top of the wet well and be made of PVC.
D. Maximum Applied Voltage: 250 Vac
E. Manufacturer:
1. Flygt ENM-10, or equal.

PART 3 EXECUTION

3.1 LEVEL CONTROLLER AND TRANSDUCER

A. Location to be approved by Owner.

B. Install transducer in accordance with manufacturer’s instructions and recommendations.

C. Controller shall be installed in a control panel as shown on Contract Drawings and in accordance with Section 16050, Paragraph 2.10.

D. Programming and set up of the controller shall be done following manufacturer's recommendation and instruction.

1. The Owner will determine the elevations that will activate the relays.

3.2 CONDUIT AND IDENTIFICATION

A. When the use of flexible conduit is required, a minimum of 18" shall be provided but the flexible conduit shall not exceed 36".

B. All Instrumentation runs shall be the full length of the conduit. No splices will be allowed.

C. The following nomenclature shall be used for identification:

1. tag # (0-10) for instrumentation info: tags, devices type and termination point
2. jb# (0-10) for junction box, power panel lighting panel and termination point
3. r# (0-10) for rack location and termination point
4. s# (0-10) for slot location and termination point
5. p# (0-10) for point location and termination point

3.3 TESTING

A. Full testing (loop check) shall be done on all instrumentation and all SCADA I/O points and will be witnessed by the owner.

B. A calibration sheet shall be supplied for all the instruments and at the time of any instrument test.

1. Analog device calibration sheet shall include the following:
   a. Time of calibration
   b. Date of calibration
   c. Name of the person performing the calibration
   d. Name of the witness, Owner
   e. Test equipment used and their calibration dates
   f. Device identification S/N, device name and tag number
   g. As found voltage reading
   h. As left voltage reading
   i. As found milliamp reading @ 0%, 25%, 50%, 75%, and 100%
   j. As left milliamp reading @ 0%, 25%, 50%, 75%, and 100%
   k. Calibration ranges

l. I/O points

2. I/O point data sheet for each I/O analog and discrete through SCADA
   a. Field point location
   b. Analog or Discrete
   c. Software point location
   d. Point function
   e. Time of verification
   f. Date of verification
   g. Name of the person verifying the point
   h. Name of the witness, Owner

END OF SECTION

SECTION 16950
ELECTRICAL TESTING

PART 1 GENERAL

1.1 SCOPE

A. Contractor will provide, and pay the cost of, electrical testing by an independent testing firm. This cost shall be included in the Contract Bid.

B. The Contractor shall immediately correct all deficiances discovered during testing by the independent firm.

1.2 REFERENCES

A. International Electrical Testing Association – Acceptance Testing Specifications (NETA-ATS), current version.

B. Related equipment specifications in all sections of Division 16.

1.3 SUBMITTALS

A. Administrative Submittals: Submit 30 days prior to performing inspections or tests:

1. Schedule for performing inspection and tests.
2. List references to be used for each test.
3. Sample copy of equipment and materials inspection form(s).
4. Sample copy of individual device test form.
5. Sample copy of individual system test form.

B. Quality Control Submittals: Submit within 15 days after completion of test:

1. Test or inspection reports and certificates for each electrical item tested.

C. Contract Closeout Submittals:

1. Operation and Maintenance Data:
   a. In accordance with Division 1.
   b. After test or inspection reports and certificates have been reviewed by OWNER and returned, insert a copy of each in operation and maintenance manual.

1.4 QUALITY ASSURANCE

A. Testing Firm Qualifications:

1. Corporately and financially independent organization functioning as an unbiased authority, for a minimum of 5 years.
2. Professionally independent of manufacturers, suppliers, and installers of electrical equipment and systems being tested.
3. Employer of engineers and technicians regularly engaged in testing and inspecting electrical equipment, installations, and systems.
4. Supervising technician having a minimum of 5 years testing experience on similar projects.
5. Full-time employed Texas Licensed Professional Engineer to provide comprehensive project report outlining services performed, results of such services, recommendations, actions taken, and opinions.

B. Test equipment shall have an operating accuracy equal to, or greater than, requirements established at NETA-ATS.

C. Test instrument calibration shall be in accordance with NETA-ATS.

1.5 SEQUENCE AND SCHEDULING

A. Perform inspection and electrical tests after equipment has been installed.

B. Perform tests with apparatus de-energized whenever feasible.

C. Inspection and electrical tests on energized equipment are to be:

1. Scheduled with OWNER prior to de-energization.
2. Minimized to avoid extended period of interruption to the operating plant equipment.

D. Notify OWNER at least 24 hours prior to performing tests on energized electrical equipment.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.1 GENERAL

A. Tests specified in this section are to be performed in accordance with the requirements of Section Division 1.

B. Tests and inspection shall establish that:

1. Electrical equipment is operational within industry and manufacturer’s tolerances.
2. Installation operates properly.

3. Equipment is suitable for energization.
4. Installation conforms to requirements of Contract Documents and NFPA 70, NFPA 70E, and ANSI C2.

C. Perform inspection and testing in accordance with NETA-ATS, industry standards, and manufacturer's recommendations.

D. Set, test, and calibrate protective relays, circuit breakers, and other applicable devices in accordance with standard values established by a short circuit and coordination study provided by CONTRACTOR.

E. Adjust mechanisms and moving parts for free mechanical movement.

F. Adjust adjustable relays and sensors to correspond to operating conditions, or as recommended by manufacturer.

G. Verify nameplate data for conformance to Contract Documents.

H. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench to manufacturer's recommendations, or as otherwise specified.

I. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

J. Provide proper lubrication of applicable moving parts.

K. Inform OWNER of working clearances not in accordance with NFPA 70.

3.2 DRY TYPE TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Compare equipment nameplate data with drawings and specifications.
2. Physical and insulator damage.
3. Proper winding connections.
4. Bolt torque level in accordance with NETA-ATS, Table 100.12, unless otherwise specified by manufacturer.
5. Defective wiring.
6. Proper operation of fans, indicators, and auxiliary devices.
7. Removal of shipping brackets, fixtures, or bracing.
8. Free and properly installed resilient mounts.
9. Cleanliness and improper blockage of ventilation passages.
10. Verify that tap-changer is set at correct ratio for rated output voltage under normal operation conditions.

11. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage for 1 minute in accordance with NETA-ATS, Table 100.5 for each:
      1) Winding-to-winding.
      2) Winding-to-ground.
   b. Results temperature corrected in accordance with NETA-ATS, Table 100.14.
   c. Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
   d. Insulation resistance test results to compare within 1 percent of adjacent windings.
2. Perform turns ratio tests at all tap positions. Turns ratio test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio.
3. Perform transformer winding resistance test.

3.3 LOW VOLTAGE CABLES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Inspect Each Individual Exposed Power Cable No. 4 and Larger for:
   a. Physical damage.
   b. Proper connections in accordance with single-line diagram.
   c. Cable bends not in conformance with manufacturer's minimum allowable bending radius where applicable.
   d. Color-coding conformance with specifications.
   e. Proper circuit identification.
2. Mechanical Connections For:
   a. Proper lug type for conductor material.
   b. Proper lug installation.
   c. Bolt torque level in accordance with NETA-ATS, Table 100.12, unless otherwise specified by manufacturer.
3. Shielded Instrumentation Cables For:
   a. Proper shield grounding.
   b. Proper terminations.
   c. Proper circuit identification.
4. Control Cables For:
   a. Proper termination.
   b. Proper circuit identification.
5. Cables Terminated Through Window Type CTs: Verify that neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests for Conductors No. 4 and Larger:

1. Insulation Resistance Tests:
   a. Utilize 1,000-volt dc megohmmeter for 600-volt insulated conductors.
   b. Test each conductor with respect to ground and to adjacent conductors per IEEE 118 procedures for 1 minute.
   c. Evaluate ohmic values by comparison with conductors of same length and type.
   d. Investigate values less than 50 megohms.
2. Continuity test by ohmmeter method to ensure proper cable connections.

3.4 SAFETY SWITCHES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Compare equipment nameplate data with drawings and specifications.
2. Proper blade pressure and alignment.
3. Proper operation of switch operating handle.
4. Adequate mechanical support for each fuse.
5. Proper contact-to-contact tightness between fuse clip and fuse.
6. Cable connection bolt torque level in accordance with NETA-ATS, Table 100.12.
7. Proper phase barrier material and installation.
8. Verify that fuse sizes and types correspond to one-line diagram.
9. Perform mechanical operational test and verify mechanical interlocking system operation and sequencing.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA-ATS, Table 100.1.
   b. Phase-to-phase and phase-to-ground for 1 minute on each pole.
   c. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Contact Resistance Tests:
   a. Contact resistance in microhms across each switch blade and fuse holder.
   b. Investigate deviation of 50 percent or more from adjacent poles or similar switches.

3.5 MOLDED AND INSULATED CASE CIRCUIT BREAKERS

A. General: Inspection and testing limited to circuit breakers rated 100 amperes and larger and to motor circuit protector breakers rated 50 amperes and larger.

B. Visual and Mechanical Inspection:

1. Proper mounting.
2. Proper conductor size.
3. Feeder designation according to nameplate and one-line diagram.
4. Cracked casings.
5. Connection bolt torque level in accordance with NETA-ATS, Table 100.12.
6. Operate breaker to verify smooth operation.
7. Compare frame size and trip setting with circuit breaker schedules or one-line diagram.
8. Verify that terminals are suitable for 75°C rated insulated conductors.

C. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA-ATS, Table 100.1.
   b. For 1 minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole.
   c. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Contact Resistance Tests:
   a. Between the line and load stab of closed contact resistance in microhms across each pole.
   b. Investigate deviation of 25 percent or more from adjacent poles and similar breakers.
3. Determine long-time pickup and delay by primary current injection.
4. Determine short-time pickup and delay by primary current injection.
5. Determine ground-fault pickup and time delay by primary current injection.
6. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data.
7. Verify correct operation of auxiliary feature such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function, and trip unit battery condition. Reset all trip logs and indicators.
8. Verify operation or charging mechanism.
9. Control Wiring Tests:
   a. Insulation resistance test at 1,000 volts dc on control wiring except that connected to solid-state components.
   b. Insulation resistance to be 1 megohm minimum.

3.6 INSTRUMENT TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Visually Check Current, Potential, and Control Transformers For:
   a. Cracked insulation.
   b. Broken leads or defective wiring.
   c. Proper connections.
   d. Adequate clearances between primary and secondary circuit wiring.
2. Verify Mechanically That:
   a. Grounding and shorting connections have good contact.
   b. Withdrawal mechanism and grounding operation, when applicable, operate properly.
3. Verify proper primary and secondary fuse sizes for potential transformers.
4. Bolt torque level in accordance with NETA-ATS, Table 100.12.

B. Electrical Tests:

1. Current Transformer Tests:
   a. Insulation resistance test of transformer and wiring-to-ground at 1,000 volts dc for 1 minute.
   b. Polarity test. Polarity results shall agree with transformer markings.
   c. Ratio-verification test using the voltage or current method in accordance with ANSI/IEEE C57.13.1.
   d. Excitation test on transformers used for relaying applications in accordance with ANSI/IEEE C57.13.1.
   e. Measure current circuit burdens at transformer terminals in accordance with ANSI/IEEE C57.13.1. Measured burdens shall be compared to instrument transformer ratings.
   f. When applicable, perform insulation-resistance tests on the primary winding with the secondary grounded. Test voltages shall be in accordance with Table 100.5.
   g. When applicable, perform dielectric withstand tests on the primary winding with the secondary grounded.
      1) Test voltages shall be in accordance with Table 100.9.
      2) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the primary winding is considered to have passed the test.
   h. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data.
   i. Verify that current transformer secondary circuits are grounded and have only one grounding point in accordance with ANSI/IEEE C57.13.3. That grounding point should be located as specified by the engineer in the project drawings.
2. Potential Transformer Tests:
   a. Insulation resistance test at test voltages in accordance with NETA-ATS, Table 100.5 for 1 minute on:
      1) Winding-to-winding.
      2) Winding-to-ground.

b. Insulation resistance measurement shall not be less than that calculated by formula in NETA-ATS, Table 100.5.
c. Polarity test to verify polarity marks or H1-X1 relationship as applicable.
d. Turns-ratio test on all tap positions. Ratio errors shall be in accordance with C57.13.
e. Measure voltage circuit burdens at transformer terminals. Measured burdens shall be compared to instrument transformer ratings.
f. When applicable, perform dielectric withstand tests on the primary winding with the secondary grounded. The test voltage shall be applied for one minute.
    1) Test voltages shall be in accordance with Table 100.9.
    2) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the primary winding is considered to have passed the test.
g. Power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data.
h. Verify that voltage transformer secondary circuits are grounded and have only one grounding point in accordance with ANSI/IEEE C57.13.3. The grounding point should be located as specified by the engineer in the project drawings.

3.7 METERING AND INSTRUMENTATION:

A. Visual and Mechanical/Electrical Inspection:

1. Verify meter and instrument connections in accordance with appropriate diagrams.
2. Verify meter multipliers.
3. Verify that meter and instrument types and scales conform to Contract Documents.
4. Check calibration of meters at cardinal points.
5. Check calibration of transducers and transmitters.
6. Check set-point and operation of pressure switches.
7. Verify operation of heat trace systems.
8. Check tightness of electrical connections.
9. Verify unit is grounded in accordance with manufacturer's instructions.
10. Set all required parameters including instrument transformer ratios, system type, frequency, power demand methods/intervals, and communications requirements.
11. Apply voltage or current as appropriate to each analog input and verify correct measurement and indication.

3.8 AUTO DIALER

A. Visual and Mechanical Inspection:

1. Verify System Wiring:
   a. Compare wiring to elementary diagrams.
   b. Check for proper conductor lacing and bundling.
   c. Check for proper conductor identification.
   d. Check lugs and terminations.
2. Verify labels and nameplates.
3. Verify component equipment and instrumentation conforms to Contract Documents.
4. Verify component electrical and mechanical connections conform to manufacturer's instructions.

B. Operational Testing:

1. Check each control panel display and switch for proper control loop function.
2. Verify each Input/Output point from the end element to the remote central operations center.

3.9 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:

1. Ground system in compliance with drawings, specifications, and NFPA 70 National Electrical Code Article 250.
2. Grounding system electrical and mechanical connections free of corrosion.
3. Equipment and circuit grounds in motor control centers and switchgear assemblies for proper connection and tightness.
4. Ground bus connections in motor control centers and switchgear assemblies for proper termination and tightness.
5. Effective transformer core and equipment grounding.
6. Accessible connections to grounding electrodes for proper fit and tightness.
7. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

B. Electrical Tests:
1. Fall-Of-Potential Test:
   a. In accordance with IEEE 81, Section 8.2.1.5 for measurement of main ground system's resistance.
   b. Main ground electrode system resistance to ground to be no greater than 5 ohms when disconnected from the utility company ground system.

c. Investigate point-to-point resistance values that exceed 0.5 ohm.

C. Contractor to ensure that the ground test was performed at the following locations:
1. Test Wells
2. Main Disconnect Switch
3. ATS
4. Pump Control Panel
5. Auto Dialer Panel

3.10 AC INDUCTION MOTORS

A. General: Inspection and testing limited to motors rated 5 hp and larger.

B. Visual and Mechanical Inspection:

1. Proper electrical and grounding connections.
2. Shaft alignment.
3. Blockage of ventilating air passageways.
4. Operate Motor and Check For:
   a. Excessive mechanical and electrical noise.
   b. Overheating.
   c. Correct rotation.
   d. Check vibration detectors, resistance temperature detectors, or motor inherent protectors for functionability and proper operation.
   e. Excessive vibration.
5. Check operation of space heaters, if applicable.
6. Cable connection bolt torque level in accordance with NETA-ATS, Table 100.12.

C. Electrical Tests:

1. Insulation Resistance Tests:
   a. In accordance with IEEE 43 at test voltages established by NETA-ATS, Table 100.1 for:
      1) Motors above 200 hp for 10-minute duration with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
      2) Motors 200 hp and less for 1-minute duration with resistances tabulated at 30 and 60 seconds.
   b. Insulation resistance values equal to, or greater than, ohmic values established by manufacturers.
2. Calculate polarization index ratios for motors 200 hp and above. Investigate index ratios less than 2.0 for Class B or Class F insulation.
3. Calculate dielectric-absorption ratio for motors 200 hp and less. Ratio shall not be less than 1.0.

4. Insulation resistance test on insulated bearings in accordance with manufacturer's instructions.
5. Measure running current and voltage, and evaluate relative to load conditions and nameplate full-load amperes.

3.11 LOW VOLTAGE MOTOR CONTROL

A. Visual and Mechanical Inspection:

1. Proper operation of indicating and monitoring devices.
2. Proper overload protection for each motor.
3. Improper blockage of air-cooling passages.
4. Integrity and contamination of bus insulation system.
5. Check nameplates for proper identification of:
   a. Equipment title and tag number with latest one-line diagram.
   b. Pushbuttons.
   c. Control switches.
   d. Pilot lights.
   e. Control relays.
   f. Circuit breakers.
   g. Indicating meters.
6. Verify that fuse and circuit breaker size and types conform to Contract Documents.
7. Verify that current and potential transformer ratios conform to Contract Documents.
8. Check Bus Connections for High Resistance by Low Resistance Ohmmeter and Calibrated Torque Wrench Applied to Bolted Joints:
   a. Ohmic value to be zero.
   b. Bolt torque level in accordance with NETA-ATS, Table 100.12, unless otherwise specified by manufacturer.
9. Check Operation and Sequencing of Electrical and Mechanical Interlock Systems By:
   a. Closure attempt for locked open devices.
   b. Opening attempt for locked closed devices.
   c. Key exchange to operate devices in OFF-NORMAL positions.
10. Verify performance of each control device and feature furnished as part of the motor control center.
11. Control Wiring:
    a. Compare wiring to local and remote control, and protective devices with elementary diagrams.
    b. Check for proper conductor lacing and bundling.
    c. Check for proper conductor identification.
    d. Check for proper conductor lugs and connections.
12. Exercise active components.
13. Inspect Contactors For:
    a. Correct mechanical operations.

b. Correct contact gap, wipe, alignment, and pressure.
c. Correct torque of all connections.

14. Compare overload heater rating with full-load current for proper size.
15. Compare motor protector with motor characteristics for proper size.
16. Perform phasing check on double-ended motor control centers to ensure proper bus phasing from each source.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA-ATS, Table 100.1.
   b. Bus section phase-to-phase and phase-to-ground for 1 minute on each phase.
   c. Contactor phase-to-ground and across open contacts for 1 minute on each phase.
   d. Starter section phase-to-phase and phase-to-ground on each phase with starter contacts closed and protective devices open.
   e. Test values to comply with NETA-ATS, Table 100.1.
2. Current Injection Through Overload Unit at 300 Percent of Motor Full-Load Current and Monitor Trip Time:
   a. Trip time in accordance with manufacturer's published data.
   b. Investigate values in excess of 120 seconds.
3. Phase loss simulation test to ensure that the SSOLR prevents the motor from attempting to start.
4. Control Wiring Tests:
   a. Apply secondary voltage to control power and potential circuits.
   b. Check voltage levels at each point on terminal boards in each device terminal.
   c. Insulation resistance test at 1,000 volts dc on control wiring except that connected to solid-state components.
      1) Insulation resistance to be 1 megohm minimum.
5. Operational test by initiating control devices to affect proper operation.

3.12 EMERGENCY SYSTEMS, ENGINE GENERATOR

A. Visual and Mechanical Inspection:
1. Compare equipment nameplate data with drawings and specifications.
2. Inspect physical and mechanical condition.
3. Inspect anchorage, alignment, and grounding in accordance with manufacturer's published data and system design.
4. Verify the unit is clean.

B. Electrical and Mechanical Tests:
1. Perform insulation-resistance tests in accordance with ANSI/IEEE Standard 43.
   a. Machines 20 horsepower (150 kilowatts) and less:

Test duration shall be one minute. Calculate dielectric absorption ratio.

b. The dielectric absorption ratio or polarization shall be compared to previously obtained results and should not be less than 1.0.

2. Test protective relay devices in accordance with section 3.08.
3. Verify phase rotation, phasing, and synchronized operation as required by the application.
4. Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable. Protection features shall operate in accordance with manufacturer's published data and system design requirements.
5. Perform vibration test for each main bearing cap. Vibration levels shall be in accordance with manufacturer's published data and shall be compared to baseline data.
6. Conduct performance test in accordance with ANSI/NFPA 110 and shall conform to manufacturer's published data and ANSI/NFPA Standard 110.
7. Verify correct functioning of the governor and regulator. Governor and regulator shall operate in accordance with manufacturer's published data and shall be compared to baseline data.

3.13 EMERGENCY SYSTEMS, AUTOMATIC TRANSFER SWITCHES

A. Visual and Mechanical Inspection:
   1. Compare equipment nameplate data with drawings and specifications.
   2. Inspect physical and mechanical condition.
   3. Inspect anchorage, alignment, and grounding in accordance with manufacturer's published data and system design.
   4. Verify the unit is clean.
   5. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
   6. Verify that manual transfer switch warnings are attached and visible.
   7. Verify tightness of control connections.
   8. Inspect bolted electrical connections for high resistance using one or more of the following methods:
      a. Use of a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50% of the lowest value.
      b. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 100.12.
      c. Perform thermographic survey per Section 3.18.
   9. Perform manual transfer operation.
   10. Verify positive mechanical interlocking between normal and alternate sources.

B. Electrical and Tests:
   1. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration shall be one minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation. Minimum insulation-resistance values of control wiring shall not be less than two megohms.
   2. Perform a contact/pole-resistance test. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
   3. Verify settings and operation of control devices. Control devices shall operate in accordance with manufacturer's published data.
   4. Calibrate and set all relays and timers in per Section 3.08.
   5. Verify phase rotation, phasing, and synchronized operation as required by the application.
   6. Perform automatic transfer tests:
      a. Simulate loss of normal power.
      b. Return to normal power.
      c. Simulate loss of emergency power.
      d. Simulate all forms of single-phase conditions.

      Automatic transfers shall operate in accordance with manufacturer's design.
   7. Verify correct operation and timing of the following functions:
      a. Normal source voltage-sensing and frequency-sensing relays.
      b. Engine start sequence.
      c. Time delay upon transfer.
      d. Alternate source voltage-sensing and frequency-sensing relays.
      e. Automatic transfer operation.
      f. Interlocks and limit switch function.
      g. Time delay and retransfer upon normal power restoration.
      h. Engine cool down and shutdown feature.

      Operation and timing shall be in accordance with manufacturer's and system design requirements.

3.14 THERMOGRAPHIC SURVEY

A. General:
   1. Equipment to be inspected shall include all current-carrying devices including switchgear, switchboards, panelboards, breakers, fuse holders, switches and bus connections/joints.
B. Visual and Mechanical Inspection:
   1. Perform thermographic survey when load is applied to the system.

2. Remove all necessary covers prior to thermographic inspection. Use appropriate caution, safety devices, and personal protective equipment.
3. Perform a follow-up thermographic survey within 12 months of final acceptance by the owner.

C. Report:
1. Provide a report which includes the following:
   Description of equipment tested.
   a. Discrepancies.
   b. Temperature difference between the area of concern and the reference area.
   c. Probable cause of temperature difference.
   d. Areas inspected. Identify inaccessible and/or unobservable areas and/or equipment.
   e. Identify load conditions at time of inspection.
   f. Provide photographs and/or thermograms of the deficient area.
   g. Recommended action.

D. Test Parameters:
1. Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1° C at 30° C.
2. Equipment shall detect emitted radiation and convert detected radiation to visual signal.
3. Thermographic surveys should be performed during periods of maximum possible loading. Refer to ANSI/NFPA 70B, Section 20.17.

END OF SECTION

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