TECHNICAL SPECIFICATIONS

FOR

Lift Station No. 1 Replacement Project Phase I

Prepared for

Rainbow Municipal Water District
Fallbrook, CA
Contract No. 14-02
July 2021

Kennedy/Jenks Project No. 1444101*02

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TECHNICAL SPECIFICATIONS

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SECTION 01010

SUMMARY OF WORK

PART 1 - GENERAL

1.01 WORK COVERED BY CONTRACT DOCUMENTS

A. The project includes: construction of new sanitary sewer piping, including demolition/abandonment of existing pipeline and manholes, and connection to existing service laterals; construction of the new Thoroughbred Lift Station, including wet well, emergency storage basin, electrical building housing electrical and controls, emergency generator, odor control, and CIPP lining and installing a Primus Line within an existing sewer to convert to a force main; import of fill material and backfill of excavations and general grading; final grading of onsite and import materials; bypass pumping of sanitary sewer during sanitary sewer, lift station, and emergency storage basin construction; implementation of storm water management systems; trench restoration, pavement repair, surface feature restoration and replacement.

1.02 WORK UNDER OTHER CONTRACTS

A. Other Construction Work: By way of the Engineer, become familiar with other contracts which have been awarded or are about to be awarded by Rainbow Municipal Water District and others for other construction work in the same or immediate area. Cooperate with the other contractors and coordinate the progress of Contractor's work with that being performed by other contractors.

1.03 WORK SEQUENCE

A. General Requirements. Perform work in accordance with the phasing indicated in the Contract Drawings and in Section 01040. The Construction Phasing Plans shall not relieve the Contractor of responsibility for scheduling the work or completion of the work in accordance with specified time frames for the interim milestones and project completion dates.
   1. The Work shall be bid, scheduled and constructed in such a manner as to result in the least possible disruption to the operations and staff of the existing systems. Modifications that affect or may affect the operation of the systems shall not be made without first obtaining written permission from the Engineer. The Contractor must fully understand any and all possible reductions on facility production and/or water quality as they plan the Work.
   2. Prior to any shutdown or flow diversion all materials, fittings, supports, equipment and tools shall be on the site and all necessary skilled labor scheduled prior to starting any connection work. The Contractor shall provide staff following shutdowns to monitor and ensure the proper operation of systems.
   3. Planned utility service shutdowns to any service area or process unit of the project shall be accomplished during periods of minimum use. In some cases this will require night or weekend work, which shall be at no additional cost to the Owner. The Contractor shall program work so that service will be restored in the minimum possible time and shall cooperate with the Owner in reducing shutdowns of the utility to a minimum. No utility shall be disconnected without prior written approval from the utility owner and Engineer. When it is

necessary to disconnect a utility, the Contractor shall give at least two (2) weeks' notice to the utility owner and to the Engineer for approval of the proposed schedule and confirmation within 72 hours of the scheduled shutdown.

4. The Contractor shall note that only certain structures, tie-ins and constraints are addressed in this Section. All work, whether or not addressed here, shall be governed by applicable parts of this Section, and schedules and procedures further submitted for approval.

B. Some construction elements can be accomplished at any time during the contract period (like new fencing and roadways), but many will require coordination with other items being completed first. Therefore a preliminary construction phase sequence is described below to help define the probable sequence of major activities required for the Contractor to comply with, in order to properly address the previously mentioned constraints. The Contractor is responsible for phasing of the work in order to honor the constraints, complete the work, coordinate with Owner's work and meet the schedule for completion.

1. Phase 1 - Thoroughbred Lift Station
2. Phase 2 - Thoroughbred Force Main – Across and downstream of San Luis Rey Bridge
    a. Connections to existing gravity sewer and re-route of LS1 force main shall be planned/phased to minimize service interruption and bypassing
3. Phase 3 - 18-inch and Olive Hill Gravity Mains
    a. Connections to existing gravity sewers and laterals to be planned/phased to minimize service interruption and bypassing
4. Phase 4 - Thoroughbred Force Main – Upstream of San Luis Rey Bridge
5. Phase 5 - Connect/Retrofit Existing Facilities
6. Phase 6 - Demolish/Abandon Existing Facilities

1.04 CONTRACTOR'S USE OF SITE AND OWNER'S CONTINUED OPERATIONS

A. The Contractor shall confine its use of the site for work and storage to the Work Area Limits shown on the Contract Drawings. The Contractor's use of adjacent lands and roads for access to move onto and off of the site and for daily access of workers, material and equipment shall be arranged and scheduled to minimize interference with the Owner's continued operations and public access.

B. The Owner intends to continue operation of portions of its existing system during all or most of the construction period. The Contractor shall plan and schedule its work to minimize impacting the Owner's continued operations and shall, at all times, maintain safe access for the Owner's operating personnel and equipment.

C. The Contractor shall be responsible for maintaining safe emergency exiting for the Owner's and Contractor's personnel in all areas affected by the Contractor's work.

D. If operation of the Owner's existing facility is adversely affected by the Contractor's work, the Owner may suffer a financial loss and may make a claim against the Contractor to recovery its loss.

1.05 DOCUMENTING EXISTING

A. Prior to commencing the Work, tour the site with the Owner and the Engineer. Examine and document photographically and in writing the condition of existing buildings, equipment, improvements, and landscape planting on or adjacent to the site. This record shall serve as a basis for determination of subsequent damage

due to the Contractor's operations and shall be signed by all parties making the tour. Record existing conditions by making a video showing all areas that may be affected during the Work. Provide a minimum of two copies of the video on DVDs or thumb drives.

1.06 SHUTDOWN OF EXISTING UTILITIES, SERVICES OR OPERATIONS

A. Obtain the Engineer's approval at least ten (10) days prior to the shutdown of any utility, service or operation of any existing facility. Give required notice and make appropriate arrangements with utility owners and other affected parties prior to shutdown of any utility service. *Base bids on work performed during normal working hours. The Contractor's Bid shall include the cost of premium time to perform work requiring utility shutdowns on weekends or outside of normal working hours.*

B. Schedule utility service or operations shutdowns for periods of minimum use and at the Owner's convenience. Have all required material, equipment and workers on site prior to beginning any work involving a possible shutdown. Perform work as required to reduce shutdown time to the minimum. In some cases, this may require increased numbers of workers and/or premium time night or weekend work.

C. The Contract Price shall include the cost of additional workers and premium time work required to minimize the impact of utility service or operations shutdowns.

1.07 REGULATORY REQUIREMENTS

A. The codes and regulations adopted by the State and other governmental authorities having jurisdiction shall establish minimum requirements for this project. This project shall comply with the following:
   1. International Building Code (IBC)
   2. Uniform Building Code Standards (UBCS)
   3. Uniform Fire Code (UFC)
   4. Uniform Mechanical Code (UMC)
   5. Uniform Plumbing Code (UPC)
   6. National Electric Code (NEC)
   7. California Fire Code (CFC) 2019 edition
   8. California Building Code (CBC)
   9. California Code of Regulations
      a. Title 19, Public Safety: Portions of the work regulated by the State Fire Marshal.
      b. Title 24, Building Standards: Regulations applicable to Essential Service Facilities, Energy Conservation, Public Assembly and Handicapped Access.

B. The latest edition of the requirements in effect at the date of submission of bids shall apply.

C. General Conditions paragraph 8.1 covers the Contractor's responsibility to comply with laws and codes applicable to Means and Methods for performing the Work.

D. General Conditions paragraph 11.2 covers the Contractor's responsibility to report code deficiencies in the design to the Engineer prior to proceeding with the Work.

E. Paragraphs addressing Pre-Engineered Systems and Performance Specifications in other Sections cover the Contractor's responsibility to comply with code requirements when (1) performance specifications are used to describe all or

portions of Work or items and (2) when pre-engineered (contractor designed) systems are specified.

F. In cases where the Contract Documents are more restrictive than applicable codes, the Contractor shall comply with the Contract Documents.

1.08 REFERENCE STANDARDS

A. When these specifications state that Work or tests shall conform to specific provisions in a referenced standard, specification, code, recommendation or manual published by an association, organization, society or agency the referenced provisions, as they apply to the Work of the Contractor only shall be considered a part of these specifications as fully as if included in total. When these specifications or applicable codes contain higher or more restrictive requirements than those contained in reference standards these specifications or applicable codes shall govern.

B. The latest edition of a referenced standard published at the time of submission of bids shall apply unless a specific date for the referenced standard is cited in these specifications.

C. General provisions in referenced standards, specifications, manuals or codes shall not change the specific duties and responsibilities between any of the parties involved in this work from those described in the General Conditions. Provisions in referenced standards with regard to measurement and payment shall not apply to this Work unless specifically cited.

1.09 SPECIFICATION LANGUAGE AND STYLE

A. Many parts of the Specifications as well as notes on the Drawings are written in the active voice and are addressed to the Contractor.
   1. When words or phrases requiring an action or performance of a task are used, it means that the Contractor shall provide the action or perform the task. For example: provide, perform, install, furnish, erect, connect, test, operate, adjust or similar words mean that the Contractor shall perform the action or task referred to.
   2. When words or phrases requiring selection, acceptance, approval, review, direction, designation or similar actions are referred to, it means that such actions are the Owner's or the Engineer's prerogative and that the Contractor must obtain such action before proceeding.

B. Requirements in the Specifications and Drawings apply to all work of a similar type, kind or class even though the word "all" or "typical" may not be stated.

1.10 DEFINITIONS

A. The following terms, when used in the Contract Documents, shall have the meanings listed:

ACCEPTABLE	"acceptable to the Engineer"
PERFORM	"perform all operations required to complete the work referred to in accordance with the intent of the Contract Documents"
PROVIDE	"furnish and install the work referred to including proper anchorage, connection to required utilities or other work, testing, adjustment and startup ready to put in service and perform the intended function"

REQUIRED	"required by the Contract Documents or required to complete the Work and produce the intended results"
SATISFACTORY	"acceptable to the Engineer"
SHOWN	"as indicated on the Drawings"
SITE	"geographical location of the Project and land within the work area shown on the contract drawings and within which the Work will be installed or built"
SPECIFIED	"as written in the Contract Documents including the Specifications and the Drawings"
SUBMIT	"submit to the Engineer"

1.11 ABBREVIATIONS

A. The following acronyms or abbreviations are used in these specifications for the organizations listed.

Abbreviation	Stands for
AASHTO	American Association of State Highway and Transportation Officials
AAMA	Architectural Aluminum Manufacturers Association
ABMA	American Boiler Manufacturers Association
ACI	American Concrete Institute
ADC	Air Diffusion Council
AGA	American Gas Association
AGMA	American Gear Manufacturers Association
AI	Asphalt Institute
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AITC	American Institute of Timber Construction
AMCA	Air Moving and Conditioning Association
ANSI	American National Standard Institute (formerly United States of America Standards Institute)
APA	American Plywood Association
API	American Petroleum Institute
APWA	American Public Works Association
AREA	American Railway Engineering Association
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	ASTM International
AWPA	American Wood-Preservers' Association
AWS	American Welding Society
AWWA	American Water Works Association
CAGI	Compressed Air and Gas Institute
CAL/OSHA	State of California Department of Industrial Relations, Division of Industrial Safety
CAL TRANS	California Department of Transportation
CBC	California Building Code
CBM	Certified Ballast Manufacturers
CBR	California Bearing Ratio
CEC	California Energy Code
CI	Chlorine Institute
CISPI	Cast Iron Soil Pipe Institute

Abbreviation	Stands for
CMAA	Crane Manufacturers Association of America
CPSC	Consumer Products Safety Commission
CRA	California Redwood Association
CRSI	Concrete Reinforcing Steel Institute
CS	Commercial Standards for the U.S. Department of Commerce
CTI	Cooling Tower Institute
District	Rainbow Municipal Water District
DFPA	Douglas Fir Plywood Association
EIA	Electronic Industries Association
EPA	U.S. Environmental Protection Agency
ETL	Electronic Testing Laboratory
FM	Factory Mutual Insurance Company
FPS	Fluid Power Society
FS	Federal Specifications
GO 95	General Order No. 95, California Public Utilities Commission Rules for Overhead Electric Line Construction
GO 128	General Order No. 128, California Public Utilities Commission Rules for Underground Electrical Construction
HI	Hydraulic Institute
HMI	Hoist Manufacturers Institute
IAPMO	International Association of Plumbing and Mechanical Officials
IBC	International Building Code, Industrial Building Code
ICBO	International Conference of Building Officials
IEEE	Institute of Electrical and Electronic Engineers
IES	Illuminating Engineering Society
IFC	International Fire Code
IGCC	Insulating Glass Certification Council
IMC	International Mechanical Code
IPCE	International Power Cable Engineers Association
ISA	Instrument Society of America
NAAMM	National Association of Architectural Metal Manufacturers
NBS	National Bureau of Standards
NCPI	National Clay Pipe Institute
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NETA	International Electrical Testing Association
NFPA	National Fire Protection Association
NGVD	National Geodetic Vertical Datum
NSF	National Sanitation Foundation
NWMA	National Woodwork Manufacturers Association
OSHA	Occupational Safety and Health Act
Owner	Rainbow Municipal Water District (unless stated otherwise)
PCA	Portland Cement Association
REA	Rural Electrification Administration
RMWD	Rainbow Municipal Water District
SAMA	Scientific Apparatus Makers Association
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
SSPC	Structural Steel Painting Council
TCA	Tile Council of America
UBC	Uniform Building Code
UFC	Uniform Fire Code

Abbreviation	Stands for
UMC	Uniform Mechanical Code
UPC	Uniform Plumbing Code
USDC	U.S. Department of Commerce
UL	Underwriters Laboratories
WCLIB	West Coast Lumber Inspection Bureau
WIC	Woodwork Institute of California
WQCB	Water Quality Control Board (Regional)
WRCB	Water Resources Control Board

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

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SECTION 01025

MEASUREMENT AND PAYMENT

PART 1 – GENERAL

1.01 SUMMARY

A. This Section defines the Lump Sum Prices, Unit Prices, and Allowances listed in the Bid Schedules, and the manner in which they will be used to determine measurement and payment for all items included in the Bid Schedules.

B. Upon Contract award, the accepted Bid Schedules will become the Payment Schedule.

1.02 BID PROPOSAL

A. Measurement and payment will be made for each Payment Schedule item independently and in accordance with the provisions as follows:

1. Lump Sum Prices: The Contractor shall provide Lump Sum Prices in the Bid Schedule for all Work in the Contract Documents, except items of Work listed in the Bid Schedule as Unit Price Items. For Lump Sum items, only the total amount shall be provided.

2. Unit Price Items: Unit Price Items are provided for additive or deductive Work not presently quantified in the Contract Documents. Each unit price shall contain all costs and charges, including, without limitation, materials, labor, fabrication, delivery, installation or application, supervision, tools, equipment, incidentals, subcontractors, indirect costs, bonds, insurance, overhead, profit, and taxes. Unit Prices shall be the exact amount per unit to be applied to the units of Work actually provided or not provided for the purpose of modifying the Contract Price or establishing the payment due the Contractor, as applicable.

a. Unit Prices provided shall be held good and in effect until the Work is completed and accepted by Owner. Contractor proposed Unit Prices which are so unbalanced as to be detrimental to the Owner's interest may be rejected or cause rejection of the Bidder's entire bid at the discretion of the Owner.

b. All Unit Price Items are included in the scope of the Contract without specific locations for the Work provided. Owner reserves the right to direct that these items of Work be performed when they are encountered, and the Contractor is obligated to accommodate this Work within the original contract duration. The Contractor will not be entitled to additional time regardless of where Work is encountered.

c. Allowance Quantities are provided by Owner as an estimate. Owner reserves the right to vary the total individual item total cost by +/- 25% by varying the Allowance Quantities.

d. When Owner's use of a Unit Price item exceeds 200% of the Payment Item Allowance Quantity, the Contractor or Owner may demand that the Unit Price Item be renegotiated for quantities in excess of 200%, whether the price is stipulated or bid. This provision is to prevail over any conflicting General Condition provision.

3. Retention: Payment for all bid items is subject to the retention provisions.

1.03 MEASUREMENT AND PAYMENT

A. This article defines the manner and method to develop the Lump Sum, Unit Price, and Allowance bid amounts of all items identified in the Payment Schedule. Bid items and amounts shall include all plant, equipment, tools, materials, labor, service, and all other items required to complete the Work included in the Contract unless specifically excluded by this Section.

B. Payment for all items of the Payment Schedule, whether lump sum or unit price, shall include all compensation to be received by the Contractor for furnishing all labor, materials, tools, equipment, supplies, transportation, subcontract work, incidentals, indirect costs, overhead, consulting services, manufactured articles, plant establishment and operations, taxes, insurance, bonds, profit, permits, and costs of compliance with public agency regulations having jurisdiction over the Work.

C. No separate payment will be made for any item that is not specifically set forth in the Payment Schedule. All costs shall be included in the individual bid items identified in the Payment Schedule for the various items of Work.

D. Work required for which no separate bid item is identified will be considered as a subsidiary obligation of the Contractor, and the cost therefore shall be included in the most applicable bid item.

E. Compensation for completion of the Work will be determined by the updated construction schedule. Payment amounts for each item will be the basis for development of budget values for activities included in the updated construction schedule.

F. All quantities shall be measured in accordance with industry standard practices, and as specified herein. The Contractor shall compute all quantities of Work performed for payment purposes. The District Representative will verify measurements. Except for time, all quantities shall be measured to the nearest rounded off whole number. Time shall be measured to the nearest tenth of an hour.

G. The following quantities shall not be included for payment:

1. Quantities of material wasted or disposed of in a manner not called for under the Contract or a consequence of the construction method used to perform the Work.

2. Rejected loads of material, including material rejected after it has been placed, by reasons of the failure of the Contractor to comply with the Contract provisions.

3. Materials placed outside the Contractor's storage and staging area stated on the Drawings or lines established by the District Representative.

4. Materials not incorporated into the final Work.

5. Materials remaining after the completion of Work.

H. No payment will be made for loading, hauling, and disposing of rejected materials.

I. Final payment for Work covered by Unit Price Items will be made on the basis of the actual measured quantities accepted by the District Representative multiplied by the Unit Price in the Payment Schedule.

1.01 DESCRIPTION OF SPECIALTY BID ITEMS

A. Bid Item 17, 12-Inch Force Main – CIPP Lining and Primus Line is Downstream Services and Construction Product Marketing's bid price that constitutes full compensation for all materials, labor, equipment, tools, and services associated with the structural CIPP lining of the existing 15-inch and 12-inch VCP sanitary sewer crossing Highway 76 and installation of the 12-inch Primus Line per the Contract Documents and scope of work provided in Appendix F. The contractor's associated materials, labor, equipment, tools, and services to coordinate, receive, and install the equipment as shown on the Drawings and specified herein, as part of the overall project shall be included in Bid Items 14 and 18. Any scope gaps not described within Appendix F are the responsibility of the Contractor. Any additional change orders for the CIPP lining and Primus Line after the General Contractor's NTP will be executed per General Conditions Article 16.

B. Bid Item 37, Excavation – Rock Removal is a per unit bid for removal of rock as described in Specification 02301. Any rock excavation shall be paid by the Owner based on the actual quantities removed and the unit cost listed in the Bid Schedule.

PART 2 - PRODUCTS

2.01 PROGRESS PAYMENT REQUIREMENTS

A. Monthly progress payment requests are due on a certain day of each month (to be determined by Owner). Payment requests will be accepted prior to the submittal date; however, payment request processing will not begin until this date for purposes of meeting Owner's pay request processing obligations under the California Public Contract Code. Failure of the Contractor to submit pay requests by the submittal date may be cause for rejection of the payment request. If rejected,

the Contractor may have to resubmit their payment request the next month. Should the submittal date fall on a holiday or weekend day during the month the Contractor shall consider the next work day as the due date.

B. Partial payment for Work performed shall be in accordance with the updated construction schedule. The District Representative will verify measurements and quantities. Each activity necessary to manage and complete the Work is identified on the construction schedule. Each activity will be assigned its respective value, a portion of the contract price.

C. Payment for all Lump Sum item costs and services incurred on this Contract shall be based on the earned value of Work accomplished during the reporting period. Earned value is determined by the completion percentage of each activity applied to the total value of the activity. No construction activity shall be deemed 100% complete until the Contractor has completed the Work and the Work has been inspected and approved by the District Representative.

D. Unit Price items will be paid based on quantities installed.

E. Earned value is derived from the current status of the updated construction schedule as determined by the monthly schedule status submittal. Each schedule status submittal is reviewed and approved by the Owner prior to the Contractor obtaining approval for the Summary of Earned Values or quantities installed and the Payment Application.

F. The Contractor shall not take advantage of any apparent error or omission on the Contract Documents, Drawings, or Specifications. The Owner shall be permitted to make corrections and interpretations as may be deemed necessary for fulfillment of the intent of the Contract Documents at no additional cost to the Owner.

2.02 PAYMENT APPLICATION

A. The Payment Application shall be submitted according to the format and instructions provided by Owner and is based on Work completed through the last day of the previous month or through the date established by the District Representative.

B. Two copies of the Payment Application shall be submitted. (One hard copy to Owner and one electronically).

C. Payment Application shall be submitted monthly.

D. The Payment Application shall contain all necessary references and attachments that substantiate the invoice for progress payment, (e.g., certified payrolls, labor reports, updated construction progress schedule, and Summary of Earned Values).

E. Payment Application shall be submitted with updated construction schedule and project status report.

PART 3 - EXECUTION

3.01 MONTHLY REVIEW OF PAYMENT APPLICATION

A. Monthly review meetings between the Contractor and Owner will be held within 7 days prior to the payment application date designated by the Owner.

B. Prior to the monthly review meeting, the Contractor shall submit an updated construction schedule and a Payment Application showing a Summary of Earned Values for the reporting and payment period. Owner will compare Contractor submitted earned values to available data.

C. The Contractor shall make any adjustments to the updated construction schedule and Payment Application, as deemed necessary based on the Owner's review. Upon the Contractor's completion of the adjustments, Owner will forward the Payment Request to Owner. Owner will determine payment amounts if agreement with Contractor is not reached.

3.02 PAYMENT FOR PRODUCTS STORED ON SITE

A. The Contractor may request payment for products (material and/or equipment) which will be incorporated in the Work and which will be delivered and stored on-site.

B. Payments for products stored at the site shall be based upon the cost of all acceptable materials and equipment not incorporated in the Work but delivered and suitably stored at the site; provided each such individual item has a value of more than $5,000 and will become a permanent part of the Work.

C. The Payment Application shall contain a bill of sale, invoice, or other documentation warranting that the Contractor has received the materials and equipment free and clear of all liens, charges, secured interests, and encumbrances and evidence that the materials and equipment are covered by appropriate property insurance as specified in the insurance provisions and other arrangements to protect the Owner's interest.

END OF SECTION

SECTION 01040

COORDINATION AND PROJECT REQUIREMENTS

PART 1 - GENERAL

1.01 PROJECT COORDINATION

A. Coordinate scheduling, submittals and work of various Sections of the Specifications and subcontractors to assure efficient and orderly sequence of interdependent construction. Provide accommodations for items to be furnished and installed by Owner and labeled "NIC" (not in contract) on the Drawings and for Owner Furnished Contractor Installed (O.F.C.I.) items.

1.02 MECHANICAL AND ELECTRICAL/CONTROLS COORDINATION

A. The Contractor's superintendent or a specially assigned assistant shall be designated the mechanical/electrical/controls coordinator and shall coordinate the exact location, space priorities and sequence of installation of all mechanical and electrical/controls work with each other and with all other trades. The mechanical/electrical/controls coordinator shall assure compliance with the requirements of this paragraph entitled "Mechanical and Electrical/Controls Coordination".

B. The location of mechanical and electrical/controls work may be indicated diagrammatically on the Drawings. Actual locations shall follow locations shown on the Drawings as closely as practicable, but shall be altered or adjusted in the field by the mechanical/electrical/controls coordinator as required by the following:
   1. In finished spaces install mechanical and electrical/controls work concealed within the space available.
   2. Organize mechanical and electrical/controls work to make efficient use of space. Combine similar items into groups; make all runs parallel to or at right angles with building lines.
   3. Layout and install work to provide adequate space and access for adjustment, servicing, and maintenance and maximize space available for future installation of additional services or replacement of existing services.
   4. Assure that all access doors required by code or required for adjustment, servicing or maintenance are provided in accordance with Section 08307. Locate access doors to provide convenient access and to coordinate with finished visual elements.
   5. Coordinate location of fixtures, registers, grills, outlets, switches, panelboards, pullboxes, access doors, and other exposed mechanical and electrical items with functional and visual elements. Verify location of questionable items with Engineer before proceeding.

C. Prepare large-scale coordinated detailed installation drawings showing the work of all affected trades to coordinate the actual installed location of all equipment and of all mechanical and electrical/controls work *for areas where available space is restricted*. Review coordination drawings with Engineer and all affected trades before proceeding.

D. Review Shop Drawings and Product Data prior to submission for the Engineer's Review to assure that physical characteristics and service requirements are compatible with contract requirements, field conditions, and other items submitted.

E. Verify that required services such as electrical power characteristics, control wiring, and utility requirements of items and equipment submitted and furnished are compatible with services provided. Notify Engineer of potential problems prior to ordering items or equipment and prior to installing services or completing construction in areas where services would have to be installed.

F. Schedule installation sequence of various elements of mechanical and electrical/controls work to achieve optimum compliance with requirements under Mechanical and Electrical/Controls Coordination in this Section.

G. Conduct regular weekly coordination meetings with affected trades and Engineer to establish and maintain coordination and resolve conflicts or disputes.

1.03 CUTTING, FITTING, AND PATCHING

A. Provide cutting, fitting, or patching required to complete the Work and to make all of its parts fit together properly. Include cutting, fitting, and patching required to:
   1. Fit the several parts together and to integrate with other work.
   2. Uncover work to install or correct ill-timed work.
   3. Provide openings in elements of work for penetrations of mechanical and electrical work.
   4. Remove and replace defective and non-conforming work.
   5. Remove samples of installed work for testing.

B. Request guidance from the Engineer prior to beginning cutting or altering construction, which affects:
   1. Structural integrity of any element.
   2. Functional performance of any element.
   3. Integrity of weather-exposed or moisture-resistant elements.
   4. Efficiency, maintenance, or safety of elements.
   5. Visual qualities of sight-exposed elements.
   6. Work by Owner or separate contractor.

C. Execute cutting and patching using workers that specialize in and are skilled in installing the type of work being cut or patched.

D. Perform work in accordance with the Contract Documents or in the absence of specific requirements comply with best trade practice for the work involved.
   1. Execute work by methods that will avoid damage to other work.
   2. Provide proper support and substrates to receive patching and finishing materials.
   3. Cut concrete materials using masonry saw or core drill. Locate all reinforcing steel, conduits and pipes with electronic detecting devices prior to cutting or core drilling existing concrete.
   4. Replace or patch work with new materials meeting the requirements of these specifications or if not specified matching materials and finishes of existing or adjacent work.
   5. Cut wall, ceiling and floor finishes to fit snugly around pipes, sleeves, ducts, conduit, and other penetrations. Provide fire and/or acoustical caulking as required by code or conditions of use.
   6. Maintain integrity of wall, ceiling, or floor construction; completely seal voids against smoke, fire and water.
   7. Refinish surfaces to match adjacent finishes. For continuous surfaces, refinish to nearest intersection; for an assembly, refinish entire unit.
   8. Report any hazardous or unsatisfactory conditions to the Engineer.

1.04 ALTERATION PROJECT PROCEDURES

A. Plan, schedule and perform alteration work as required to minimize impacting the Owner's continued operations. See Section 01010 paragraph titled "Contractor's Use of Site and Owner's Continued Operations."

B. The existing lift station must remain in operation during construction. Schedule utility interruptions, piping connections, and interruption of existing lift station operations as required to permit continued compliance with regulatory requirements and to meet Owner's flow and processing requirements.

C. Perform cutting, fitting, and patching in accordance with provisions in other paragraphs of this Section. Where new work abuts or aligns with existing work, perform a smooth even transition. When a smooth unnoticeable transition is not feasible cut existing surfaces along a straight line at a natural dividing point and provide a groove or cover plate as recommended by the Engineer.

D. Provide new construction in accordance with the technical specifications or if not specified provide new construction matching adjacent or similar existing work in material and finish.

1.05 CONNECTIONS TO UNDERGROUND UTILITIES, CONDUITS, OR PROCESS PIPING

A. Obtain best available current information on location, identification and marking of existing utilities, piping and conduits and other underground facilities before beginning any excavation. In areas where utilities participate in Underground Service Alert, contact DigAlert for information at least 48 hours in advance of beginning work. Give Engineer 24 hours’ notice before beginning work.

B. The location of existing utilities and underground facilities known to the Design Engineer are shown in their approximate location based on information available at the time of preparing the Drawings. The actual location, size, type and number of utilities and underground facilities may differ from that shown and utilities or underground facilities may be present that are not shown. See General Conditions Article 5 and 8.9.1 for the Contractor's responsibilities and for differing conditions that warrant a change in Contract Price.

C. Use extreme care when excavating or working in areas that may contain existing utilities, process piping, conduits or other underground facilities. Use careful potholing, hand digging and probing to determine the exact location of underground installation. Some locations contain multiple pipes or conduits. Prior to performing any subsurface work, investigate, determine and prepare a plan to turn off or disconnect each utility believed to be in the within 100 feet of the subsurface work in the event of an accidental breach of a utility conduit.

D. Where connections to existing utilities or other underground facilities is required or where new piping or conduits may cross or interfere with existing utilities or underground facilities, carefully excavate and uncover existing installations to a point 1 foot below the pipe or conduit to determine the actual elevation and alignment. Call the Engineer's attention to differing existing conditions that may require a clarification or change.

E. Shutdown of existing utilities, services or operations shall be done in accordance with Section 01010.

1.06 FIELD ENGINEERING AND LAYOUT

A. See General Conditions, Article 5.2 regarding reference points provided by Owner.

B. General Conditions, Article 5.4 requires the Contractor to accurately layout the Work including the corners of buildings and other structures and the elevation of every floor, deck, roof, tank bottom, and channel.

C. Employ a licensed Land Surveyor to layout all detailed dimensions and elevations from reference points. Use recognized engineering survey methods and documentation techniques.

1.07 PRECONSTRUCTION MEETING

A. Prior to beginning the Work, the Contractor and its key personnel and Subcontractors including the Contractor's Superintendent, Project Manager, and Field Engineer shall attend a meeting with the Owner and the Engineer to discuss the following:
   1. Name, Authority, and Responsibilities of Parties Involved
   2. Project Procedures:
      a. Progress meetings
      b. Correspondence
      c. Notification
      d. Submittal of Product Data, Shop Drawing Samples, and Proposed Equivalents
      e. Requests for Information
      f. Response to Requests for Information
      g. Requests for Quotation
      h. Work Directive Change
      i. Change Orders
      j. Engineer's "Items of Concern List"
      k. Application for Payment
   3. Temporary Schedule and Contractor's Construction Schedule
   4. Temporary Facilities and Control
   5. Testing During Construction
   6. Contractors Coordination
   7. Mechanical/Electrical Coordination
   8. Maintenance of Record Drawings
   9. Owner Provided Items or Work and Owner Furnished Contractor Installed items
   10. Early Beneficial or Partial Occupancy
   11. Final Testing, Startup, and Balancing
   12. Punch Lists and Project Closeout Procedures
   13. Final Deliverables including Record Drawings, Operation and Maintenance Manuals, and Special Guarantees.

1.08 PROGRESS MEETINGS

A. The Engineer will conduct semi-*monthly* progress meetings with Contractor and Owner at job site. Attendance required by Contractor's project manager, superintendent and affected Subcontractors and suppliers. The Engineer will prepare, maintain, and distribute agenda and dated record of: (1) actions required and taken and (2) decisions needed and made.

B. Agenda:

1. Review critical items/action list.
2. Review work progress. Compare actual progress with planned progress shown on Contractor's CPM Construction Schedule. Discuss corrective action required. Compare actual and projected progress with Contractor's CPM Construction Schedule, propose methods to correct deficiencies.
3. Review status of Submittals; review delivery dates and delivery dates for critical items.
4. Review coordination problems.
5. Schedule needed testing and critical inspections.
6. Review critical requirements for each trade or major piece of equipment prior to beginning work or installation.
7. Discuss Contractor Quality Control.
8. Discuss open items on Engineer's "Items of Concern List."
9. Discuss impact of proposed changes on progress Schedule.
10. Other business.

1.09 PERFORMANCE SPECIFICATIONS AND CONTRACTOR DESIGNED WORK

A. Work under this Contract may be specified by a combination of descriptive, performance, reference standard and proprietary specifications. In the event of conflict between any of the various specification methods used to specify a single item the order of precedence shall be the order in which the methods are listed in the preceding sentence. The terms used to describe types of Specifications are taken from the Construction Specification Institute (CSI) Handbook of Practice.

B. Where Specifications are used to define the characteristics of Contractor designed systems, items or components, the Contractor shall be fully responsible to design, engineer, manufacture, and install the systems, items and components to meet the specified functional requirements, performance requirements, quality standards, durability standards and conditions of use as well as all applicable codes, regulations and referenced trade or industry standards. The Contractor shall perform such design by employing engineers licensed in the State in which the Work is being constructed. The Contractor's design submittals shall include calculations and assumptions on which the design is based and shall be stamped and signed by appropriately licensed engineers.

C. The Owner and the Engineer shall have the right to rely on the expertise and professional competence of the Contractor's design. Favorable review of the Contractor's design submittal shall not relieve the Contractor from full responsibility for the adequacy of the Contractor's design.

1.10 MATERIAL AND EQUIPMENT

A. General:
   1. Verify that products delivered meet requirements of Contract Documents and the requirements for Favorably Reviewed submittals.

B. Compatibility of Equipment and Material:
   1. Similar items, equipment, devices or products furnished under a single specification section shall all be made by the same maker and have interchangeable parts.
   2. In addition, but only if so stated in each affected Specification Section, similar items furnished under two or more Specification Sections shall be made by the same maker and have interchangeable parts.

3. All similar materials or products that are interrelated or used together in an assembly shall be compatible with each other.

C. Transportation and Handling:
   1. Transport and handle products in accordance with manufacturer's instructions.
   2. Promptly inspect shipments to assure that products comply with requirements, quantities are correct, and products are undamaged.
   3. Provide equipment and personnel to handle products by methods to prevent soiling, disfigurement, or damage.

D. Storage and Protection:
   1. Store and protect products in accordance with manufacturer's instructions. Seals and labels shall be intact and legible.
   2. Store moisture-sensitive products including finish woodwork, gypsum products, acoustical products, motors, electrical equipment, instruments and controls in weather-tight, humidity- and temperature-controlled enclosures.
   3. For exterior storage of fabricated products, place items on sloped supports, aboveground.
   4. Cover products subject to deterioration from moisture, dust, or sunlight with opaque watertight but breathable sheet covering. Provide ventilation to avoid condensation.
   5. Provide offsite storage and protection including insurance coverage when site does not permit onsite storage or protection.
   6. Store loose granular materials on solid flat surfaces in a well-drained area. Prevent mixing with foreign matter.
   7. Provide facilities, equipment and personnel to store products by methods to prevent soiling, disfigurement, or damage.
   8. Arrange storage of products to permit access for inspection. Periodically inspect to assure products are undamaged and are maintained under specified conditions.

E. Installation Standards and Manufacturers' Recommendations:
   1. Install all products and materials in strict compliance with the most restrictive of the following:
      a. The manufacturer's or provider's written instructions or recommendations. Follow step-by-step installation procedures.
      b. Recommendations of referenced trade associations or standards.
      c. The Contract Specifications and Drawings.
   2. Where conflicts exist, present alternatives with advantages and disadvantages to Engineer for decision.

F. If reference standards or manufacturer's instructions contain provisions that would alter or are at variance with relationships between the parties to the Contract set forth in the Contract Documents, the provisions in the Contract Documents shall take precedence. See General Conditions paragraph 3.5.

1.11 BACKING, SUPPORTS AND FASTENERS

A. Provide backing, supports, bracing, fasteners and other provisions required for the proper support and attachment of all work. Backing, supports, bracing and fasteners shall be sized to resist vertical and horizontal loads including seismic and wind loads required by codes listed under Regulatory Requirements in Section 01010 and in accordance with Seismic Design Requirements in Section 01190. Where finishes in existing facilities must be removed to install backing or where

finishes are installed in new construction prior to installing backing the Contractor shall remove finishes, install backing and reinstall finishes.

B. Use of explosive powder-driven fasteners is NOT PERMITTED.

C. Low velocity, pneumatic-type, power-driven fasteners may be used only where specifically shown, specified or approved and only where they meet the structural requirements for a particular assembly with a safety factor of at least 400 percent. Power-driven fasteners may not be used for electrical or mechanical installations or to attach any items loaded in withdrawal or subject to vibration.

1.12 SAFETY

A. In accordance with generally accepted construction practice, applicable law and the General Conditions, especially Article 13, the Contractor shall be solely and exclusively responsible for and have control over:
   1. Construction means, methods, techniques, sequences, procedures and for coordinating all portions of the Work under the Contract Documents.
   2. Safety of employees engaged in the work while on and off the site.
   3. Safety of the Owner, the Engineer, the Design Engineer, and others who may visit or be affected by the work.
   4. Safety of the work itself including material and equipment to be incorporated therein, whether in storage on or off the site, under care, custody or control of the Contractor or the Contractor's subcontractors or sub-subcontractors.
   5. Safety of other property at the site or adjacent thereto, such as trees, shrubs, lawns, walks, pavements, roadways, structures, utilities and underground facilities not designated for removal, relocation or replacement in the course of construction.
   6. Safety programs, equipment and protective devices required to assure the safety of persons and property for whom/which the Contractor is responsible.

B. The Owner, the Engineer, and the Design Engineer and each of their officers, employees, agents and consultants shall not be responsible for any construction means, methods, techniques, sequences, nor for safety in, on or about the site, nor for coordinating any part of the Work.

C. The Contractor shall give notices and comply with applicable laws, ordinances, rules, regulations, and lawful orders of public authorities bearing on safety of persons or property or their protection from damage, injury or loss.

D. The Contractor shall erect and maintain, as required by existing conditions and performance of the Contract, necessary fences and other safeguards for safety and protection of persons and property on and off the site and shall: (1) post danger signs and other warnings against hazards, (2) promulgate safety regulations, and (3) notify owners and users of adjacent sites and utilities when the Contractor's operations may affect them.

E. The Contractor shall designate a responsible member of the Contractor's organization at the site whose duty shall be the prevention of accidents. This person shall be the Contractor's Superintendent unless otherwise designated by the Contractor in writing to the Owner and Engineer.

F. The Contractor shall be responsible for initiating, maintaining and supervising all safety precautions and programs required in connection with the Work and shall send copies of all accident, injury or work-related illness reports and of all notices of unsafe conditions to the Engineer.

G. The Contractor shall not load or permit heavy weights to be placed on any part of the construction or site so as to endanger its safety.

H. The duties of the Owner, the Engineer and the Design Engineer in conducting review of the Contractor's performance is not intended to include review of the adequacy of the Contractor's work methods, equipment, bracing, scaffolding or safety measures in, on, or near the construction site. See General Conditions, paragraph 15.2.

I. The Contractor is hereby informed that work on this project could be hazardous. The Contractor shall carefully instruct all personnel working in potentially hazardous work areas as to potential dangers and shall provide such necessary safety equipment and instructions as required to prevent injury to personnel and damage to property, and to comply with all applicable laws and regulations including State OSHA, Federal OSHA, and other regulations referenced in these Contract Documents.

J. The Contractor shall, at all times, maintain the job in a condition that is safe for the Owner, the Engineer and their consultants to make site visits and to conduct construction reviews. If the Owner or the Engineer cannot allow personnel to visit the job because it is not safe, the Contractor is not providing required safe access to the Work as required by General Conditions, Article 13.

K. The Contractor shall prepare a Safety Plan meeting the requirements of applicable regulations. As a minimum, the Contractor's Safety Plan shall set forth definite procedures for informing workers about safety, for instructing workers in safe practices, for assuring that workers are using appropriate safety equipment and safe work practices and for reporting accidents.

1.13 EXCAVATION AND TRENCHING; WORK WITHIN CONFINED SPACES

A. Submit specific plans to the Owner showing details of provisions for worker protection from caving ground in accordance with Section 6705 of the California State Labor Code. The detailed plans shall show the design of shoring, bracing, sloping banks or other provisions and shall be prepared, signed and stamped by a Civil or Structural Engineer licensed in the State in which the Work is performed and retained by the Contractor. The Owner's acceptance of the detailed plans submitted is only an acknowledgment of the submission and does not constitute review or approval of the designs, design assumptions, criteria, completeness, applicability to areas of intended use, or implementation of the plans, which are solely the responsibility of the Contractor and its Registered Engineer.

B. Work within Confined Spaces: Work within confined spaces is subject to applicable laws, regulations and safety.

C. The foregoing provisions do NOT reduce the requirement for the Contractor to maintain safety in ALL operations performed by the Contractor or its Subcontractors.

1.14 CONTRACTOR'S QUALITY CONTROL

A. The Contractor shall be fully responsible for inspecting the work of its suppliers and subcontractors to assure that the work when completed will comply with the standards for materials and workmanship required by the Contract Documents. See General Conditions paragraph 14.2.

B. Inspections, periodic observations and testing performed by the Owner or the Engineer are for the Owner's benefit and information only and shall not be construed as partial or incremental acceptance of the work and shall not be deemed to establish any duty on the part of the Owner or the Engineer to the Contractor, its subcontractors or suppliers. See *General Conditions paragraphs 15.1 and 15.2*.

C. The Engineer will have authority to reject Defective Work. The Engineer will have authority to require additional inspection or testing of the Work whether or not such Work is fabricated, installed or completed. Neither this authority of the Engineer nor a decision not to exercise such authority shall give rise to a duty or responsibility of the Engineer to the Contractor, subcontractors, material and equipment suppliers, their agents or employees, or other persons performing portions of the Work.

D. Observations by the Engineer or tests, inspections or approvals by others shall not relieve the Contractor from its obligation to perform the Work in accordance with the Contract Documents.

E. The Contractor shall:
   1. Monitor quality control over suppliers, manufacturer, products, services, site conditions, and workmanship, to produce work of specified quality.
   2. Comply fully with manufacturer's installation instructions, including performing each step in sequence as recommended by the manufacturer.
   3. Submit a Request for Information (RFI) to the Engineer before proceeding with work when manufacturers' instructions or reference standards conflict with Contract Documents.
   4. Comply with specified standards as a minimum quality for the work except when more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.
   5. Perform work by persons specializing in the specific trade and class of work required and qualified to produce workmanship of specified quality.
   6. Secure products in place with positive anchorage devices designed and sized to withstand seismic, static and dynamic loading, vibration, and physical distortion or disfigurement.

F. If reference standards or manufacturers' instructions contain provisions that would alter or are at variance with relationships between the parties to the Contract set forth in the Contract Documents, the provisions in the Contract Documents shall take precedence.

G. The Contractor shall provide assistance required by the Engineer to adequately inspect the Work including ladders, scaffolding, lighting, ventilation and other aids to facilitate access and provide a safe working environment.

1.15 TESTING LABORATORY SERVICES AND CERTIFIED LABORATORY REPORTS

A. Provide testing services in accordance with General Conditions Article 17 and specific requirements contained in each technical specification section. Submit Certified Laboratory Reports required by technical specification sections.

B. Unless otherwise specified, the Contractor shall arrange and pay for tests, inspections and approvals other than Special Inspections that are required by laws, ordinances, rules, regulations, orders of public authorities having jurisdiction or by the Contract Documents. All such tests, inspections and approvals shall be performed by an independent testing laboratory or inspection agency acceptable to the Engineer or to the appropriate public authority. Samples to be tested and items of work to be inspected will be selected by the Engineer or the public authority requiring the test or inspection. Test reports, inspection reports and certificates shall be submitted directly to the Engineer by the performing laboratory or agency. The Contractor shall notify the Engineer at least two (2) days prior to all tests and inspections to permit observation by the Engineer.

C. The Contractor shall provide access for Special Inspections and notify the Owner two (2) working days in advance of when work requires Special Inspection.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 01140

ENVIRONMENTAL PROTECTION

PART 1 - GENERAL

1.01 SCOPE

A. This specification also describes work necessary by the Contractor to allow the Owner to comply with the California State Water Resources Control Board Construction Activities Storm Water General Permit No. 2009-0009-DWQ (NPDES No. CAS000002) (Permit) for discharge of storm water associated with construction activities pertaining to linear underground/overhead projects (LUP) and specific construction sites. Specifically, this includes the development and implementation of a Storm Water Pollution Prevention Plan (SWPPP). The work shall reflect the Contractor's experience, resources and capabilities in determining and meeting the requirements of the Permit. Definitions of abbreviations pertaining to SWPPP are provided in Section 1.06.B.

B. During the progress of the work, keep the work areas occupied by the Contractor in a neat and clean condition and protect the environment both onsite and offsite, throughout and upon completion of the construction project.

1.02 SUBMITTALS

A. Submit the SWPPP in electronic format and in hard copy and as follows:
   1. Submit in accordance with Section 01300.
   2. Submit Risk Type information that will be basis for SWPPP, including supportive information for determination, within fifteen (15) calendar days of Award.
   3. Submit name and qualifications of the Qualified SWPPP Developer (QSD) responsible for preparing the SWPPP.
   4. Submit Draft SWPPP.
   5. Upon Favorable Review, coordinate with Owner to ensure SWPPP is submitted to the Stormwater Multiple Application and Report Tracking System (SMARTS).
   6. If, with Owner approval, Contractor performed SWPPP upload into SMARTS, submit QSD notification of SMARTS upload with request for the Owner's Legally Responsible Person (LRP) to certify the SWPPP SMARTS upload as authorized to proceed.
   7. Submit Final SWPPP with Waste Discharge Identification (WDID) number.

   If Contractor is to prepare Draft SWPPP (see Section 1.06.B). Then submit as listed above.

B. Develop an Environmental Protection Plan and submit in accordance with Section 01300 within thirty (30) days from the date of the Notice to Proceed. The Environmental Protection Plan shall include, but not be limited to, the following items:
   1. Copies of required permits.
   2. Proposed disposal site(s).
   3. Copies of any agreements with public or private landowners regarding equipment, materials storage, borrow sites, fill sites, or disposal sites. Any

such agreement made by the Contractor shall be invalid if its execution causes violation of local or regional grading or land use regulations.

4. Storm Water Pollution Plan Amendment, as necessary.

C. Distribute the favorably reviewed plan to all employees and to all subcontractors and their employees.

1.03 ENVIRONMENTAL IMPACT MITIGATION MEASURES

A. Comply with all environmental mitigation measures that are included in the Contract Documents.

B. Mitigation and Monitoring Requirements: Review and comply with the environmental impact mitigation and monitoring requirements listed in Table 1. Comply with all federal, state and local regulations pertaining to environmental mitigation.

Table 1: Mitigation and Monitoring Requirements

Environmental Factor	Mitigation and Monitoring Requirements
Air Quality	• Fugitive Dust control BMPs • Vehicle Emissions Control BMPs
Biological Resources	• Construction Monitoring and Temporary Fencing • Pre-construction Nesting Bird Survey and Avoidance • Pre-Construction Sensitive Bird Surveys and Noise Attenuation
Construction Storage Areas	• Proper storage of materials
Cultural Resources	• Cultural Resources Management During Construction • Construction Monitoring for Cultural Resources • Unanticipated Discovery of Cultural Materials • Unanticipated Discovery of Paleontological Materials
Fire Prevention	• Proper material storage • Provide fire extinguisher • Control ignition sources
Fish and Wildlife Resources	• BMPs to minimize fish and wildlife disturbances
Hazard & Hazardous Materials, Hydrology/ Water Quality	• Preparation of a Spill Prevention Control and Countermeasures (SPCC) Plan
Land Resources	• Tree protection BMPs
Noise Control	• Follow local noise ordinances
Odor Control	• BMPs to minimize creation of nuisance odors
Revegetation of Disturbed Areas	• Follow tree and shrub planting guidelines
Sanitation	• Properly dispose of sanitary and construction wastes
Water Resources	• Follow applicable regulations to protect water resources on construction site including but not limited to erosion and sediment control

1.04 MITIGATION AND MONITORING OF ENVIRONMENTAL FACTORS

A. Requirements: All operations shall comply with all federal, state and local regulations pertaining to water, air, solid waste and noise pollution.

B. Definitions of Contaminants:

1. Sediment: Soil and other debris that have been eroded and transported by runoff water.
2. Solid Waste: Rubbish, debris, garbage and other discarded solid materials resulting from construction activities, including a variety of combustible and non-combustible wastes, such as ashes, waste materials that result from construction or maintenance and repair work, leaves and tree trimmings.
3. Chemical Waste: Includes petroleum products, bituminous materials, salts, acids, alkalies, herbicides, pesticides, disinfectants, organic chemicals and inorganic wastes. Some of the above may be classified as "hazardous."
4. Sanitary Wastes:
    a. Sewage: That which is considered as domestic sanitary sewage.
    b. Garbage: Refuse and scraps resulting from preparation, cooking, dispensing and consumption of food.
5. Hazardous Materials: As defined by applicable laws and regulations. Undisclosed hazardous material contamination, if encountered will constitute a changed site condition. The Owner may retain a separate contractor to dispose of undisclosed hazardous material encountered.

C. Protection of Natural Resources:
1. General: It is intended that the natural resources within the project boundaries and outside the limits of permanent work performed under this Contract be preserved in their existing condition or be restored to an equivalent or improved condition upon completion of the work. Confine construction activities to areas defined by the public roads, easements, and work area limits shown on the Drawings. Return construction areas to their pre-construction elevations except where surface elevations are otherwise noted to be changed. Maintain natural drainage patterns. Conduct construction activities to avoid ponding stagnant water conducive to mosquito breeding.
2. Project activities requiring the removal and/or trimming of vegetation suitable for nesting birds shall occur outside of the general bird breeding season (February 15-August 31). If the activities cannot avoid the general bird breeding season, a qualified biologist shall be retained to conduct a pre-activity nesting bird survey within 7 days prior to the activities to confirm the presence or absence of active bird nests. If no active bird nests are found by the qualified biologist, then the activities shall proceed with the reassurance that no violation to the MBTA and CFG Code would occur. If an active bird nest is found by the qualified biologist, then vegetation removal and/or trimming activities at the nest location shall not be allowed to occur until the qualified biologist has determined that the nest is no longer active.
3. A qualified biologist shall survey areas that would be subject to construction noise levels exceeding 60 dBA LEQ for the presence of the coastal California gnatcatcher, least Bell’s vireo, yellow-breasted chat and Cooper’s hawk. Surveys for the species shall be conducted pursuant to the protocol survey guidelines established by the U.S. Fish and Wildlife Service within the breeding season prior to the commencement of construction. If any of these species are present, then the following conditions must be met:
4. If operation of construction equipment occurs during the breeding seasons for the coastal California gnatcatcher (February 15-August 31), nesting raptors (January 15-July 15), or least Bell’s vireo (March 15-September 15), pre-construction survey(s) shall be conducted by a qualified biologist as appropriate to determine whether these species occur within the areas potentially impacted by noise. An analysis showing that either: (1) noise

generated by construction activities would not exceed 60 dBA LEQ at the edge of occupied habitat, or (2) existing ambient noise levels already exceed 60 dBA LEQ must be completed by a qualified acoustician (possessing current noise engineer license or registration with monitoring noise level experience with listed animal species) at least two weeks prior to the commencement of construction activities. Prior to the commencement of any construction activities, areas restricted from such activities shall be staked or fenced under the supervision of a qualified biologist; or

At least two weeks prior to the commencement of construction activities, under the direction of a qualified acoustician, noise attenuation measures (e.g., berms, walls) shall be implemented to ensure that noise levels resulting from construction activities will not exceed 60 dBA LEQ at the edge of habitat occupied by the listed species. Concurrent with the commencement of construction activities and the construction of necessary noise attenuation facilities, noise monitoring* shall be conducted at the edge of the occupied habitat area to ensure that noise levels do not exceed 60 dBA LEQ. If the noise attenuation techniques implemented are determined to be inadequate by the qualified acoustician or biologist, then the associated construction activities shall cease until such time that adequate noise attenuation is achieved or until the end of the breeding season (September 16).

* Construction noise monitoring shall continue at least twice weekly on varying days, or more frequently depending on the construction activity, to verify that noise levels at the edge of occupied habitat are maintained below 60 dBA LEQ or to the ambient noise level if it already exceeds 60 dBA LEQ. If not, other measures shall be implemented in consultation with the biologist and the USFWS and CDFW, as necessary, to reduce noise levels to below 60 dBA LEQ or to the ambient noise level if it already exceeds 60 dBA LEQ. Such measures may include, but are not limited to, limitations on the placement of construction equipment and the simultaneous use of equipment.

5. Air Quality:
    a. Employ measures to prevent the creation of air pollution.
        1) Unpaved areas where vehicles are operated shall be periodically wetted down or given an equivalent form of treatment, to eliminate dust formation.
        2) Store all volatile liquids, including fuels or solvents in closed containers.
        3) No open burning of debris, lumber or other scrap will be permitted.
        4) Properly maintain equipment to reduce gaseous pollutant emissions.
    b. No person shall engage in construction or demolition activity in a manner that discharges visible dust emissions into the atmosphere beyond the property line for a period or periods aggregating more than 3 minutes in any 60-minute period; and
    c. Visible roadway dust as a result of active operations, spillage from transport trucks, erosion, or track-out/carry-out shall be minimized by the use of any of the equally effective trackout/carry-out and erosion control measures listed in Rule 55 that apply to the project or operation. These measures include: track-out grates or gravel beds at each egress point; wheel-washing at each egress during muddy conditions; soil binders, chemical soil stabilizers, geotextiles, mulching, or seeding;

watering for dust control; and using secured tarps or cargo covering, watering, or treating of transported material for outbound transport trucks. Erosion control measures must be removed at the conclusion of each work day when active operations cease, or every 24 hours for continuous operations.

6. Construction Storage Areas:
    a. Storage of construction equipment and materials shall be limited to the designated Contractor's storage area.
    b. Store and service equipment at the designated Contractor's storage area. No dumping of surplus concrete or grout on the site will be permitted.
7. Cultural Resources: Cultural resources have been identified previously outside of the project area. In the event cultural resources are discovered during subsurface excavations at locations of the work, the Contractor shall comply with requirements of NRS.381 as follows:
    a. All departments, commissions, boards and other agencies of the state and its political subdivisions shall cooperate with the Nevada Division of Historic Preservation and Archaeology in order to salvage or preserve historic, prehistoric or paleoenvironmental evidence located on property owned or controlled by the United States, the State of Nevada or its political subdivisions.
    b. When any agency of the state or its political subdivisions is preparing to or has contracted to, excavate or perform work of any kind on property owned or controlled by the United States, the State of Nevada or its political subdivisions which may endanger historic, prehistoric or paleoenvironmental evidence found on the property, or when any artifact, site or other historic, prehistoric, or paleoenvironmental evidence is discovered in the course of such excavation or work, the agency or the Contractor hired by the agency shall notify the Division and cooperate with the Division to the fullest extent practicable, within the appropriations available to the agency or political subdivision for the purpose, to preserve or permit study of such evidence before its destruction, displacement or removal.
    c. In the event that artifacts, human remains, or other cultural resources are discovered during excavations at locations of the Work, the Contractor shall protect the discovered items, notify the Engineer, and comply with applicable law.
8. Fire Prevention: Take steps to prevent fires including, but not limited to the following:
    a. Provide spark arrestors on all internal combustion engines.
    b. Store and handle flammable liquids in accordance with the Flammable and Combustible Liquids Code, NFPA 30.
    c. Provide fire extinguishers at hazardous locations or operations, such as welding.
9. Fish and Wildlife Resources: Perform all work and take such steps required to prevent any interference or disturbance to fish and wildlife. The Contractor shall not be permitted to alter water flows or otherwise disturb native habitat adjacent to the project area which are critical to fish and wildlife except as may be indicated or specified.
10. Hazards:

a. Oil wastes shall not be allowed to flow onto the ground or into surface waters. Containers shall be required at the construction site for the disposal of materials such as paint, paint thinner, solvents, motor oil, fuels, resins and other environmentally deleterious substances.

11. Land Resources: Do not remove, cut, deface, injure or destroy trees or shrubs outside the work area limits. Do not remove, deface, injure or destroy trees within the work area without permission from the Engineer or unless noted on the drawings.
    a. Temporary Construction: Obliterate all signs of temporary construction facilities such as haul roads, work areas, structures, foundations of temporary structures, stockpiles of excess or waste materials, or any other vestiges of construction as directed by the Engineer. Level all temporary roads, parking areas and any other areas that have become compacted or shaped. Any unpaved areas where vehicles are operated shall receive a suitable surface treatment or shall be periodically wetted down to prevent construction operations from producing dust damage and nuisance to persons and property, at no additional cost to the Owner. Keep haul roads clear at all times of any object that creates an unsafe condition. Promptly remove any contaminants or construction material dropped from construction vehicles. Do not drop mud and debris from construction equipment on public streets. Sweep clean turning areas and pavement entrances as necessary.
12. Noise Control: Noise levels from project-related demolition, grading, and construction activities shall not exceed the noise limit specified in San Diego County Code Sections 36.408 and 36.409 of 75 dBA (8-hour average).

    If work is to occur at night between 7:00 p.m. and 7:00 a.m. within 300 feet of occupied residences, noise from construction activities shall be reduced to 75 dBA (1-hour average).

    The District shall employ measures to reduce construction/demolition noise including, but not be limited to, the following:
    a. Construction equipment shall be properly outfitted and maintained with manufacturer-recommended noise-reduction devices.
    b. Diesel equipment shall be operated with closed engine doors and equipped with factory-recommended mufflers.
    c. Mobile or fixed “package” equipment (e.g., arc-welders and air compressors) shall be equipped with shrouds and noise control features that are readily available for that type of equipment.
    d. Electrically powered equipment shall be used instead of pneumatic or internal-combustion powered equipment, where feasible.
    e. Unnecessary idling of internal combustion engines (e.g., in excess of 5 minutes) shall be prohibited.
    f. Material stockpiles and mobile equipment staging, parking, and maintenance areas shall be located as far as practicable from noise sensitive receptors.
    g. The use of noise-producing signals, including horns, whistles, alarms, and bells, shall be for safety warning purposes only.
    h. No project-related public address or music system shall be audible at any adjacent sensitive receptor.
    i. Any truck or equipment equipped with back-up alarm moving within 300 feet of a noise-sensitive land use (residence, school, or church) should

have the normal back-up alarm disengaged and safety provided by lights and flagman or broad-spectrum noise backup alarm (as appropriate for conditions) used in compliance with the Occupational Safety and Health Administration safety guidelines.

j. Temporary sound barriers or sound blankets shall be installed between construction operations and adjacent noise-sensitive receptors. The project Contractor shall construct a 12-foot high temporary noise barrier meeting the specifications listed below (or of a Sound Transmission Control [STC] 19 rating or better) to attenuate noise.

k. The District shall notify residences within 300 feet of the project's disturbance area in writing within one week of any construction activity. The notification shall describe the activities anticipated, provide dates and hours, and provide contact information with a description of a complaint and response procedure.

l. The on-site construction supervisor shall have the responsibility and authority to receive and resolve noise complaints. A clear appeal process for the affected resident shall be established prior to construction commencement to allow for resolution of noise problems that cannot be immediately solved by the site supervisor.

13. Odor Control: Employ measures to prevent the creation of odors.
    a. Store all volatile liquids, including fuels or solvents in closed containers.
    b. No open burning of debris, lumber or other scrap will be permitted.
    c. Properly maintain equipment to reduce gaseous pollutant emissions.
14. Revegetation of Disturbed Areas: Tree and Shrubs Replacement: Replace trees and shrubs damaged by the construction or as noted on the Drawings.
15. Sanitation: During the construction period, provide adequate and conveniently located chemical sanitation facilities, properly screened, for use of construction crews, the Engineer and visitors to the site
16. Water Resources: Comply with all applicable federal, state and local regulations concerning the discharge (directly or indirectly) of pollutants to the underground and natural waters. This project is required to be covered under the CA Construction General Permit. Refer to Section 1.06 for SWPPP requirements for implementation of Best Management Practices (BMPs) that shall be considered and implemented to minimize the potential for impacts to water resources.
    a. Exercise every reasonable precaution to protect streams, lakes, reservoirs, bays and coastal waters from pollution with fuels, oils, bitumens, calcium chloride and other harmful materials and conduct and schedule operations so as to avoid or minimize muddying and silting of said streams, lakes, reservoirs, bays and coastal waters.

       Water pollution control work is intended to provide prevention control and abatement of water pollution to streams, waterways and other bodies of water, and shall consist of constructing those facilities that may be shown on the Drawings, specified herein or in the Special Provisions, or directed by the Engineer. In order to provide effective and continuous control of water pollution, it may be necessary for the Contractor to perform the Contract work in small or multiple units, on an out-of-phase schedule, and with modified construction procedures. The Contractor shall provide temporary water pollution control measures, including but not limited to, dikes, basins, and ditches, and shall apply straw and seed, which become necessary as a result of his operations. The Contractor shall coordinate water pollution control work with all other work done on the Contract.

b. Submit a plan to control water pollution effectively during construction of the Work. Such program shall show the schedule for the erosion control work included in the Contract and for all water pollution control measures, which the Contractor proposes to take in connection with construction of the project to minimize the effects of his operations upon adjacent streams and other bodies of water. The Contractor shall not perform any clearing and grubbing or earthwork on the project, other than that specifically authorized in writing by the Engineer, until such plan has been accepted. The Contractor may request the Engineer to waive the requirement for submission of a written plan for control of water pollution when the nature of the Contractor's operation is such that erosion is not likely to occur. Waiver of this requirement will not relieve the Contractor from responsibility for compliance with the other provisions of this Section. Waiver of the requirement for a written plan for control of water pollution will not preclude requiring submittal of a written plan at a later time if the Engineer deems it necessary because of the effect of the Contractor's operations.

c. If the measures being taken by the Contractor are inadequate to control water pollution effectively, the Engineer may direct the Contractor to revise his operations and his water pollution control program. Such directions will be in writing and will specify the items of work for which the Contractor's water pollution control measures are inadequate. No further work shall be performed on said items until the water pollution control measures are adequate; and if also required, a revised water pollution control plan has been accepted.

d. Where erosion which will cause water pollution is probable due to the nature of the material or the season of the year, the Contractor's operations shall be so scheduled that permanent erosion control features will be installed concurrently with or immediately following grading operations.

e. Nothing in the terms of the Contract nor in the provisions in this Section shall relieve the Contractor of the responsibility for compliance with Sections 5650 and 12015 of the California Fish and Game Code, or other applicable statutes relating to prevention or abatement of water pollution.

f. The Contractor shall also conform to the following provisions:
    1) Where working areas encroach on live streams, barriers adequate to prevent the flow of muddy water into streams shall be constructed and maintained between working areas and streams and during construction of such barriers, muddying of streams shall be held to a minimum.
    2) Removal of material from beneath a flowing stream shall not be commenced until adequate means, such as a bypass channel, are provided to carry the stream free from mud or silt around the removal operations.
    3) Should the Contractor's operations require transportation of materials across live streams, such operations shall be conducted without muddying the stream. Mechanized equipment shall not be operated in the stream channels of such live streams except as may be necessary to construct crossings or barriers and fills at channel changes.
    4) Water containing mud or silt from aggregate washing or other operations shall be treated by filtration, or retention in a settling pond, or ponds, adequate to prevent muddy water from entering live streams.

5) Oily or greasy substances originating from the Contractor's operations shall not be allowed to enter or be placed where they will later enter a live stream.
6) Portland cement or fresh portland cement concrete shall not be allowed to enter flowing water of streams.
7) When operations are completed, the flow of streams shall be returned as nearly as possible to a meandering thread without creating possible future bank erosion and settling; pond sites shall be graded so they will drain and will blend in with the surrounding terrain.
8) Material derived from roadway work shall not be deposited in a live stream channel where it could be washed away by high stream flows.
9) Where there is possible migration of anadromous fish in streams affected by construction on the project, the Contractor shall conduct his operations so as to allow free passage of such migratory fish.

D. Execution: Training.
1. Provide pre-construction training to ensure staff is aware of project specific environmental impacts
2. Provide weekly training to review staff awareness of environmental factors
3. Ensure photo and ongoing compliance documentation is acquired and properly kept.

1.05 DISPOSAL OPERATIONS

A. Solid Waste Management:
1. Daily remove all debris such as spent air filters, oil cartridges, cans, bottles, combustibles and litter. Take care to prevent trash and papers from blowing onto adjacent property. Encourage personnel to use refuse containers. Convey contents to a sanitary landfill.
2. Washing of concrete containers where wastewater may reach adjacent property or natural water courses shall not be permitted. Provide temporary, lined concrete washout stations per SWPPP. Remove any excess concrete to the sanitary landfill. Remove temporary concrete washout station(s) at completion of the project.

B. Chemical Waste and Hazardous Materials Management: Furnish containers for storage of spent chemicals used during construction operations. Dispose of chemicals and hazardous materials in accordance with applicable regulations.

C. Dispose of vegetation, weeds, rubble, and other materials removed by the clearing, stripping and grubbing operations off site at a suitable disposal site in accordance with applicable regulations.

D. Excavated Materials:
1. Native soil complying with the requirements of Section 02301 Earthwork, may be used for backfill, fill and embankments as allowed by that section.
2. Spoil Material:
a. Remove all material which is excavated in excess of that required for backfill, and such excavated material which is unsuitable for backfill, from the site and dispose of off site in accordance with applicable regulations. Remove rubbish and materials unsuitable for backfill immediately following excavation. Remove material in excess of that required for backfill immediately following backfill operations.
b. Rubbish shall consist of all materials not classified as suitable materials or rubble and shall include shrubbery, trees, timber, trash and garbage.

1.06 STORMWATER POLLUTION PREVENTION PLAN REQUIREMENTS

A. The Contractor shall prepare and submit a Draft SWPPP before work shall begin on the site. The SWPPP shall be prepared in accordance with the NPDES construction permit procedures and requirements in effect at the time of Bidding. Contractor shall provide a QSD to prepare the Risk Level Assessment, prepare the SWPPP and, upon favorable review by the Engineer and the Owner, ensure the submittal of the SWPPP to the SMARTS database. If, with Owner approval, Contractor performed SWPPP upload into SMARTS, Contractor shall submit QSD notification of SMARTS upload with request for the Owner's LRP to certify the SWPPP SMARTS upload. Contractor shall be provided the WDID number to finalize the SWPPP.

B. The Draft SWPPP shall identify and mitigate pollutant sources that could affect the quality of stormwater discharges from the construction site. Control practices shall include those that effectively target pollutants in stormwater discharges and shall comply with requirements of the Permit. Within fifteen (15) calendar days of Bid Selection, submit Risk Type information that will be basis for SWPPP, including supportive information for determination.

C. Definitions and Abbreviations for SWPPP:
   1. Approved Signatory – A person designated by the Owner who has legal authority to sign, certify, and electronically submit Permit Registration Documents and Notices of Termination on behalf of the Legally Responsible Person.
   2. BMP – Best Management Practice
   3. CSMP – Construction Site Monitoring Program
   4. Contractor – The person or persons, firm, partnership, corporation or combination thereof, private or municipal, who enters into the Contract with the Owner to construct the project.
   5. Discharger – The Legally Responsible Person or entity subject to the General Permit.
   6. Permit – National Pollutant Discharge Elimination System General Permit for Stormwater Discharges Associated with Construction and Land Disturbance Activities, Order No. 2009-0009-DWQ (as amended by 2010-0014-DWQ and 2012-0006-DWQ), NPDES No. CAS000002 adopted and made effective on 17 July 2012.
   7. Legally Responsible Person (LRP) – The person designated by the Owner who possesses the title of the land or the leasehold interest of a mineral estate upon which the construction activities will occur for the regulated site.
   8. LUP – Linear Underground Projects
   9. PRDs – Permit Registration Documents
   10. Qualified SWPPP Developer (QSD) – The Contractor's employee or individual(s) retained by the Contractor who is authorized to develop and revise SWPPPs.
   11. Qualified SWPPP Practitioner (QSP) – The Contractor's employee or individual(s) retained by the Contractor who is/are assigned responsibility for non-stormwater and stormwater visual observations, sampling and analysis, and responsibility to ensure full compliance with the General Permit and implementation of all elements of the SWPPP, including the preparation of the annual compliance evaluation and elimination of all unauthorized discharges.
   12. SWPPP – Stormwater Pollution Prevention Plan

D. The Contractor shall incorporate the actual construction means and methods to be employed to be in compliance with the SWPPP. The Contractor shall submit an updated SWPPP when significant changes occur for the project and in accordance with the requirements of the NPDES General Permit. Submittal shall also include submittal to the Owner in accordance Section 01300.

E. The Contractor shall have a Designated SWPPP Manager prepare updates to the SWPPP during construction as required by the Permit and be on site to oversee the implementation, respond to changed conditions, and monitor the SWPPP.

F. The Contractor will be responsible for amending, implementing, and maintaining the SWPPP, as necessary.

1.07 CONSTRUCTION DEWATERING WATER DISCHARGES PERMIT REQUIREMENTS

A. Construction Dewatering:
   1. The discharge of water or drilling waste products shall be in accordance with the requirements of the federal, state, or local agencies having jurisdiction. The Contractor shall be responsible for determining the responsible authority and complying with its regulations.
   2. For construction dewatering, the Contractor shall, in reference to the Permit and in accordance with the SWPPP, discharge dewatering water under NPDES General Permit No. CAG919003 General Waste Discharge Requirements for Groundwater Extraction Discharges to Surface Waters within the San Diego Region. Contractor is responsible for adhering to requirements of NPDES No. CAG919003.
   3. For construction dewatering, at the contractor's option and at no additional cost to the Owner, the contractor may acquire a separate NPDES permit to discharge dewatering water. Contractor shall furnish a copy of said NPDES permit to the owner and demonstrate adherence throughout construction activities.

B. Contractor shall, in reference to the Permit and in accordance with the SWPPP, develop, implement and operate a water discharge and treatment system for all dewatering and pipeline dewatering in accordance with NPDES General Permit No. CAG919003, the contract documents and the SWPPP. Prior to conducting any dewatering at the site, the Contractor shall submit a dewatering plan for review by the Engineer and Owner.

C. Contractor shall be responsible for providing certified personnel, acceptable to the Owner, to install and operate the water discharge treatment system and to implement all necessary water pollution prevention procedures to comply with water quality requirements. At all times, Contractor shall permit the Owner to access the Project site, including the treatment system and all pollution control equipment and measures, to monitor and sample all discharges. As required by the SWPPP and the Contract Documents, the Contractor shall prepare and submit reports to the Owner as necessary to comply with all requirements of the NPDES Permit and the SWPPP. Reports shall be submitted by the Contractor to the Owner weekly during construction dewatering activities.

D. Contractor shall operate the water discharge treatment system in accordance with best industry practices. If Contractor violates any such practices or any obligations under the Contract Documents, the NPDES Permit, or the SWPPP related to water pollution control and prevention, the Contractor shall be responsible and shall pay any fines imposed on the Owner by any regulatory agency due to such Contractor

violations in accordance with Contractor's indemnity obligations under the General Conditions. Contractor's indemnity obligations shall include, but are not limited to, payment of all costs associated with Owner's staff time, outside consultant attorney fees and any other charges incurred by the Owner directly due to the actions of the Contractor that cause any violation of the existing NPDES Permits or the SWPPP requirements.

E. If the Owner or the Owner's representative determines that the Contactor is negligent in or is acting recklessly or in willful disregard of its obligations to comply with the existing NPDES Permits or the SWPPP requirements, the Owner shall withhold progress payments until water quality and Contractor implementation, monitoring and reporting activities are in accordance with such requirements. Prior to withholding any progress payment or portion of such payment, the Owner will provide the Contractor with written notice of the proposed withholding and reasons therefore, including providing copies of any sampling results, notices of violation or other documentation of the violation.

F. The Contractor is responsible for all monitoring, sampling and reporting activities required under the NPDES Permit and the SWPPP.

END OF SECTION

SECTION 01190

SEISMIC REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section is applicable to the following secondary structural system elements, non-structural components, and/or equipment supported by structures.
   1. Mechanical, electrical, and plumbing equipment and appurtenances, including, but not limited to:
      a. Fire protection piping, supports, tank and other components.
      b. Monorails, conveyors, jib cranes, etc.
   2. Conduit, piping, cable trays, raceways, ducts and similar systems.
   3. All equipment specifically listed in this specification.
   4. Storage racks, suspended ceilings, light fixtures, raised floors, partitions, store-front, windows, louvers, architectural features and other non-structural components.

1.02 REFERENCES

A. American Society of Civil Engineers Standard ASCE 7 10, Minimum Design Loads for Buildings and Other Structures, Chapters 11, 13, 15.

B. International Building Code (IBC) Section 1613.

C. Additional Building Codes as referenced in 01 04 00

D. California Building Code, 2019 Edition

1.03 DEFINITIONS

A. Engineer of Record: The Engineer responsible for the preparation of Contract Documents.

B. Specialty Engineer: Structural or Civil Engineer licensed in the State where the project is being built responsible for specific elements of the primary structural system, the secondary structural system, non-structural elements and/or equipment supported by structures. The Specialty Engineer shall be provided by the Contractor.

1.04 GENERAL DESIGN REQUIREMENTS

A. The Contractor and Specialty Engineer are responsible for producing structural designs that resist applicable loads including: Dead, Live, Wind, Seismic, Fluid, Snow, Rain, Earth, operational, or other special loads applicable to the component being designed.

B. Minimum design loads shall be based on guidelines given in this Section, the Drawings, ASCE 7-10, IBC Chapter 16, equipment manufacturer's recommendations and/or other industry accepted design standard for the component being designed (i.e. AWWA D100, API 650, ANSI MH16.1).

1.05 SEISMIC DESIGN REQUIREMENTS

A. The Contractor is responsible for producing designs that resist the total seismic forces in accordance with the seismic design criteria. The Contractor is responsible for coordinating between the Engineer of Record and the Specialty Engineer. The Contractor is responsible to coordinate the favorably reviewed design in the field, and shall provide the proposed design, including any modifications required to the primary structure, at no additional cost to the owner.

B. The seismic design for non-structural components and equipment shall be in accordance with the IBC Chapter 16, and the required coefficients and factors for determining the total design seismic forces are shown on the Drawings.

C. Coordinate the layout so that adequate space is provided between items for relative motion. Provide additional supports and restraints between items of different systems when necessary to prevent seismic impacts or interaction.

D. Design non-building structures in accordance with chapter 15 of ASCE 7-10; all designs utilizing chapter 15 shall include the design and anchorage of the entire non-building structure.

E. Design anchorages of all elements of structures, nonstructural components, and equipment supported by structures, to resist static and dynamic operational loads, plus total seismic loads specified in the IBC, ASCE 7-10 Section 13.3.1, and as follows:
   1. For suspended equipment, multiply dead load by 1.2 and add 0.2SDS to account for vertical seismic effects in the downward direction.
   2. For anchorage uplift, multiply dead load by 0.9 and subtract 0.2SDS if used to reduce vertical seismic effects.
   3. Post-installed anchors installed in concrete shall be prequalified for seismic application in accordance with ACI 355.2.

F. Design Basis and Coordination: Contractor shall note that the layout of the structure and equipment pads is based on the first named manufacturer and model for the equipment to be anchored.
   1. Contractor shall coordinate all attachments and related work and shall provide connections as noted in the favorably reviewed shop drawings.
   2. For all suppliers, if the dimensions required by the Contractor's submitted anchorage calculations deviate from those provided on the Contract Drawings, Contractor shall note the deviation in the submittal for review and provide the favorably reviewed pad at no additional cost to the Owner.
   3. If a model or manufacturer other than the first name supplier is submitted for use by the Contractor, Contractor shall coordinate all related work and deviations from the Contract Drawings.
   4. Where Contractor's specialty engineer proposes a deviation from the contract drawings for any manufacturer, and that deviation is favorably reviewed by the Engineer, Contractor shall provide that modification to the structure at no additional cost.

1.06 DESIGN REQUIREMENTS FOR PIPING, CONDUIT, AND DUCTS

A. The Contractor is responsible for producing designs for support of piping, conduit, duct or other systems to resist total seismic forces based on the seismic design criteria coefficients specified above, unless shown on the Contract Documents. Except where the technical specifications give specific exemption from resistance

of seismic forces, all supports shall be designed to meet seismic criteria. Support systems for piping, conduit, duct or other systems greater than 5 inches in diameter are shown on the Contract Documents.

B. Where possible, pipes, conduit, and their connections shall be constructed of ductile materials (e.g., copper, ductile iron, steel or aluminum and brazed, welded or screwed connections). Pipes, conduits and their connections, constructed of nonductile materials (e.g., cast iron, no-hub pipe and plastic), shall have the brace spacing reduced to one-half of the spacing allowed for ductile material.

C. Seismic restraints may be omitted for the following conditions, where flexible connections are provided between components and the associated ductwork, piping and conduit:
   1. Fuel piping less than 1-inch nominal pipe size.
   2. All other piping suspended by individual hangers 12 inches or less in length from the top of the pipe to the bottom of the structural support for the hanger, where the hangers are detailed to avoid bending of the hangers and their connections
   3. Air-handling ducts not carrying hazardous gases or used for smoke control with less than 6 square feet in cross-sectional area or weighing less than 17 pounds/foot.

D. All trapeze assemblies supporting pipes, ducts and conduit shall be braced to resist the total seismic forces considering the weight of the elements on the trapeze. Pipes, ducts and conduit supported by a trapeze where none of those elements would individually be braced need not be braced if connections from the pipe/conduit/ductwork to component or directional changes do not restrict the movement of the trapeze. If this flexibility is not provided, bracing will be required when the aggregate weight of the pipes and conduit exceed 10 pounds/foot or ducting exceeds 17 pounds/foot. The weight shall be determined assuming all pipes and conduit are filled with water.

E. As an alternative to designing the supports and anchorage, where an approved national standard provides a basis for the earthquake-resistant design, submit standard, data, and details for piping, conduit, duct or other systems:
   1. For ductwork, mechanical piping, process piping and electrical conduits, follow Guidelines for Seismic Restraints of Mechanical Systems by SMACNA modified as follows:
      a. Seismically brace piping regardless of size or location. Provide transverse braces at all changes in direction and at the end of all pipe runs. Space transverse braces not more than 20 feet apart. Provide longitudinal braces at 40-foot centers.
      b. Seismically brace all ductwork regardless of size or location. Provide transverse braces at all changes in direction and at each end of run. Space braces not over 20 feet apart. Provide longitudinal braces at 40-foot centers.

1.07 DESIGN REQUIREMENTS FOR SUBMERGED ITEMS

A. To allow for water sloshing, design rigid items such as piping or equipment supports for the hydrodynamic loads by contents and surrounding fluid.

1.08 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Shop Drawings for non-building structures and contractor designed components: Submit signed and sealed structural calculations and detailed drawings for the following listed elements and where required in Divisions 2 through 17 of the primary structural system and their attachments, the secondary structural system and their attachments, permanent non-structural components and their attachments, and the attachments and anchorage for permanent equipment supported by the structure:
   1. List items where entire package shall be designed by the Contractor
   2. Any components or equipment where Contractor's Specialty Engineer had designed using chapter 15 of ASCE 7-10 (i.e. which are non-building structures rather than equipment)

C. Seismic Certification of Equipment.
   1. Certification is required for the following elements or components:
      a. Any components or equipment where the component importance factor Ip is designated as greater than 1.0.
   2. Certification may consist of one of the following methods:
      a. Project-specific component design and documentation determined to be acceptable by the Engineer and the authority having jurisdiction.
      b. Written certification from the manufacturer that the equipment is capable of resisting the internal seismic loads due to the loading conditions noted herein and meeting the requirements based on one of the following:
         1) Analysis, where section 13.2.2 allows, or
         2) Testing meeting ASCE 7-10 section 13.2.5, or
         3) Experience Data meeting ASCE 7-10 section 13.2.6.
   3. Level 2 Certification shall consist of a written certification from the manufacturer, and accompanying test results or experiential evidence, indicating compliance with ASCE 7 Chapter 13.2.2.
   4. For elements designed using chapter 15, Contractor shall submit complete calculations for the element or non-building structure in lieu of seismic certification.

D. Shop Drawings for Anchorage Calculations: Where required in the equipment specifications in Divisions 2 through 17 or listed below, submit signed and sealed structural calculations and detailed drawings from the Contractor's Specialty Engineer.
   1. Required anchorage items include:
      a. Submersible Wastewater Pumps
      b. Standby diesel Engine-Generator
      c. Motor Control Center
      d. Odor Control System

E. Structural calculations and detailed drawings shall be prepared by the Contractor's Specialty Engineer.

F. Structural calculations and detailed drawings shall clearly show the total design seismic forces which will be transferred from the elements of the structural system, non-structural components, and/or equipment and their attachments to the primary structure. Calculations must be reviewed by Engineer of Record for general conformance with the design criteria and building code and therefore calculations shall include:

1. Seismic and wind load criteria used to determine design lateral and uplift forces. For external equipment, a statement should be made as to whether wind controls for all equipment.
2. Derivation of forces used, including at least one complete sample calculation, showing the process used so that Engineer of Record may determine general compliance. Printouts of spreadsheets without explanation of calculations used to determine values are not acceptable.
3. Adequacy of anchorage to concrete and masonry or attachment to the primary structure to transfer the design forces from the element.
4. Detail drawings shall note:
    a. Required concrete strength,
    b. Anchor type, dimensions, and materials. Coordinate material selection with Section 05090.
    c. Edge distance, spacing, embedment depth, substrate thickness and any supplementary reinforcing required for anchors installed in concrete.
    d. Required dimensions of equipment pads based on equipment size and edge distance. The Contractor shall coordinate dimensions of equipment pads, including any revisions required to meet the requirements of the favorably reviewed submittal by the Specialty Engineer at no additional cost to the Owner.

G. The Engineer of Record's review of items within a Specification Section cannot be completed until all related items have been coordinated and submitted for review.

H. Quality Assurance Submittals
1. Test Reports: Submit test reports for tension testing of anchors.
2. Verification of installation: Submit a letter from the Contractor's Specialty Engineer verifying that the installation was performed as required by the Specialty Engineer's calculations.

1.09 QUALITY ASSURANCE

A. Qualifications: The Contractor is responsible for submitting signed and sealed structural calculations and detailed drawings from a Specialty Structural or Civil Engineer licensed in the State where the project is being built.

B. Regulatory Requirements: Comply with the State with California adopted and amended versions of the International Building Code (IBC) Section 1613, the referenced sections of ASCE 7 plus clarifications and additions specified in this Section.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

PART 4 - FIELD QUALITY CONTROL

A. Site Tests: Tension testing of expansion or adhesive anchors utilized for anchorage shall be done in the presence of the Owner's Representative and a report of the test results shall be submitted. See Specification Section 05090 for additional requirements.

B. Inspection: Special Inspection shall be provided for high strength bolting or bolts installed in concrete. See Specification Section 05090 for additional requirements.

END OF SECTION

SECTION 01300

SUBMITTALS

PART 1 - GENERAL

1.01 SUBMITTAL PROCEDURES

A. Accompany each submittal with a Transmittal form from the General Conditions and shall contain the following information:
   1. Contractor's name and the name of Subcontractor or supplier who prepared the submittal.
   2. The project name and identifying number.
   3. Description of the submittal and reference to the Contract requirement or technical specification section and paragraph number being addressed.

B. Unless otherwise specified, provide submittals in electronic PDF searchable format.

C. Submittals which include more than one (1) item or piece of equipment shall include a Table of Contents following the standard submittal form and cover sheets

D. Each submittal shall include a copy of the specification section and all referenced and applicable sections with addendum updates included. For each specification section, check-mark each paragraph to indicate specification compliance with the full paragraph as a whole or marked to indicate requested deviations from specification requirements. Each deviation from the specifications requested by the Contractor shall be underlined and referenced by a unique number in the margin to the right of the identified paragraph. The submittal shall include a detailed written explanation of the reasons for requesting the deviation that is clearly labeled to correspond with the unique number provided in the margin. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal on the basis that the submittal is incomplete and will be returned to the Contractor REJECTED – RESUBMIT with no further consideration.

E. Project Initiation Submittals. At a minimum, provide the following project initiation submittals prior to mobilization.
   1. Designation of Superintendent: Include name, address, home telephone number and a brief resume.
   2. List of Subcontractors and Major Suppliers: Include address, telephone number and name of responsible party.
   3. Schedule of Values, in a form acceptable to the Engineer: See General Conditions Article 2.

1.02 SCHEDULE OF SUBMITTALS

A. See General Conditions Article 12. Within fifteen (15) days after the Notice to Proceed, submit a Schedule of Submittals showing the date by which each submittal required for Product Review or Product Information will be made. Identify the items that will be included in each submittal by listing the item or group of items and the Specification Section and paragraph number under which they are

specified. Indicate whether the submittal is required for Product Review of Proposed Equivalents, Shop Drawings, Product Data or Samples or required for Product Information only.

1.03 PLAN OF OPERATIONS

A. Before beginning on site work, submit a plan showing Contractor's intended use of the site assigned to it. Show location of enclosing fence, access points and gates. Show location for Contractor's, Subcontractor's, and Engineer's field office and parking. Show location of Contractor's and Subcontractor's work areas and storage areas.

1.04 CONSTRUCTION SCHEDULE

A. See General Conditions Article 5.

B. The form of Construction Schedule shall conform to Section 01312.

1.05 SHOP DRAWING, PRODUCT DATA AND SAMPLES SUBMITTED FOR PRODUCT REVIEW

A. This paragraph covers submittal of Shop Drawings, Product Data and Samples required for the Engineer's review referred to as Product Review submittals in the Technical Specifications (Divisions 2 through 17). Submittals required for information only are referred to as Product Information submittals in the Technical Specifications and are covered in this Section. Also see General Conditions Article 8. All shop drawings, product data and samples shall be considered as Product Review submittals unless specifically called out as a Product Information submittal in a technical specification.

B. The Contractor shall make all Product Review submittals early enough to allow adequate time for the Engineer's review, for manufacture and for delivery at the construction site without causing delay to the Work. Submittals shall be made early enough to allow for unforeseen delays such as:
   1. Failure to obtain Favorable Review because of inadequate or incomplete submittal or because the item submitted does not meet the requirements of the Contract Documents.
   2. Delays in manufacture.
   3. Delays in delivery.

C. Content of Submittals:
   1. Each submittal shall include all of the items and material required for a complete assembly, system or Specification Section.
   2. Submittals shall contain all of the physical, technical and performance data required by the specifications or necessary to demonstrate conclusively that the items comply with the requirements of the Contract Documents.
   3. Include information on characteristics of electrical or utility service required and verification that requirements have been coordinated with services provided by the Work and by other interconnected elements of the Work.
   4. Provide verification that the physical characteristics of items submitted, including size, configuration, clearances, mounting points, utility connection points and service access points, are suitable for the space provided and are compatible with other interrelated items that are existing or have or will be submitted.

5. Label each Product Data Submittal, Shop Drawing and Sample with the information required in paragraph 1.01A of this Section. Highlight or mark every page of every copy of all Product Data submittals to show the specific items being submitted and all options included or choices offered.
6. Additional requirements for Product Review submittals are contained in the Technical Specification sections.
7. Designation of work as "NIC" or "by others," shown on Shop Drawings, shall mean that the work will be the responsibility of the Contractor rather than the subcontractor or supplier who has prepared the Shop Drawings.

D. Compatibility of Equipment and Material: Verify that items contained in the same or in different submittals meet the requirements in the paragraph titled "Material and Equipment" in Section 01040 especially the subparagraphs titled "Compatibility of Material and Equipment."

E. Requirements for Contractor Designed Items and for First Specified (Named) Items: Verify that items meet the requirements in the paragraph titled "Performance Specifications and Contractor Designed Items" in Section 01040.

F. Requirements for the Contractor's review and stamping of submittals prepared by the Contractor or by Subcontractors or suppliers prior to submitting them to the Engineer are covered in General Conditions Article 12.

G. Submittals that contain deviations from the requirements of the Contract Documents shall be accompanied by a separate letter explaining the deviations. See General Conditions Article 12. The Contractor's letter shall:
1. Describe the deviation from the specifications requested and identify with a unique number and reference to the Specification Section paragraph or Drawing requirement. The letter shall include a detailed written explanation of the reasons for requesting the deviation that is clearly labeled to correspond with the unique number provided.
2. Describe the proposed alternate material, item or construction and explain its advantages and/or disadvantages to the Owner.
3. State the reduction in Contract Price if any that is offered to the Owner.

H. Engineer's Review Procedure and Meaning:
1. The Engineer will stamp and mark each Product Review submittal prior to returning it to the Contractor. The stamp will indicate whether or not the review was favorable and what action is required of the Contractor. Review categories" No Exceptions Taken" and "Make Corrections Noted" both indicate Favorable Review.
2. At a minimum, Favorable Review is contingent on:
   a. The compatibility of items included in a submittal with other related or interdependent items included in previous or future submittals.
   b. Future submittal of items related to or required to be part of this submittal that were not included with this submittal.
3. Favorable Review of a submittal does not constitute approval or deletion of items required as part of the submittal but not included with the submittal. Favorable Review of items included in the submittal does not constitute deletion of specified features, options or accessories that were not included in the submittal.
4. The action required by the Contractor for each category of review is as follows:
   a. **NO EXCEPTIONS TAKEN**. NO RESUBMITTAL REQUIRED.
   b. **MAKE CORRECTIONS NOTED**:

1) NO RESUBMITTAL REQUIRED. The Contractor shall make corrections noted prior to manufacture.
2) PARTIAL RESUBMITTALS REQUIRED. The Contractor shall submit related accessory or optional items as noted which are required but were not included with the submittal and/or shall resubmit unsatisfactory portions or attributes of items as noted. The Contractor may proceed to manufacture those portions of the submittal that will be unaffected by required resubmittals.

c. **AMEND AND RESUBMIT**. The Contractor shall amend and resubmit the submittal as noted or required to comply with the Contract Documents.

d. **REJECTED - RESUBMIT**. The item submitted does not comply with the Contract Documents. Resubmit items that comply with the requirements of the Contract Documents.

e. **NOT REVIEWED**. The item submitted is incomplete or does not comply with the Contract Documents. The item has not been reviewed and is returned to the Contractor for correction.

f. **RECEIPT ACKNOWLEDGED**. Receipt of a submittal that is not subject to the Owner's review and approval is acknowledged; and, is being filed for information purposes only. Generally used in acknowledging receipt of Product Information. No further submittal activity is required by the Contractor.

5. The letter of transmittal accompanying the returned Product Review submittal may contain numbered notes. Marking a corresponding number on a Shop Drawing or Product Data submittal shall have the same affect as applying the entire note to the submittal.

I. Re-submittals that contain changes that were not requested by the Engineer on the previous submittal shall be accompanied by a letter explaining the change.

J. Favorable Review Required Prior to Proceeding: Do not proceed with manufacture, fabrication, delivery or installation of items prior to obtaining the Engineers Favorable Review of Product Review submittals. See General Conditions Article 12.

K. Intent and Limitation on Engineer's Review:
1. See General Conditions Article 12.
2. The Contractor has primary responsibility for submitting and providing work that complies with the requirements of the Contract Documents. That responsibility cannot be delegated in whole or in part to subcontractors or suppliers. Neither the Engineer's Favorable Review nor the Engineer's failure to notice or comment on deficiencies in the Contractor's submittals shall relieve the Contractor from the duty to provide work, which complies with the requirements of the Contract Documents.

1.06 PROPOSED EQUIVALENTS (SUBSTITUTIONS)

A. See General Conditions Article 9.

B. The term "first specified item" or "first named maker" refers to the first product identified in the Specifications by a model number or trade name and/or by a maker's name for a specified item. When the first specified item is followed by a second maker's name and "or equal," the Contractor may submit Proposed Equivalent (Substitution) items for the Engineer's review. Proposed Equivalent (Substitution) items that are in the Engineer's judgment equal to the first specified

item in quality, utility, and appearance, will be Favorably Reviewed. Where a product description and first maker's name is followed by "or equal" with no second maker's name, it means the specifier knows of no equivalent product and the Contractor may submit Proposed Equivalent (Substitution) products by other makers for review. Where the term "or equal" is omitted, it means that the named item is required to meet the Owner's needs; no products or makers other than those specified will be considered.

C. Submit Proposed Equivalent (Substitutions) and comply with the submittal requirements for Shop Drawings, Product Data, and Samples submitted for Product Review in another paragraph of this Section.

D. Time of Submittal:
   1. Refer to General Conditions Article 9 for submittal of Proposed Equivalents (Substitutions) requirements.
   2. The Engineer's agreement to a later submittal date shall be in writing and shall not be construed as Favorable Review or acceptance of the manufacturer or item proposed.

E. Content of submittals shall be the same as that required for Product Data, Shop Drawings and Samples submitted for Product Review in another paragraph of this Section. In addition, the Contractor shall provide information on several recent similar installations of the item to verify its suitability. The information shall include the project name and location, the Owner's name, address, telephone number and name of a knowledgeable person to contact for information on performance of the product.

F. When the Contractor has listed specific maker's products submitted with its Bid, no changes will be permitted without submittal of acceptable evidence justifying the change and the Engineer's written approval.

G. If a non-equivalent substitute is submitted for review, it shall be accompanied by a proposed reduction in Contract Price which shall include the increased cost of Engineering service required to evaluate the proposed substitute (which shall be paid to the Owner whether or not the substitute is accepted) plus the greater of 1) the difference in price between the first specified item and the item submitted and 2) the difference in value to the Owner between the two items.

1.07 PRODUCT INFORMATION SUBMITTALS

A. Submittal for Informational Purpose Only is an item required for the Owner's permanent records relating, in part, to future maintenance, repair, modification, replacement of work or as otherwise required. The Contractor shall clearly separate information for Product Review from information for Product Information in submittals that include both.

B. Make Product Information submittals prior to delivering material, products or items for which Product Information submittals are required.

C. The Contractor has the sole and exclusive responsibility for furnishing products and work that meets the requirements of the Contract Documents.

D. The Engineer reserves the right to comment on any submittal and to reject any product or work delivered, installed or otherwise at any time that the Engineer become aware that it is defective or does not meet the requirements of the Contract Document. See General Conditions Articles 9, 15, and 17.

1.08 OPERATION AND MAINTENANCE MANUALS AND PARTS LISTS

A. Operation and maintenance (O&M) information shall be submitted in a format best suited for the type of manual to be provided to the Owner. Unless otherwise specified, provide information in electronic PDF searchable format.

B. Provide operation and maintenance manuals and parts list for all equipment furnished under this Contract. Comply with the detailed requirements in Technical Specification sections. Include instructions for delivery, storage, assembly, installation, lubrication, adjusting, startup, operation and maintenance. Provide PDF bookmarks for all items listed in subparagraphs 1 through 5 below.

1. For all equipment include:
   a. Startup instructions
   b. Normal operation instructions.
   c. Trouble shooting instructions.
   d. Lubrication instructions.
   e. Maintenance and reinstallation instructions, and manufacturer's recommended preventative maintenance schedule.
   f. Parts identification.
   g. List of spare parts recommended to have on hand.
   h. Operator safety instructions.
   i. Cleaning instructions.
   j. Theory of operation to discrete component level.
   k. Schematic diagrams, flow diagrams, wiring diagrams, logic diagrams, etc. to discrete component level.
   l. Parts list showing all discrete components with part number,
   m. Manufacturers' service and maintenance technical manuals.
2. For all Electrical Equipment, provide the following additional information:
   a. Equipment ratings.
   b. Calibration curves and rating tables if appropriate.
3. For Complex Equipment provide in addition:
   a. Alternate specified operating modes.
   b. Emergency shutdown instructions.
   c. Normal shutdown instructions.
   d. Long-term shutdown instructions.
4. Operation and maintenance manuals for systems composed of separate pieces of equipment shall include a system explanation of items 1, a, b, and c, and 3a through c, as well as the instructions for each separate piece of equipment.

C. Submit at least fifteen (15) days prior to Facility Startup and Training specified in Section 01650.

C. When standard manufacturer's literature is used highlight or mark all copies to shop specific items and options provided.

1.09 MANUFACTURER'S CERTIFICATES

A. When specified in Technical Specification section, submit manufacturers' certificate to Engineer for review. Indicate material or product conforms to or exceeds specified requirements. Submit supporting reference data, affidavits, and certifications as appropriate. Certificates may be recent or previous test results on material or product, but must be acceptable to the Engineer.

1.10 CONSTRUCTION PHOTOGRAPHS

A. Submit digital photographs in electronic JPEG format each month to Engineer with Application for Payment.

B. Take two site photographs from different directions and five interior photographs to show progress of the Work. Take photographs within five (5) days of each Application for Payment date.

C. Identify photographs with date, time, orientation and project identification.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

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SECTION 01312

CONSTRUCTION SCHEDULES

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes provisions for Contractor developed and maintained construction schedules.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with Specifications Section 01300, Submittals, and the following special provisions provided herein.

B. Construction schedule submittals shall consist of electronic copies.

C. Baseline Construction Schedule

1. The Contractor shall submit the baseline construction schedule within 10 work days after receipt of the Notice to Proceed.

2. Owner will meet with the Contractor to review and discuss the proposed construction schedule within 10 work days after receipt of the submittal. At this meeting, Owner will inform the Contractor if the construction schedule is acceptable or if it must be revised and resubmitted.

3. In the event that correction of the baseline construction schedule is required, the Contractor shall resubmit the revised construction schedule within 10 work days of the meeting. Owner will meet with the Contractor to review and discuss the revised construction schedule within (10) work days after receipt of the resubmittal. At this meeting, Owner will inform the Contractor if the construction schedule is acceptable or if it must be revised and resubmitted.

D. Construction Schedule Updates

An updated construction schedule shall be submitted to Owner at the end of each month, with the Contractor’s progress payment application.

E. Narrative Progress Report

A written narrative progress report shall be submitted to the Owner at the end of each month, with the Contractor’s progress payment application.

F. Failure to submit each package by the required date may result in a reduction in progress payment by Owner for the corresponding month.

G. Look-Ahead Schedule: Look Ahead Schedule shall be submitted weekly and a regular agenda item in the project coordination meetings. The Contractor shall submit the Look Ahead Schedule at least 24 hours prior to the project coordination meeting. The number of copies submitted, and the layout and format of the look-ahead schedule shall be acceptable to Owner.

1.03 CONSTRUCTION SCHEDULE

A. The Contractor shall provide a computer-generated construction schedule using, Microsoft Project, or equal software, that has the capability of producing a Gantt chart and identify critical path.

B. The construction schedule shall show in detail the Contractor's plan for performing the Work. The degree of detail shall be to the satisfaction of the Owner and shall include, as a minimum:

1. The means, methods, and sequences for performing the Work.

2. Mobilization of plant and equipment.

3. Submission and approval of critical submittals.

4. Fabrication and delivery of critical equipment and materials.

5. Approvals and permits required by regulatory agencies or other third parties.

6. Access to and availability of work areas.

7. Identification of interfaces and dependencies with preceding, concurrent, and follow-on subcontractors.

8. Specified project phasing, milestones, and completion dates.

9. Testing.

10. The activities of the Owner that may affect progress or affect required dates for completion of all or part of the Work, including delivery of Owner furnished equipment.

11. Owner startup, testing, and dewatering.

C. Revisions to the Baseline Construction Schedule

1. The Contractor shall immediately advise Owner of proposed or required changes in the construction schedule logic or delays to the progress of the Work.

2. The Contractor shall furnish a revised schedule within (10) work days of the adoption of a change. The revised schedule shall be accompanied with a written narrative description of the change, the necessity for the change, the impact of the change to the specified schedule milestones, and the cost to Owner if the revised schedule is accepted.

3. The Contractor shall furnish a revised schedule within 10 work days of the award by Owner of an adjustment in the time of completion of the Work.

D. Monthly Construction Schedule Updates

1. The Contractor shall update the current construction schedule monthly to indicate:

a. Actual activity-start dates

b. Actual activity-completion dates

c. Estimated duration, in work days, to complete each activity that is started but not completed

d. Actual total progress achieved to date on each activity in percent

e. Non-work days granted by the Owner.

1.04 NARRATIVE PROGRESS REPORT

A. As part of the monthly update process, the Contractor shall prepare a narrative progress report. The report shall describe the physical progress during the report period, the Contractor's plans for continuing the Work during the forthcoming report period, and actions planned to correct Work that is behind schedule. The report shall also provide a discussion of potential delays and problems and their impact on performance and the overall project completion date.

B. If the Project falls behind schedule by more than 20 work days, the report shall contain proposed alternatives for schedule recovery.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

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SECTION 01500

CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS

PART 1 - GENERAL

1.01 TEMPORARY UTILITIES

A. Sanitary Facilities: Provide and maintain self-contained portable sanitary facilities for the Contractor's, subcontractor's, Engineer's, and Owner's use. Facilities shall comply with applicable regulations and shall be serviced, cleaned and disinfected frequently.

B. Temporary Water, Power and Telephone Service:
   1. Water: Connect to existing water service and provide backflow prevention devices. Install a meter and reimburse the Owner for the cost of water used.
   2. Power: Connect to the existing electrical service with a service disconnect switch. Provide overcurrent and ground fault protection. Provide a meter and reimburse Owner for the cost of energy used.
   3. Telephone: Provide temporary telephone service and facsimile line service for the Contractor's and Engineer's use. Pay periodic charges for the telephone and internet services to the Engineer's office.

C. Temporary Heat: Provide temporary heat for enclosed spaces for the proper installation of finishes, such as floor coverings, wall coverings, woodwork and painting, and to protect all work and moisture sensitive electrical equipment against injury, dampness and cold. Fuel, equipment, and installation shall comply with all applicable codes and regulations. Salamander heaters or other space heaters using kerosene are not permitted. Use permanent heating system after revisions have been completed, provided Contractor replaces or cleans filters on completion of the project.

D. Temporary Ventilation: Provide equipment to ventilate enclosed areas to facilitate curing concrete, to dissipate humidity and to prevent accumulation of dust, fumes, or gases. Utilize ventilation equipment and supplement with temporary fans to maintain clean air and safe conditions for construction operations. Replace or clean filters on existing or new equipment on completion of the project.

E. Temporary Lighting: Provide and maintain lighting for construction operations to achieve a minimum lighting level of 20 foot-candles for rough work and 60 foot-candles for finish work.

F. Temporary Fire Protection:
   1. Provide and maintain fire protection equipment, including extinguishers, fire hoses, and other equipment required by law or insurance carriers, or as necessary for proper fire protection during the course of the work.
   2. Use fire protection equipment only for fighting fires.
   3. Locate fire extinguishers in field offices, storage sheds, tool houses, temporary buildings, and throughout the construction site. In the area under construction, provide at least one (1) fire extinguisher for each 5,000 square feet of enclosed space and locate fire extinguishers not over 100 feet apart.

1.02 TEMPORARY CONSTRUCTION

A. The Contractor is solely and exclusively responsible for the design, construction and maintenance of all temporary construction including forms, falsework, shoring, scaffolding, stairs, ladders and all other similar items. See Section 01040.

B. Construct adequate and safe forms and falsework to rigidly support partially completed structures. Provide temporary bridges and decking to maintain vehicular and pedestrian access. Design and construct temporary forms, falsework, bridges and decking in accordance with applicable regulations and codes.

1.03 BARRICADES, FENCES AND ENCLOSURES

A. See General Conditions Article 13 and Section 01040.

B. Barricades: Provide temporary guardrails, ladders, stairs, guards, and barricades to protect persons in accordance with applicable regulations, including California Code of Regulations Title 8 and Cal/OSHA.

C. Fences:
   1. Provide a temporary 6-foot-high chain-link fence completely around the site to exclude unauthorized persons from construction areas.

   2. Existing fences enclose some of the present facilities site. The fences are for the protection and security of the present operating facilities. If it is necessary for the Contractor to remove some of the fences for installation of new work, the Contractor shall provide equivalent temporary protection and security. Replace fencing removed by the Contractor with new fencing of equivalent quality prior to completion of the project.

D. Enclosures:
   1. Provide protective dust covering at doors and other openings to contain dust within the construction area.
   2. Provide temporary partitions to prevent dust and moisture from entering Owner-occupied areas and to prevent damage to existing materials and equipment. Temporary partitions shall be of non-combustible construction such as metal studs and gypsum board.
   3. Provide temporary watertight closures for openings in exterior surfaces as required to protect interiors from weather, moisture, humidity and extreme temperature.

1.04 PROTECTION OF INSTALLED WORK

A. Provide temporary and removable protection for installed products. Control activity in immediate work area to minimize damage.

B. Prohibit traffic or storage upon waterproofed or roofed surfaces. If traffic or activity is unavoidable, provide adequate protection to prevent damage to waterproof membranes and comply with recommendations for protection of the waterproofing or roofing material manufacturer.

C. Provide heavy planking to protect curbs, gutters, culverts, paving and similar surfaces from damage by heavy equipment or vehicles.

1.05 SECURITY

A. Provide security and facilities to protect the Work, existing facilities, and Owner's operations from unauthorized entry, vandalism, or theft.

B. Employ the services of a licensed security firm to patrol the site during non-working hours.

1.06 ACCESS ROADS AND PARKING AREAS

A. Access Roads: Use only access roads designated on the Drawings.

B. Parking:
   1. Construct temporary gravel surfaced parking areas for construction personnel where shown on the Drawings in the Contractor's storage areas.

1.07 TEMPORARY CONTROLS

A. Cleaning:
   1. During Construction: Maintain the site and all work in a clean orderly fashion free of waste debris and rubbish. Store debris in covered containers. Pick up and remove debris daily if required, but not less frequently than weekly. Burning debris on site is not permitted. Remove debris from permanently closed spaces prior to enclosing them. Clean mud from vehicles before leaving the site.
   2. If work under this Contract creates dusty, dirty or unsightly conditions in adjacent areas, the Contractor shall immediately cleanup the affected areas.
   3. Final cleanup is specified in Section 01700.

B. Dust Control: Employ measures to prevent the creation of dust which may produce damage or nuisance to property or persons. Be responsible for all damage resulting from dust produced by construction operations. Periodically wet down unpaved areas where vehicles are operated. See Division 2 Earthwork specification sections.

C. Erosion and Sediment Control: Employ measures to prevent erosion and trap any sediment created by construction operations before it leaves the site. Prevent sediment from entering streams or other water bodies.

D. Noise Control: Comply with regulations limiting construction noise levels. Use whisper quite air compressors. Use jack hammers with exhaust mufflers. Prevent noise disturbance to the public and adjacent property owners. Employ measures required to limit construction noise to 75 dBA at construction site boundaries.

E. Pest and Rodent Control: Avoid creating conditions conducive to pests and rodents. Comply with regulations governing the use of chemicals to control pests and rodents.

F. Water Control: Maintain excavations free of water. Grade site to drain. See Division 2 Earthwork specification sections.

1.08 PROTECTION OF TREES

A. Remove only those trees designated on the Drawings for removal. Protect all other trees on the site.

B. Protect all trees to remain on the site from damage. Do not cut roots larger than 2 inches in diameter during excavating or trenching operations.

C. Do not attach ropes, cables, guys or braces to trees designated to be preserved.

D. Do not trim any trees without the Engineer's authorization.

1.09 TRAFFIC REGULATION

A. Conduct operations so as to offer the least possible obstruction and inconvenience to public traffic. Do not overload or damage paved or improved surfaces, sidewalks, curbs or gutters.

B. Provide temporary barricades, lights, flag persons and other means to safely control pedestrian and vehicular traffic entering and leaving the project site and on the project site.

1.10 PROJECT SIGN

A. Provide an 8 foot-wide by 6 foot-high project sign using ¾ inch exterior grade plywood and braced wood frame construction. Paint all surfaces with two coats of exterior house paint. Employ a professional sign painter to letter sign in accordance with Engineer's small scale design and color selection (two colors).
   1. List project title and names of Owner, Engineer, and Contractor.
   2. Erect the sign where directed by the Engineer. Locate bottom edge of the sign 8 feet above the ground.
   3. Maintain sign in good condition and remove it on project completion.

1.11 FIELD OFFICES

A. Contractor's Office at the Site: Maintain a suitable office at the site for the Contractor's Superintendent who shall be authorized to receive submittals, drawings, instructions, or other communications from the Engineer or the Owner.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01550

TRAFFIC CONTROL

PART 1 - GENERAL

1.01 OBJECTIVES

A. Provide for safe movement of vehicular, bicycle and pedestrian traffic through and around Contractor's construction operations. Traffic control requirements set forth herein are the minimum requirements imposed. The Contractor shall be solely responsible for providing all protective measures necessary.

B. Proper traffic movement through the work area depends upon the driver controlling and directing his/her vehicle properly under unexpected situations and pedestrian attention to signs. The means of clarifying such conditions to the public include signs, flaggers, pavement markings, barricades, lights, cones and delineators.

C. No one standard sequence of signs or control devices will suit all conditions, which may result from construction operations. Even for the same work the conditions may vary from hour to hour, requiring adjustment and revision of the traffic control program in effect.

D. The traffic control requirements specified herein are intended to establish general principles to be observed in the control and regulation of traffic through and around construction operations anticipated for this project. All pedestrian and vehicular detours are subject to review by the police chief, sheriff or enforcement officer of the agencies having jurisdiction, and the Contractor shall revise the detours as ordered, at no additional cost.

E. Cleanup site each day after completing work and remove all traffic hazards. Daily traffic control measures shall continue until cleanup activities have been satisfactorily completed and all of the Contractor's equipment has been removed from the traveled way area.

1.02 DESCRIPTION OF WORK

A. Work Included:
   1. At all times, provide safe and adequate passage for vehicular and pedestrian traffic through, around and adjacent to all construction operations by use of detours, bridging, backfilling, paving, traffic barriers or other favorably reviewed means.
   2. Establish and maintain detours and conduct construction operations in such a manner as to minimize hazard, inconvenience and disruption to the public.
   3. Traffic control shall be directed equally to the regulation and protection of pedestrian traffic including pedestrians, bicyclists, joggers, skaters, skateboarders, etc.
   4. Provide for protection of pedestrians and separation of pedestrians from construction operations at all times.
   5. Direct, divert and detour traffic through, around and adjacent to construction operations in accordance with the traffic control plans as specified herein or in accordance with favorably reviewed Traffic Control Plans. Revise the

Traffic Control Plan, as necessary, only with the favorable review of the Engineer.

1.03 REFERENCES

A. Manual of Traffic Controls, California Department of Transportation.

B. Work Area Traffic Control Handbook, Building News Incorporated, P.O. Box 3031, Terminal Annex, Los Angeles, California 90051.

C. Manual on Uniform Traffic Control Devices (MUTCD) (Traffic control for construction and maintenance work zones shall follow Part 6 of the 2006 MUTCD as amended by Part 6 of the 2006 MUTCD California supplement. These two parts must be used together.)

D. Standard Specifications for Construction of Local Streets and Road, July 2006, California Department of Transportation.

E. Standard Plans for Construction of Local Streets and Road, July 2006, California Department of Transportation.

1.04 SUBMITTALS

A. Traffic Control Plan:
   1. Submit a Traffic Control Plan (TCP) in accordance with the procedures specified in Section 01300 under the Product Information category to clearly describe proposed traffic control measures. The plan shall be generally in accordance with the illustrations included in the *Manual of Traffic Control and in the Work Area Traffic Control Handbook.*
   2. Submittal shall consist of scaled drawings for each situation anticipated to be encountered, i.e., intersections, mid-block (each during working and non-working hours), etc.
   3. Scaled drawings shall show signs, traffic control devices and flaggers as required.
   4. Designate a Traffic Lead who will have responsibility for planning, preparing, contacting agencies, and implementing the TCP. Provide not less than 30 days written notice of transfer or termination of this individual to assure a smooth transition to a new Lead.

PART 2 - PRODUCTS

2.01 CONSTRUCTION SIGNS

A. The term "Construction Area Signs" shall include all temporary signs required for the direction of public traffic through or around the work during construction. These signs are shown in or referred to in the current Manual of Traffic Controls or MUTCD. Construction area signs shall be installed at the locations shown on the Drawings, the TCP and at other locations as directed by the Engineer

B. All construction area signs shall conform to the dimensions, color and legend requirements of the current Manual of Traffic Controls or MUTCD and these specifications. All sign panels shall be the product of a commercial sign manufacturer, and shall be as specified in these specifications. The base material of construction area signs shall not be plywood or cardboard unless specifically identified in these specifications.

C. Sign panels for all construction area signs shall be visible at 500 feet and legible at 300 feet, at noon on a cloudless day and at night under illumination of legal low beam headlights, by persons with vision of or corrected to 20/20, except that the nighttime requirement shall not apply to fabric sign panels for portable signs

D. Temporary warning signs in construction areas shall have a black legend on an orange background. Color for other signs shall follow the standard for all highway signs.

E. All signs used during hours of darkness shall be reflectorized or illuminated.

F. Stationary Mounted Signs
   1. Stationary mounted signs shall be installed on wood posts in the same manner as shown on the Drawings for installation of roadside signs, except as follows.
   2. The height to the bottom of the sign panel above the edge of traveled way shall be at least 7 feet.
   3. Construction area sign posts may be installed on above ground temporary platform sign supports as favorably reviewed by the Engineer, or the signs may be installed on existing lighting standards or other supports as favorably reviewed by the Engineer. When construction area signs are installed on existing lighting standards, holes shall not be made in the standards to support the sign.
   4. The post embedment shall be 3 feet if post holes are backfilled around the posts with 3,000 PSI batch plant mix concrete.
   5. Sign panels for stationary mounted signs shall consist of Type II, Type III or Type IV retroreflective sheeting applied to an aluminum substrate conforming to the requirements in the California Department of Transportation's "Specifications for Reflective Sheeting Aluminum Signs." Copies of the Department's "Specifications for Reflective Sheeting Aluminum Signs," "Framing Details for Sheet Aluminum Signs," and sign specification sheets may be obtained from the Department's Office of Business Management, Materiel Operations Branch, 1900 Royal Oaks Drive, Sacramento, CA 95815.
   6. Sign panel fastening hardware shall be commercial quality.

G. Portable Signs
   1. Each portable sign shall consist of a base, standard or framework and a sign panel. The units shall be capable of being delivered to the site of use and placed in immediate operation.
   2. Sign panels for portable signs shall conform to the provisions for sign panels for stationary mounted signs in California Department of Transportation Section 12 3.06A, "Stationary Mounted Signs," or shall be Type VI retroreflective sheeting, or shall be cotton drill fabric, flexible industrial nylon fabric or other approved fabric. Fabric signs shall not be used during the hours of darkness. Size, color, and legend requirements for portable signs shall be as described for stationary mounted sign panels in Section 12 3.06A. The height to the bottom of the sign panel above the edge of traveled way shall be at least 1 foot.

H. "No Parking" signs posted shall be of heavy card stock and not less than 1.75 square feet of surface area on the face. Background color shall be white and letters shall be printed in red water-resistant ink, except that day, date, and time of restriction may be printed in black water-resistant ink. The signs shall be printed with the words "Tow Away" and "No Parking" with a character height of not less

than 2.75 inches and a stroke width of not less than 0.5 inches. The day, date, and time of the particular restriction shall be printed or attached below the above-mentioned wording in characters of not less than 2.0 inches in height and 0.4 inches in stroke width. The day of the week shall be written out or properly abbreviated with three to four letters; date or dates of restriction shall be listed completely; the beginning and ending times shall be clearly listed on the sign.

2.02 CONES AND PORTABLE DELINEATORS

A. Cones:
   1. Traffic cones shall be fluorescent and of good commercial quality, flexible material suitable for the purpose intended. The outer section of the portion above the base of the cone shall be translucent and be of a highly pigmented fluorescent orange polyvinyl compound.
   2. The overall height of the cone shall be at least 28 inches and the bottom inside diameter shall be not less than 10.5 inches. The base shall be of sufficient mass and size or shall be anchored in a manner that the traffic cone will remain in an upright position.
   3. During the hours of darkness traffic cones shall be affixed with retroreflective cone sleeves. The retroreflective sheeting of sleeves on the traffic cones shall be visible at 1,000 feet at night under illumination of legal high beam headlights, by persons with vision of or corrected to 20/20.

B. Portable Delineators:
   1. Portable delineators shall be orange in color.
   2. The overall height of the channelizer shall not be less than 36 inches and the width shall not be less than 3 inches. The base shall be of sufficient mass and size or shall be anchored in a manner that the traffic cone will remain in an upright position.
   3. Channelizers shall have affixed white retroreflective sheeting. The retroreflective sheeting shall be 3 inches x 12 inches in size. The retroreflective sheeting shall be visible at 1,000 feet at night under illumination of legal high beam headlights, by persons with vision of or corrected to 20/20.

2.03 BARRICADES

A. Barricades shall be Type I, Type II or Type III barricades as set forth in the Manual of Traffic Controls OR MUTCD.

B. Barricades used during hours of darkness shall be equipped with flashers.

C. Markings for barricade rails shall be alternate orange and white stripes. The entire area of orange and white stripes shall be Type I, engineering grade, or Type II, super engineering grade, retroreflective sheeting. The color of the orange retroreflective sheeting shall conform to PR No. 6, Highway Orange, of the Federal Highway Administration's Color Tolerance Chart. Retroreflective sheeting shall be placed on rail surfaces in such a manner that no air bubbles or voids are present between the rail surface and retroreflective sheeting. The predominate color for barricade components other than rails shall be white, except that unpainted galvanized metal or aluminum may be used. Sign owner identification shall not be imprinted on the reflectorized face of any rail, but may be imprinted elsewhere.

D. Ballasting shall be by means of sand-filled bags placed on the lower parts of the frame or stays, but shall not be placed on top of the barricade nor over any reflectorized barricade rail face facing traffic.

2.04 TEMPORARY RAILING (TYPE K)

A. Temporary railing shall consist of interconnected new or undamaged used precast concrete barrier units as shown on the Drawings. Exposed surfaces of new and used units shall be freshly coated with white color paint prior to their first use on the project. The paint shall conform to the provisions in California Department of Transportation Section 91 4.05, "Paint; Acrylic Emulsion, Exterior White and Light and Medium Tints".

B. Reinforcing steel shall conform to the provisions in California Department of Transportation Section 52, "Reinforcement". Steel bars to receive bolts at ends of concrete panels shall conform to the requirements in ASTM Designation: A 36/A 36M. The bolts shall conform to the requirements in ASTM Designation: A 307.

C. A round bar of the same diameter may be substituted for the end-connecting bolt shown on the Drawings. The bar shall conform to the requirements in ASTM Designation: A 36/A 36M, shall have a minimum length of 26 inches and shall have a 3-inch diameter by 3/8-inch-thick plate welded on the upper end with a 3/16-inch fillet weld.

D. Temporary railing (Type K) shall be set on firm, stable foundation. The foundation shall be graded to provide a uniform bearing throughout the entire length of the railing.

E. Abutting ends of precast concrete units shall be placed and maintained in alignment without substantial offset to each other. The precast concrete units shall be positioned straight on tangent alignment and on a true arc on curved alignment.

F. Each rail unit placed within 10 feet of a traffic lane shall have a reflector installed on top of the rail. Reflectors shall be as specified and adhesive shall conform to the reflector manufacturer's recommendations. A Type P marker panel shall also be installed at each end of railing installed adjacent to a two lane, two-way highway and at the end facing traffic of railing installed adjacent to a one-way roadbed. If the railing is placed on a skew, the marker shall be installed at the end of the skew nearest the traveled way. Type P marker panels shall conform to the provisions in California Department of Transportation Section 82, "Markers and Delineators," except that the Contractor shall furnish the marker panels.

2.05 FLASHING ARROW SIGNS

A. Flashing arrow signs shall be finished with commercial quality flat black enamel and shall be equipped with yellow or amber lamps that form arrows or arrowheads as required. Each lamp shall be provided with a visor and the lamps shall be controlled by an electronic circuit that will provide between 30 and 45 complete operating cycles per minute in each of the displays and modes specified. The control shall include provisions for dimming the lamps by reducing the voltage to 50 percent, ±5 percent, for nighttime use. Type I signs shall have both manual and automatic photoelectric dimming controls. Dimming in both modes shall be continuously variable over the entire dimming range.

B. Flashing arrow signs shall conform to the Manual of Traffic Controls orR MUTCD legibility requirements. The minimum legibility distance is the distance at which

flashing arrow signs shall be legible at noon on a cloudless day and at night by persons with vision of or corrected to 20/20

C. Flashing arrow signs shall be capable of being operated in four (4) different display modes as follows. The display to be used shall be as directed by the Engineer:
   1. Pass Left Display
   2. Pass Right Display
   3. Simultaneous Display - the lamps forming both right and left arrowheads and the lamps of the arrow shaft shall flash simultaneously.
   4. Caution Display - a combination of lamps not resembling any other display or mode shall flash.

D. Flashing arrow signs shall also be capable of operating in one or both of the following modes, at the option of the Contractor:
   1. Flashing Arrow Mode - all lamps forming the arrowhead and shaft shall flash on and off simultaneously.
   2. Sequential Mode - either arrowheads or arrows shall flash sequentially in the direction indicated.

E. Each flashing arrow sign shall be mounted on a truck or on a trailer and shall be capable of operating while the vehicle is moving and shall be capable of being placed and maintained in operation at locations as specified or as directed by the Engineer.

F. Flashing arrow signs shall be mounted to provide a minimum of 7 feet between the bottom of the sign and the roadway.

G. Electrical energy to operate the sign shall not be obtained from the vehicle on which the sign is mounted or from a generating plant mounted on the vehicle. Regardless of the source, the supply of electrical energy shall be capable of operating the sign in the manner specified.

2.06 PORTABLE TRAFFIC SIGNALS FOR ONE-LANE WORK ZONES

A. Provide two (2) portable traffic signals for work zone traffic control during the construction that have the following features:
   1. Portable traffic signals with adjustable overhead lights that can clear H20 truck height clearance requirements. Provide two (2) lights per unit.
   2. Battery powered capable of running for 21 days without being recharged and include a solar panel to recharge the batteries.
   3. Motion activation to sense traffic build-up.
   4. Work zone light to allow workers to know which signal is red and which is green with a different flashing pattern or other means.
   5. Preemption system to allow emergency vehicle immediate pass through the signal work zone.
   6. Digital speed display to display vehicle speed through the work zone.
   7. Back plates to enhance visibility of the traffic lights.
   8. Manual operation of the signals through use of a hand controller module that lets a flagger control the signals. Provide a means to eliminate possible conflicting indications at each signal during manual controller use.
   9. The portable signals shall be linked and be able to communicate and assign only the proper right-of-way assignment at a time.
   10. Provide for wireless radio communication between the traffic signals that conforms to MUTCD guidelines.

PART 3 - EXECUTION

3.01 DIVERTING PEDESTRIAN TRAFFIC

A. Whenever construction operations obstruct the flow of pedestrian traffic or present a hazard to pedestrians, take appropriate action to protect and separate pedestrians from the work area.

B. Such action may include placement of barricades between pedestrians and work areas, placement of warning signs, and provision of personnel as required to protect pedestrians as conditions warrant.

3.02 DIVERTING VEHICULAR TRAFFIC

A. Whenever construction operations obstruct the flow of vehicular traffic or present a hazard to vehicles operating in the vicinity of construction operations, take appropriate action to warn, detour and otherwise protect approaching drivers and vehicles.

3.03 MAINTAINING TRAFFIC CONTROL

A. General:
   1. Traffic control devices shall be provided in sufficient quantities and types as required to provide safe and adequate traffic control. To properly provide for changing traffic conditions and damage caused by public traffic or otherwise, the Contractor shall be prepared to furnish on short notice additional construction area sign panels, posts and mounting hardware or portable sign mounts. The Contractor shall maintain an inventory of the commonly required items at the jobsite or shall make arrangements with a supplier who is able, on a daily basis, to furnish the items on short notice.
   2. During hours of darkness, approved lights and/or flares shall be included, in proper working order, to illuminate signs and hazards and alert approaching traffic.
   3. Barricades shall be furnished and maintained along all open trenches in contact with traffic.
   4. No work may begin on any day or at any time before traffic control devices have been placed, test-driven and, if required, adjusted and revised.
   5. When leaving a work area and entering a roadway carrying public traffic, the Contractor's equipment, whether empty or loaded, shall yield to public traffic.

B. Traffic Control Placement:
   1. All traffic control devices shall be placed in accordance with the Manual of Traffic Controls or MUTCD and the favorably reviewed Traffic Control Plan.
   2. Locations of devices shall be adjusted to suit the conditions and circumstances of each detour situation. In all cases, signs shall be placed to most effectively convey their messages to approaching traffic.

C. Test Drive of Detour:
   1. Immediately after traffic control devices have been placed, the detour shall be test-driven by the Engineer and Contractor's representative.
   2. Test drive shall include approach to the detour from each possible direction and traversing full length of each detour route.
   3. Adjust and revise all traffic control devices as determined to be required by test drive-through and repeat test drive if determined necessary by the Engineer.

4. Provide additional traffic control devices if required to maintain flow of traffic through construction operation.

D. Maintenance of Traffic Control Devices:
   1. Maintain all traffic control devices, at proper locations and in proper working order, at all times during construction operations and whenever a hazard resulting from Contractor's operations exists.
   2. Adjust and revise traffic control devices, placement, etc., to suit changing conditions around construction operations.
   3. Clean all construction area sign panels at the time of installation and as often thereafter as the Engineer determines to be necessary. Used signs with the specified sheeting material will be considered satisfactory if they conform to the requirements for visibility and legibility and the colors conform to the requirements of the current Manual of Traffic Controls or MUTCD. A significant difference between day and nighttime retroreflective color will be grounds for rejecting signs.
   4. Monitor all traffic control on a daily basis and replace or restore any traffic control devices that have been displaced or damaged.

E. Removal of Traffic Control Devices:
   1. Traffic control devices shall remain in place at all times required to alert approaching traffic of upcoming hazards.
   2. After hazard has been removed, all traffic control devices shall be removed. Signs shall be removed or their messages covered until removed.
   3. Existing roadside signs conflicting with the construction area signs shall be removed and reset upon completion of work or securely covered as determined by the Engineer.

3.04 FLAGGERS

A. General: Flaggers shall perform their duties and shall be provided with the necessary equipment in conformance with the current "Instructions to Flaggers" of the California Department of Transportation.

B. Employ flaggers:
   1. As required for each specific detour in the Traffic Control Plan.
   2. At all locations on a construction site where barricades and warning signs are in sufficient to properly control traffic.

C. Placement: Where flaggers are required, they shall be logically placed in relation to the equipment or operation so as to give adequate warning and shall be placed approximately 100 feet ahead of impact point.

D. Warning Signs:
   1. A warning sign shall be placed ahead of the flagger reading: "Flagger Ahead." The distance between the sign and the flagger should be based on the average traffic speed, allowing approximately 50 feet for each 10 miles per hour.
   2. During hours of darkness, flagger stations shall be illuminated such that the flagger will be clearly visible to approaching traffic. Lights for illuminating the flagger station shall receive favorable review by the Engineer before use.

E. Equipment:
   1. Each flagger shall be provided with and wear a red or orange warning garment when flagging. Flaggers shall be provided with approved hand signs and two-way radios for communication.

2. When flagging during hours of darkness, a flagger shall signal with a red light or flare and shall have a belt and suspender harness outside his/her garment fitted with reflectors or made from reflectorized cloth, unless the garment is well reflectorized in one of these ways.

3.05 NOTIFICATIONS

A. Notify in writing all agencies having jurisdiction and service providers and all affected residents and businesses at least 48 hours, excluding holidays and weekends, prior to instituting any lane closure or detour. At the end of each day's work, inform the ambulance services, police and fire departments and affected community service providers of the status of all detours and/or lane or road closures.

B. List of agencies and service providers to be notified:
   1. County of San Diego
      a. Fire Department
      b. Police Department
      c. Public Works Department
   2. U.S. Postal Service
   3. Caltrans
   4. Caltrans District 11

3.06 EMERGENCY VEHICLE ACCESS THROUGH DETOURS

A. During all detours and/or street closures, provide for movement of emergency vehicles through the work area.

B. It is essential that the Contractor's work and equipment does not impede egress from any fire or police station to other areas of their service area.

3.07 ACCESS TO PRIVATE PROPERTY

A. General: Schedule and organize operations to minimize disruption of access to private property.

B. Notification: Prior to blocking access to any private driveway or parking lot entrance, notify the resident or business owner or tenant of pending closure at least 72 hours in advance and allow resident to remove vehicles.

C. Nights: During non-working hours no driveway, house or parking lot shall be denied access to a public roadway.

3.08 NIGHT DETOURS

A. General: The Contractor shall not be permitted to maintain any lane closure or road closure during non-working hours without first obtaining written approval of the Engineer.

B. Restoration of Pavement:
   1. During non-working hours, restore travel lanes to their original alignment and configuration by means of backfilling and temporary pavement or bridging the trench with beams and steel plates designed to support H-20 vehicles.
   2. Place "ROUGH ROAD" signs conforming to the Manual of Traffic Control or MUTCD at uneven temporary pavement or bridging.

3.09 PARKING RESTRICTIONS

A. General: Post approved "NO PARKING" signs at all locations necessary to establish work areas and detour traffic.

B. Signs:
   1. Signs shall read: "NO PARKING CONSTRUCTION TOW-AWAY ZONE." Show hours of parking restriction and indicate telephone number of police agency having jurisdiction.
   2. Signs shall be mounted such that the wording "No Parking" is at an elevation at least 3 feet and not more than 7 feet above the adjacent flow line. Signs may be tied with string to trees and power poles, taped to existing sign poles, or mounted to stakes or barricades provided by the Contractor. The signs shall be placed as needed to control the parking of cars within the construction zone; signs shall be placed at intervals of 75 feet or less along each side of the roadway.
   3. Signs shall be placed at least 24 hours in advance of restriction. Upon completion of the work, all signs, stakes, and barricades shall be promptly and completely removed and disposed of by the Contractor. The Contractor shall promptly reset or replace all damaged or defective signs.

C. Towing of Vehicles:
   1. The Contractor shall be fully responsible for the adequate removal of all parked cars. All vehicle removal shall be coordinated by the Contractor with the Police Department. The Contractor shall notify the Police Department upon posting of the parking restrictions for a particular street. For removal of parked vehicles, the Contractor shall notify the Police not less than two (2) hours prior to the needed removal with the address nearest the parked vehicle, make, model, color and license number. The Owner shall not be responsible for any delay or additional costs associated with the removal of parked cars that obstruct the construction operation.
   2. If a vehicle owner successfully contests a towing citation in court, and their citation is dismissed for causes related to the Contractor's failure to perform the requirements of this section, the Contractor shall reimburse the vehicle owner for the cost of any claims associated with the towing citation.

3.10 BRIDGING OVER TRENCHES AND EXCAVATIONS

A. General:
   1. For excavations not backfilled or permitted to remain open, bridging shall be placed across all trenches and excavations in existing streets and at driveways when work is not in progress.

B. Design of Bridging:
   1. Bridging for vehicular traffic shall be of sufficient width to accommodate the required number of travel lanes.
   2. Bridging shall be designed to support H 20 vehicular traffic.
   3. All bridging shall be set flush with travel surface or a satisfactory transition from travel surface to top of bridging shall be provided.
      a. A satisfactory transition shall mean a change in elevation between the levels of not less than 12 inches horizontal to 1 inch vertical.
      b. Transition may be accomplished by means of temporary pavement.

3.11 TEMPORARY TRAFFIC LANES

A. Temporary traffic lanes shall be at least 10 feet wide, unless otherwise indicated on the Traffic Control Plan. Provide an additional 2 feet of clearance from curbs. The length of temporary lanes should be limited to the area under construction and the distance necessary to divert traffic.

3.12 TEMPORARY PAVEMENT MARKERS

A. Wherever the Contractor's operations obliterate pavement delineation, including pavement markers and painted or thermoplastic lines for lane lines, stop bars, crosswalks, pavement legends, etc., such pavement delineation shall be replaced at the Contractor's expense by either permanent or temporary delineation before opening the traveled way to public traffic.

B. Temporary delineation shall consist of reflective traffic line tape applied in pieces not less than 12 inches long and not less than 4 inches wide. The tape pieces shall be spaced no more than 12 feet apart on curves and no more than 24 feet apart on tangents. For final resurfacing, provide reflective tabs or 3M 5710 or 5711 removable tape or approved equal at the above listed spacing.

C. Install temporary stop bars, limit lines and crosswalks at any location where the construction operation obliterated the existing delineations. These temporary stop bars, limit lines and crosswalks shall consist of 6-inch-wide 3M 5710 removable tape or approved equal.

D. Reflective line tape or tabs shall be applied in accordance with the manufacturer's instructions. Temporary delineation shall be the same color as the permanent delineation.

3.13 STAGING AREAS

A. The Contractor's equipment shall not be parked within any traffic lanes after working hours.

B. The Contractor shall provide its own staging areas.

3.14 TRUCK TRAFFIC PLAN AND RESTRICTIONS

A. Control the delivery and haul routes of all trucks having three or more axles used in conjunction with this work. This control shall extend to all such trucks owned by the Contractor, subcontractors, second and lower tier subcontractors, material suppliers, commercial haulers, and deliverers of equipment.

B. To reduce tracking of dirt, tack coat, and other objectionable material onto various streets, the Contractor shall limit the number of truck haul routes.

C. Arterial and collector streets shall be used for truck and equipment access.

D. Trucks and equipment shall not be routed or parked on residential streets unless otherwise approved by the Engineer or Owner.

3.15 MAINTAINING EXISTING AND TEMPORARY SIGNAL LIGHTING AND ELECTRICAL SYSTEMS

A. Ensure effective operation of existing traffic signals and street lights within the construction area, in accordance with 86-1.06 "Maintaining Existing and Temporary

Electrical Systems" of the State of California Department of Transportation Standard Specifications dated July 2006.

B. When working within 100 feet of any signalized intersection, arrange with the County of San Diego's or Caltrans' Traffic Engineer and Traffic Signal Technician to modify the controller timing as required to properly handle traffic during construction.

C. Damage to Signal Lighting Electrical Systems:
   1. Ascertain the exact location and depth of all existing detectors, conduits, pull boxes, and other electrical facilities before using any tools or equipment that may damage those facilities or interfere with any electrical system.
   2. In the event that traffic signal or street light conductors are damaged, arrange for their repair within 24 hours. If a permanent repair is not possible or infeasible, make temporary repairs to ensure safe and efficient operation, until permanent repairs can be made. Both temporary and permanent repairs shall be made at the Contractor's expense and in coordination with the County of San Diego's or Caltrans' Traffic Engineer and Traffic Signal Technician.
   3. In the event that in-pavement loop detectors are damaged, contact and coordinate with the County of San Diego's or Caltrans' Traffic Engineer and Traffic Signal Technician to modify the controller timing as required to properly handle traffic during construction. Arrange for immediate replacement of loop detectors upon completion of construction work within the traffic lane where the damage occurred.

END OF SECTION

SECTION 01650

FACILITY STARTUP

PART 1 - GENERAL

1.01 EQUIPMENT AND FACILITY STARTUP

A. Commission all systems and equipment to verify performance, function, and correct operation by performing procedures to activate, startup, adjust, test, and demonstrate that the work is in operating order in accordance with the general requirements of this Section and the detailed requirements of the technical sections under the system or equipment specified. To ensure that the work is ready for full-time operation, the procedures shall include verification, balancing, calibration, witness testing, documentation, inspection by equipment manufacturers and operator training where specified.

B. Notification: Notify the Engineer five (5) days prior to starting each system or piece of equipment.

C. Coordination: During the startup period, coordinate the operation of the lift stations with Engineer, subcontractors, Owner's operators, and manufacturer's representatives. Furnish test equipment, measuring devices and supplies required to conduct tests.

D. Maintain the equipment until acceptance. Provide all lubricants, chemicals, and electricity necessary until acceptance.

E. Furnish all expendable supplies, gas, water, etc., required for startup, demonstration and testing and dispose of all waste or used supplies, water, etc.

F. Favorably reviewed Operations and Maintenance (O&M) Manuals are required twenty (20) days before the startup of new equipment/facilities.

1.02 SUBMITTALS

A. Startup Plan, Forms, and Schedule: Prepare a facility startup plan and schedule. The plan shall include test methods and procedures and sample forms for recording test data.

B. Provide Affidavits as described in paragraph 1.04 B.

C. Submit documentation of tests, balancing reports, and the like.

1.03 INITIAL STARTUP AND OPERATION OF FACILITIES

A. The following listing is a general sequence of startup activity steps to be used in placing facility systems into operation:
   1. File an application for generator startup with Air Pollution Control District (APCD) San Diego prior to commencing construction.
   2. Perform initial lubrication of equipment and have manufacturers check and adjust equipment. Provide all subsequent lubrication and maintenance, and such staff as required for test operation until the Owner assumes equipment maintenance responsibility after Step 15 below.
   3. Perform satisfactory testing of electrical work required prior to energizing of the electrical system.

4. After completion of Step 3, perform satisfactory electrical testing required after energizing of the electrical system.
5. Complete calibration of instruments.
6. Satisfactorily complete system verification of instrumentation work.
7. After completion of Steps 2 and 4, perform a rotational test of equipment and correct backward rotating drives.
8. After completion of Steps 6 and 7, test operate the equipment by manually initiating the operation. Where manual operation bypasses alarm or safety monitoring, provide continuous supervision of such parameters. Perform this step using water in lieu of chemicals or other process liquids. Use dry air or nitrogen in lieu of hazardous gases. Following testing with water, chemical lines shall be drained and be fully dried, in accordance with the specifications, prior to introduction of chemical.
9. Concurrent with Step 8, perform instrumentation and control testing and adjustments as related to the equipment being tested.
10. Concurrent with Step 8 and where possible at this stage of startup, complete the performance testing specified for the equipment.
11. Concurrent with Step 8, perform adjustments of the electrical work as related to the equipment being tested.
12. Repeat Steps 2 through 11 as required for other equipment items and plant systems until all plant process components and utility systems are ready for lift stations' operation. It may be necessary for the Contractor to put portions of the newly constructed facility in service before constructing other portions of the facility or completing the Work as a whole.
13. Submit the required documentation of testing, calibration, and equipment affidavits.
14. Notify the Owner and the Engineer 45 days before total lift stations' operation is to occur so that the Owner may make arrangements for full-time operation. This notification shall have an accuracy of plus or minus seven (7) days. Notify the Owner and Engineer again, exactly seven (7) days before total lift station operation is to begin.
15. 30-Day Plant Startup and Initial Operation Test: Upon completion of all the above steps, the lift stations shall be started up and operated on a complete full-time basis beginning on the indicated date. The Owner will provide operating personnel and untreated water. For five (5) consecutive days beginning with the start-up day, the Contractor shall have at the lift station site, during the day shift, a mechanic, an electrician and an instrument engineer. Representatives of manufacturers of critical equipment shall also be present for these five (5) days as needed or as required elsewhere in the Specifications. The Contractor shall also provide these personnel, on a 24-hour per day, "on call" basis, if necessary, to adjust, repair, and correct deficiencies as required to keep the facilities in continuous operation for a period of 30 calendar days. The Contractor shall train the operators in the proper operation and the control of the new facilities. The Contractor shall also furnish all such mechanical and electrical workers as required to make adjustments to and perform all required maintenance for the operating equipment until the end of the 30-day initial operation period. Maintenance of operating equipment shall include lubrication, adjustments, replacements, and modifications as required.
16. After successful completion of the 30-day initial operation period, the Owner will take over maintenance duties as well as operation and will begin to provide and pay for lubricants. If continuous process operation is interrupted

for a period of four (4) consecutive hours or more due to a failure of the equipment or work provided by the Contractor, then the counting of the 5-day and/or 30-day periods, described in Step 15 above, shall be restarted at day one if these periods have not reached satisfactory completion.

17. Following the commencement of Step 15, satisfactorily complete equipment performance testing, electrical testing and adjustments, and instrumentation/control testing and adjustments to the extent that such testing and adjustments could not be made prior to full lift station operation.
18. Submit any remaining documentation of testing, balancing reports, equipment affidavits and the like commissioning before acceptance.

1.04 MANUFACTURER'S FIELD SERVICE AND AFFIDAVITS

A. Field Service: Where specified, manufacturers of equipment shall provide field service. Field service shall be provided by an authorized factory-trained and qualified manufacturer's representative for the specific equipment. Equipment shall not be considered ready for full-time operation until after the manufacturer's representative has checked and adjusted the equipment, and certified by written affidavit that the equipment has been properly installed, tested, adjusted, lubricated, and calibrated, and is ready for full-time operation.

B. Affidavits: Acceptable affidavits shall be submitted prior to completion of the work.
   1. Affidavits shall contain the following specific wording:
      "The [Name of Equipment] has been properly installed, tested, adjusted, lubricated, and calibrated, and is ready for full-time operation. The installation has been inspected and has been found to be in conformance with our (the manufacturer's) standards and requirements."
   2. Except for insertion of the equipment name, no amplification, dilution, or modification of this specific wording will be permitted.

1.05 TRAINING

A. Submit two Operation and Maintenance Manuals and Parts Lists specified in Section 01300 at least fifteen (15) days prior to the first training session.

B. Demonstrate the operation, maintenance and safety procedures for all systems and equipment to personnel designated by the Owner. Provide 8 hours of classroom training and 12 hours of onsite demonstration of systems and equipment.

C. In addition to overall training specified above, provide special demonstration and training for specific pieces of equipment specified in the Technical Specification Sections.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

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SECTION 01700

CONTRACT CLOSEOUT

PART 1 - GENERAL

1.01 FINAL CLEANUP

A. Prior to Final Inspection, the Contractor shall clean the entire construction area and all other areas affected by the performance of work under this Contract. Perform cleaning using personnel specializing in and skilled in cleaning and maintenance work. Perform repair work using personnel skilled in executing the type of work being repaired. Perform all work to the highest trade standards applicable to that type of work.
   1. Remove all temporary construction, signs, tools, equipment, excess material and debris.
   2. Remove all lumps, splatters, spots and stains caused by paint, adhesive, asphalt, concrete, mortar, sealant or other foreign material from exposed or finished surfaces. Remove all temporary labels.
   3. Repair, patch or replace new or existing work including pavement, sidewalks, curbs, gutters, catch basins, gratings, manholes, covers, landscaping, plant materials and other items that have been damaged, broken, cracked or chipped as a result of performing this Work.
   4. Sweep clean and wash down all exterior pavement surfaces. Remove all hazardous material and material that may cause sediment in drainage systems prior to washdown. Remove all grease and oil stains on pavement caused by Contractor's equipment.

1.02 CONTRACTOR'S ACTION LIST OF ITEMS TO BE CORRECTED AND/OR COMPLETED

A. During construction, the Contractor shall maintain an action list of items to be corrected and/or completed. Regularly add items and update the list as information becomes available or as requested by the Engineer. Deliver a current copy of the list to the Engineer at each progress meeting.

1.03 SEMIFINAL INSPECTION/SUBSTANTIAL COMPLETION

A. Substantial Completion includes compliance with the following requirements:

   1. The Contractor has, substantially completed the construction and erection of the Work in conformance with the Contract Documents.

   2. The Contractor has installed, adjusted, and successfully tested Products, equipment, and systems. The facilities are constructed as indicated by the erection, installation, and operations and maintenance instructions of the Suppliers.

   3. The Contractor has provided and completed the following items as approved by Owner:

      a. Contract Closeout Deliverables.
      b. Special Supplier's Warranties.

B. When the Contractor considers the Work nearly complete, the Contractor shall review the Contract Documents, inspect the Work, and use the Contractor's action list to prepare a Contractor's Punch List of all deficient or uncompleted items. Complete or correct the items on the Punch List. When the Work is Substantially Complete, notify the Engineer in writing that the Contractor has reviewed the Contract Documents, inspected the Work and believes that the Work is Substantially Complete and ready for Semifinal Inspection.

C. Prior to the pre-final and final inspections, the Contractor must complete the following:

1. Clean site; sweep paved areas, rake clean unpaved surfaces.

2. Remove waste and surplus materials, rubbish, fencing, equipment, temporary utilities, and construction facilities from the site.

C. On receipt of the Contractor's Punch List and notice that the work is ready for Semifinal Inspection, the Engineer will inspect the Work. The Engineer may add additional items to the Contractor's Punch List, may find that the Work is not ready for inspection, may find that the Work is ready for inspection but not Substantially Complete or may find that the Work is Substantially Complete. When the Engineer finds the Work is Substantially Complete, he/she will prepare a Final Punch List and a notice of Substantial Complete, which will state the date of Substantial Completion and the time agreed to by the Owner and the Contractor (not to exceed 30 calendar days) in which the Work shall be fully complete and ready for Final Inspection.

D. The discrepancy list(s) and punchlist will include all items of work found to be unsatisfactory, missing, incomplete, damaged, incorrect, or improperly installed or constructed. Prior to Final Acceptance, the Contractor shall correct the punchlist items by re-work, modification, or replacement, at the option of Owner and at no additional cost to Owner. Owner will re-inspect punchlist items upon notice by the Contractor that they are complete.

1.04 FINAL INSPECTION, FINAL COMPLETION AND FINAL PAYMENT

A. When the Contractor has completed or corrected all the items on the Engineer's Final Punch List, the Contractor shall give the Engineer written notice that the Work is ready for Final Inspection. When the Engineer finds the Work acceptable and fully complete in accordance with the Contract Documents, and upon receipt of a final Application for Payment and all final submittals, the Engineer will recommend that the Owner issue a Notice of Final Completion, make Final Payment and Accept the Work stating that to the best of the Engineer's knowledge, information and belief, and on the basis of the Engineer's observations and inspection, the Work has been fully completed in accordance with the terms and conditions of the Contract Documents.

B. Final Submittals include:
1. Operation and Maintenance Manuals and Parts Lists
2. Record Drawings
3. Extra Materials
4. Special Guarantees

5. Insurance Certificate showing required continuation of coverage beyond Final Payment. See General Conditions, Article 19.
6. Release of Liens. See General Conditions, paragraph 20.8.
7. Waiver of Claims by Contractor. See General Conditions, paragraph 20.11.
8. And any other submittals required by the Contract Documents and not previously received.

C. The Owner will record the Notice of Final Completion at the County Recorders Office.

D. The Owner will make Final Payment to the Contractor 35 calendar days after recording the Notice of Final Completion.

1.05 RECORD DRAWINGS

A. The Contractor shall maintain on the jobsite, a complete set of Contract Documents and a complete file of all addenda, contract modifications and favorably reviewed submittals. The Contractor shall prepare a set of Record Drawings concurrently with the construction of the Work and in accordance with the following:
   1. Show the invert elevation of all gravity piping and the top of pipe, top of conduit or top of protective concrete encasement for other utilities. Elevations shall be related to a permanent visible elevation benchmark set at the site by the Contractor.
   2. Show the horizontal location of underground utilities measured from permanent visible physical features such as face of building, face of tank, or centerline of manhole.
   3. Comply with detailed requirements in technical specification sections describing the type of information required on Record Drawings. The Contractor's copy of Contract Documents, Contract modifications and Record Drawings shall be available to the Engineer for weekly verification that the records are being currently updated.

B. Submit Record Drawings and obtain acceptance prior to completion.

1.06 EXTRA MATERIALS

A. Deliver specified extra materials and parts to Owner. Itemize all items on a transmittal letter in duplicate and obtain signature of receiving party. Submit copies of signed transmittals for all specified extra materials and parts prior to completion.

1.07 SPECIAL GUARANTEES

A. Article 19 of the General Conditions covers the Contractor's responsibility to remedy defects due to faulty workmanship and materials, which appear within one (1) year from the date of Final Completion and acceptance by the Owner.

B. Guarantees for more than one (1) year when called for in various sections of the Specifications shall be evidenced by the Contract Documents and in the form of a special guarantee written on the letterhead of the Contractor, subcontractor, or supplier doing the work and/or supplying the item to be guaranteed, and countersigned by the Contractor as follows. Failure to provide the special guarantee on the letterhead shall not relieve the Contractor, subcontractor, or supplier from its obligations for the special guarantees.

C. Special Guarantee:

We hereby guarantee that the _____ which we have provided in the _____, Project, was done in accordance with the Drawings and Specifications, and that the work, as installed, will fulfill the requirements of the guarantee included in Specification Section _____. We agree to repair or replace any or all of our work, together with any other adjacent work which may be damaged or displaced by so doing, that may prove to be defective in workmanship or material (with the exception of defects due to ordinary wear and tear, and unusual abuse or neglect) within a period of _____ years from the date of acceptance of the abovenamed facility, without any expense whatsoever to the Owner. In the event of our failure to comply with the above-mentioned conditions within the period set forth in Article 19 of the General Conditions after being notified in writing by the Owner, we, collectively or separately, do hereby authorize the Owner to proceed to have said defects repaired and made good at our expense, and we will honor and pay the costs and charges therefore upon demand. We understand that the provisions of General Conditions Articles 18 and 19 apply to this Special Guarantee.

Signed _____
(Subcontractor or Supplier)

Company_____

Address_____

Telephone Number_____

Countersigned_____
(Contractor)

D. Submit two (2) notarized original signed copies of each required Special Guarantee prior to completion.

1.08 TWELVE-MONTH INSPECTION

A. Thirty (30) days prior to the expiration of the one-year guarantee period described in General Conditions, Article 19, the Contractor shall tour the project with the Engineer and/or the Owner to prepare a list of corrective work required under the one-year guarantee. The Contractor shall correct all items found to be defective within 20 days of receipt of the list of items to be corrected.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 02050

DEMOLITION

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide all demolition required to perform the work covered under this contract including without limitation:
   1. Remove existing construction shown to be removed.
   2. Remove and replace existing construction and/or finishes as required to provide access to perform other work included in this contract.
   3. Include removal of mechanical and electrical work that is to be abandoned and is contained in construction to be removed whether or not the mechanical and electrical work is shown. Disconnect and cap off utilities in accordance with applicable codes and safety regulations.
   4. Where utilities that are not shown pass through construction that must be removed and those utilities serve other areas notify the Engineer before disrupting service. If rerouting is required to maintain service, the Owner may issue a Change Order to accomplish the required work.
   5. Store and protect items intended for reuse.
   6. Assume ownership of debris and unwanted materials, remove from the site and dispose of legally.
      a. Special requirements for waste management during deconstruction and construction operations.
         1) Protect the environment, both onsite and offsite, during deconstruction and construction operations.
         2) Prevent environmental pollution and damage.
         3) Maximize source reduction, reuse, and recycling of solid waste.
   7. Include the cost of removing and disposing of hazardous material including without limitation asbestos or asbestos-containing material, lead-containing paint, and PCBs.
   8. Comply with all State permit requirements for demolition. The Contractor shall perform a pre-demolition survey to determine whether hazardous material is present. If material is identified as hazardous, retain qualified and State-licensed Contractor to remove and dispose of the materials legally.
   9. If illegal electrical wiring is encountered such as “BX” or nonmetallic sheathed cable, notify the Engineer.
   10. Remove and properly dispose of unwanted fixed equipment, including without limitation unwanted lockers, shelving, hoods, equipment, machinery, and devices built into or attached to the building. Remove all loose items including rubbish, debris, furniture, etc.

1.02 NOISE AND DUST CONTROL

A. Perform work in accordance with requirements in Division 1. Particular attention is directed without limitation to paragraphs titled: Owner and Contractor's Use of Premises, Cleanup During Construction, Fire Protection During Construction, Maintenance of Exit Routes for Building Users, Temporary Dust Barriers, Noise Control and Care of Existing Facilities.

B. Provide temporary partitions to control dust and noise and exclude unauthorized persons.

C. Perform work in a manner to cause least disturbance to building occupants and least damage to work to remain.

D. Maintain adequate means of safe, clear egress for building occupants.

E. Employ all available techniques for construction noise abatement. Use remote, well-mufflered air compressors and newest noise suppressed pneumatic and electric tools.

1.03 WARNING

A. The Contractor is advised that work under this Section may be hazardous. The Contractor is to take all necessary precautions to ensure the safety of workers and property. Removal of and/or working in areas containing even minor amounts of hazardous material including without limitation, asbestos, lead-based paint, PCBs or other hazardous materials requires special precautions, knowledge, and procedures. If hazardous material is suspected, notify the Engineer or Owner.

1.04 QUALITY ASSURANCE

A. Maximize use of source reduction and recycling procedures.

B. Diversion Goals: A minimum 50 percent by weight of total project solid waste to be diverted from landfill.

1.05 PRECONSTRUCTION MEETING

A. After award of Contract and prior to the commencement of the Work, schedule and conduct meeting with Owner and Architect to discuss the proposed Waste Management Plan and to develop mutual understanding relative to details of environmental protection.

1.06 SUBMITTALS

A. Information to be submitted in accordance with Section 01300.

B. Submit copies of all executed permits.

C. Submit copy of post-asbestos abatement survey that certifies all asbestos has been cleared from the building prior to demolition.

D. Submit approval agreements with the hazardous waste treatment, storage, and disposal facility (TSDF) licensed to receive the hazardous materials.

E. Solid Waste Management Plan: Not less than 10 days before the Pre-construction meeting, prepare and submit a Solid Waste Management Plan including, but not limited to, the following:
   1. List of the recycling facilities, reuse facilities, municipal solid waste landfills and other disposal area(s) to be used. Include:
      a. Name, location, and phone number.
      b. Copy of permit or license for each facility.
   2. Identify materials that cannot be recycled or reused. Provide explanation or justification.
   3. Revise and resubmit Plan as required by Owner.
      a. Approval of Contractor's Plan will not relieve the Contractor of responsibility for compliance with applicable environmental regulations.

F. Progress Documentation: Document solid waste disposal and diversion. Include the quantity by weight of waste generated; waste diverted through sale, reuse, or recycling; and waste disposed by landfill or incineration. Identify landfills, recycling centers, waste processors, and other organizations that process or receive the solid waste.
   1. Document on Contractor provided form submitted to and approved by Owner.
   2. With each Application for Payment, submit updated documentation for solid waste disposal and diversion.
   3. With each Application for Payment, submit manifests, weight tickets, receipts, and invoices specifically identifying the Project and waste material.

G. Record Submittals: With Record Submittals as specified in Section 01780, submit the following:
   1. Summary of solid waste disposal and diversion. Submit on form approved by Owner.

1.07 PERMITS

A. Contractor shall fill out, submit and pay for the following permits:
   1. County of San Diego
      a. Encroachment Permit
      b. Excavation Permit

B. Refer to Appendix A for the CDPHE requirements and procedures for the asbestos abatement and building demolition.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.01 SOLID WASTE MANAGEMENT

A. Develop and implement a waste management program in accordance with ASTM E1609 and as specified herein.

B. Collection: Implement a recycling/reuse program that includes separate collection of waste materials of the following types as appropriate to the project waste and to the available recycling and reuse programs in the project area:
   1. Land clearing debris.
   2. Asphalt.
   3. Concrete and Masonry.
   4. Metal.
      a. Ferrous.
      b. Non-ferrous.
   5. Wood, nails, and staples allowed.
   6. Debris.
   7. Glass, colored glass allowed.
   8. Paper.
      a. Bond.
      b. Newsprint.
      c. Cardboard and paper packaging materials.

9. Plastic
    a. Type 1: Polyethylene Terephthalate (PET, PETE).
    b. Type 2: High Density Polyethylene (HDPE).
    c. Type 3: Vinyl (Polyvinyl Chloride or PVC).
    d. Type 4: Low Density Polyethylene (LDPE).
    e. Type 5: Polypropylene (PP).
    f. Type 6: Polystyrene (PS).
    g. Type 7: Other. Use of this code indicates the package in question is made with a resin other than the six listed above, or is made of more than one resin listed above, and used in a multi-layer combination.
10. Gypsum.
11. Non-hazardous paint and paint cans.
12. Flooring.
    a. Resilient Flooring.
13. Insulation.
14. Ceiling Tiles
15. Others as appropriate.

C. Recycling/Reuse: Maximize recycling and reuse of materials.
1. Recycling/Reuse on project site: Coordinate with Engineer.
2. Recycling/Reuse off project site: The following is a partial list for Contractor's information only. For more information, contact the State Department of Environmental Quality and the local Integrated Solid Waste Management Office.
    a. Habitat for Humanity, a non-profit housing organization that rehabilitates and builds housing for low-income families. Sites requiring donated materials vary. Contact the national hotline (800) HABITAT.
    b. California Materials Exchange (CAL-MAX) Program sponsored by the California Integrated Waste Management Board; (916) 255-2369.

D. Handling:
1. Clean materials that are contaminated prior to placing in collection containers. Deliver materials in accordance with recycling or reuse facility requirements (e.g., free of dirt, adhesives, solvents, petroleum contamination, and other substances deleterious to recycling process).
2. Arrange for collection by or delivery to the appropriate recycling or reuse facility.
3. Hazardous Waste and Hazardous Materials: Handle in accordance with applicable regulations.

E. Composting: In accordance with State Extension Service recommendations and as follows:
1. Moisture content: Maintain between 35 percent and 60 percent.
2. Carbon to nitrogen (C/N) ratio: Maintain at approximately 30 to 1 by weight.
3. Where the proposed Waste Management Plan incorporates composting of plastics, assess the potential effect of each type of plastic to be included on the composting process in accordance with ASTM D6002.

3.02 REMOVAL OF CONSTRUCTION IN AREAS TO RECEIVE NEW WORK

A. Remove structural work including but not limited to sanitary sewer lines and associated manholes designated for removal. Take precautions not to damage structural work intended to remain. Where temporary shoring is needed, submit a

design prepared by an appropriately licensed engineer for review before proceeding.

B. If structural elements are encountered that were not shown, protect them from damage and report their presence to the Engineer.

3.03 REMOVAL OF LIMITED PORTIONS OF EXISTING CONSTRUCTION TO PERMIT MODIFICATIONS

A. Provide careful, selective cutting and removal of existing construction as required to permit relocation or modification of partitions, doors, or openings. Cut and remove the least amount of work possible except when a larger area needs to be removed to permit strengthening existing construction or when required to remove finishes to a natural break line such as a corner or change in material.

B. Protect existing construction to remain with temporary coverings.

C. Treat existing mechanical, electrical, or structural work as described in other parts of this Section.

D. When modifications are complete, replace removed work with new construction and finishes to match adjacent existing work. Standards of material and workmanship shall be in accordance with other portions of this Specification or if not covered then in accordance with current practice for this class of work. Salvaged materials may be used for replacement if in good condition.

3.04 REMOVAL OF EXISTING CONSTRUCTION TO PROVIDE ACCESS TO PERFORM WORK

A. Provide careful selective cutting and removal of existing construction where required to permit installation of new concealed mechanical or electrical work, or installation of equipment, fixtures or devices.

B. Treat existing mechanical, electrical, or structural work as described in other parts of this Section.

C. Replace and/or patch removed construction and finishes in accordance with other parts of this Section.

3.05 PROTECTION OF WORK TO REMAIN

A. Protect all work to remain. Repair damage with materials, workmanship, and finishes matching existing work when new.

B. Most existing floor finishes will not be replaced in this contract. It is essential these floors be protected from any damage due to impact, dirt, abrasion, paints, and solvents.

3.06 CUTTING HOLES IN CONCRETE AND/OR CONCRETE MASONRY UNIT (CMU)

A. The Contractor is cautioned that electrical conduits and reinforcing that are not shown on Drawings may be concealed in concrete CMU construction. Use electronic detection equipment to locate concealed items before cutting holes. Take all required precautions to avoid damage to existing conduits or reinforcing.

B. New openings in existing concrete walls or slabs may be saw cut to opening perimeter lines where Drawings do not call for adding reinforcing trim bars to strengthen openings. Do not run saw kerfs past corners of openings. Complete concrete removal at opening corners by chipping and grinding. Take all required precautions to avoid water damage to existing construction or the Owner's property.

C. Where Drawings call for adding reinforcing trim bars to strengthen openings, limit saw cutting to a depth of 3/4 inch to avoid cutting existing reinforcing steel. Carefully chip out concrete to avoid damaging existing reinforcing steel which is to remain.

D. Use chipping guns to chip out small holes for pipes or conduits. Proceed carefully to avoid damage to concealed conduits. Core drilling is permitted only at the Contractor's risk and only with the Engineer’s permission. If core drilling is used, the Contractor shall: 1) use electronic detection equipment to locate conduit before drilling, 2) take precaution to avoid water damage to existing construction or the Owner's property, and 3) replace, at its own expense, any damaged electrical or signal wiring or conduits.

3.07 REMOVE UNWANTED FIXED EQUIPMENT

A. Remove manhole ring and covers. Cut off protruding bolts or attachment devices flush with existing surfaces.

B. Remove unwanted lockers, shelving, hoods, fixed and built-in equipment, machinery, machinery bases and similar items whether shown or not. Cut off protruding bolts or attachment devices flush with existing surfaces.

C. If items are designated on the Drawings to be salvaged, remove them carefully without causing damage. Deliver items to be turned over to the Owner to the Owner’s storage facility at 3707 Old Highway 395, Fallbrook, California 92028.

D. Store and protect items to be reused until time of need on jobsite.

3.08 IF HAZARDOUS MATERIALS ARE ENCOUNTERED

A. If hazardous materials are discovered, comply with paragraph 1.01 of this Section and all applicable laws.

3.09 REMOVAL AND DISPOSAL OF MATERIAL

A. Store debris in suitable covered containers located where directed by the Engineer and remove from site when full. Burning on the site is not permitted.

B. Removed material (other than material to be reused) shall become the property of the Contractor who shall remove it from the site and dispose of it in a legal manner.

3.10 UTILITY LOCATES AND DEMOLITION

A. There are electrical conduits that may nor may not be shown on the Drawings. Locate, demolish, and restore as required for the construction.

END OF SECTION

SECTION 02065

CONTROLLED LOW STRENGTH MATERIAL

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: This Section covers the work necessary for backfilling in confined areas around structures, pipelines or trenches, where specified or where access for compaction equipment is limited.

B. Related Sections:
   1. Section 03300: Cast-in-Place Concrete

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM) Standard Specification or Test Method:
   1. ASTM C33 Concrete Aggregates
   2. ASTM C94 Ready-Mixed Concrete
   3. ASTM C143 Slump of Hydraulic-Cement Concrete
   4. ASTM C150 Portland Cement
   5. ASTM C260 Air-Entraining Admixtures for Concrete
   6. ASTM C618 Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
   7. ASTM C685 Concrete Made by Volumetric Batching and Continuous Mixing
   8. ASTM D4318 Liquid Limit, Plastic Limit, and Plasticity Index of Soils
   9. ASTM D4832 Preparation and Testing of Soil-Cement Slurry Test Cylinders

B. American Concrete Institute (ACI):
   1. ACI 229 Controlled Low Strength Materials (CLSM)
   2. ACI 304 Guide for Measuring, Mixing, Transporting and Placing Concrete

C. State of California, Department of Transportation (CALTRANS):
   1. Section 19-3.062 Slurry Cement Backfill
   2. Section 19-3.025 Soil Cement Bedding

1.03 DEFINITIONS

A. Controlled Low Strength Material (CLSM): A mixture of portland cement, fly ash, aggregates and admixtures proportioned to provide a nonsegregating, self-consolidating, free-flowing and hand-excavatable material, which will result in a hardened, dense, nonsettling fill.

1.04 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Product Data:
   1. Concrete mix product certification: Submit certified laboratory test results that the mix proportions and materials comply with these Specifications. Submit certification on cementitious products and aggregates performed within the past 6 months.
      a. Cementitious materials.
      b. Coarse and fine aggregates.
      c. Admixtures.
      d. Water.

C. Quality Assurance/Control Submittals:
   1. Design Data: Submit a mix design for the material to be used.
   2. Test Reports: Submit trial laboratory and testing data with cylinder breaks performed at 7, 14, and 28 days.
   3. Certificates: Ready-mix plant certification.

1.05 QUALITY ASSURANCE

A. Certifications:
   1. Products and Materials Tests: Certified by independent commercial testing laboratories.
   2. Mix Designs: By an independent commercial testing laboratory, complying with ASTM C1077 and favorably reviewed by the Engineer. Mix design proportions shall be established on the basis of field experience and trial mixtures with the materials to be employed in accordance with UBC Section 1905.
   3. Mix Test Results.
      a. Submit result statistics of satisfactory mix designs if available from prior projects. Comply with UBC Section 1905.3.
      b. Submit test results of trial batches prepared for this project. Comply with UBC Section 1905.3.
      c. Allow adequate time for review of submittals and adjustments to comply with the Specifications.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Materials shall conform to the following:
   1. Portland Cement: ASTM C150, Type II or V.
   2. Aggregate: Comply with ASTM C33. Aggregate shall consist of fine aggregate, with or without coarse aggregate, with a minimum size of 1-inch, free of clay, organics, and other deleterious materials. Less than 10 percent by weight shall pass the No. 200 sieve, and material passing the No. 40 sieve shall be nonplastic as determined in accordance with ASTM D4318.
   3. Water: Potable.
   4. Fly Ash: ASTM C618, Class F unless otherwise approved.
   5. Admixtures: Air entraining; ASTM C260. Air content limited to 6% unless demonstrated to avoid segregation. Provide a liquid admixture such as DaraFill manufactured by W.R. Grace when air contents from 15-35% are required.

2.02 MIXES

A. Performance Requirements: The CLSM shall be proportioned to be a nonsegregating, free-flowing, self-consolidating, low-shrink slurry.

B. Mix Design Requirements: The Contractor and its supplier shall determine the materials and proportions used to meet the requirements of the Specifications. The mix design shall be prepared for a range of aggregate gradations that are expected to be used.

C. Strength: The unconfined compressive strength at 28 days shall be 100 psi (±50 psi) as per ASTM D4832.

D. Flowability: The slump shall be 7 inches (±1inch) as per ASTM C143.

E. Density: The density shall be between 115-145 lb/cy.

F. Minimum Cement Content: For compliance with Caltrans 185 lb/cy (110 kg/m3) for slurry cement backfill, 295 lb/cy (175kg/m3) for soil cement bedding.

2.03 SOURCE QUALITY CONTROL

A. Mix, transport, and place CLSM in accordance with the methods and procedures in ACI 304 and ASTM C94.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Site Verification of Conditions: CLSM batching, mixing, and placing may be started if the weather conditions are favorably and when the air temperature is 34°F and rising. At the time of placement, the CLSM must have a temperature of at least 40°F. Mixing and placing shall stop when the air temperature is 38°F or less and falling.

B. Subgrade on which CLSM is to be placed shall be free of disturbed or softened materials, debris, and water.

3.02 PREPARATION

A. Protection: Take appropriate precautions to prevent pipe displacement and/or flotation.

3.03 CONSTRUCTION

A. Special Techniques: Contain CLSM in trench sections using bulkheads or fill materials to confine the flow of material.

B. CLSM shall be placed in lifts not exceeding 6 feet in height, with a time interval of not less than 1 hour between lifts.

3.04 FIELD QUALITY CONTROL

A. Field Control Testing: Performed by the Contractor:
   1. After completion of the trial mix work, and prior to CLSM placement operations, the Contractor shall prepare field trial mixes. The initial mix shall be based on the design mix. Additional trial mixes may be made by varying the proportions as may be required to produce a dense, homogenous material with good workability.
   2. Manufacture of the field trial mixes shall be accomplished utilizing the equipment that will be used on the job.
   3. Compressive strength: A set of six standard 6 inch x 12 inch cylinders will be cast for each mix.
      a. Making, storing and initial cure of cylinders: ASTM C94 or C685. Provide site storage and initial cure, 16 hours minimum and 24 hours maximum.
      b. Testing laboratory: Provided by Contractor.
      c. Final cure and tests of cylinders: ASTM D4832. Testing laboratory will transport cylinders from site, cure, test and provide report. Test one specimen at 7 days, one at 14 days, one at 21 days, and two at 28 days. One specimen shall be held as a "spare" and may be used in the event of questionable results from one of the scheduled tests.

B. Site Tests: Performed by the Engineer:
   1. Test frequency: Each mix type placed, each day placed.
   2. Compressive strength: A set of four standard 6-inch x 12-inch cylinders will be cast for each mix and for 100 cubic yards or fraction thereof.
      a. Making, storing and initial cure of cylinders: ASTM C94 or C685. Provide site storage and initial cure, 16 hours minimum and 24 hours maximum.
      b. Testing laboratory: Provided by Owner.
      c. Final cure and tests of cylinders: ASTM D4832. Testing laboratory will transport cylinders from site, cure, test and provide report. Test one specimen at 7 days, and two at 28 days. One specimen shall be held as a "spare" and may be used in the event of questionable results from one of the scheduled tests.
   3. Slump: Test will be performed on each 50 cubic yards or fraction thereof. Test each sample used for strength tests.
      a. Testing: ASTM C143.
      b. Results outside the limits indicate possible cause for rejection of concrete. The Engineer shall be the sole judge.

3.05 PROTECTION

A. When backfilling against retaining walls or other below grade structures, protection shall be provided to the wall or structure from the lateral pressures exerted by the material.

B. Protect facilities from bleed water. Make provisions for runoff of bleed water.

C. Provide steel plates to span trenches and prevent traffic contact if necessary. No traffic or construction equipment shall be allowed on CLSM for at least 24 hours after placement, or until the material is hard enough to prevent rutting or damage.

END OF SECTION

SECTION 02070

WASTEWATER FLOW MANAGEMENT PLAN

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Planning and implementation of wastewater flow diversions.

1.02 SUBMITTALS

A. Wastewater Flow Management Plan as specified herein.

B. Public Notification Letter: Submit public notification letter/flyer to Engineer for review and acceptance prior to distribution to public.

1.03 GENERAL REQUIREMENTS

A. Contractor shall provide labor, materials, and supervision to temporarily provide bypass pumping and flow control around the Contractor's work in accordance with the specific needs of the inspection, cleaning, or rehabilitation work.

B. The means and methods of accomplishing and maintaining the bypass system shall be the sole responsibility of the Contractor.

C. No interruption of sewage flow shall be permitted throughout the duration of the project.

D. The Contractor is advised that the bypass plans must provide for accessibility to pedestrians and vehicular traffic in accordance with local agency/property owner requirements.

E. Bypass Operation will be required 24 hours per day during the period of Work. The bypass pumps and piping flow shall be continuously monitored by a competent operator.

F. Contractor shall inspect upstream and downstream diversion structures / manholes prior to installation. Any modifications, excavations, or improvements required for the upstream and downstream manholes to facilitate bypass pumping equipment should be included in the Wastewater Flow Management Plan submitted by the Contractor and shall be performed by the Contractor. The Contractor is responsible for providing pumps and temporary storage, if required, to handle the incoming flows.

G. Bypass pumping shall be performed in a manner so as not to create a public nuisance or health hazard and shall conform to current practices. The Contractor shall supply and operate equipment for pumping the listed flow rates with provisions for 100% backup pumping capacity onsite during pumping operation. Discharge line locations and street crossings shall be coordinated with the appropriate governing agency.

1.04 PUBLIC RELATIONS

A. The Contractor is responsible for contacting property owners and businesses that are affected by the construction activities to inform them of the Work to be done and the estimated schedule and timing for the Work. Written notice shall be delivered to each home or business 2 weeks prior to installation of the liner. Notice shall include a local telephone number of the Contractor, and contract information for the Owner or Engineer. Written notices must be reviewed by the Engineer prior to distribution to the public.

1.05 WASTEWATER FLOW MANAGEMENT PLAN

A. The Contractor shall submit to the Engineer a Wastewater Flow Management Plan (WFMP) at least fifteen (15) working days prior to implementation of flow diversion/bypass. The WFMP shall indicate the sequence of diversion operations, and all other operations the Contractor will establish to maintain wastewater service during the diversion/bypass period. The WFMP shall be reviewed and accepted by the Engineer before flow can be diverted/bypassed. No deviation from the approved WFMP will be allowed without prior approval from the Owner or Engineer.

B. The WFMP shall include, but not be limited to, the following:
   1. Drawings indicating the scheme and location of pumps, suction piping, discharge piping, and temporary sewer plugs for each of the project sites.
   2. Capacities and sizes of pumps, standby equipment, and power requirements if applicable.
   3. Design calculations proving adequacy of the system and selected equipment, including static lift, friction losses, fitting losses, flow velocity, pump curves showing operating range, and pipe thickness calculations.
   4. The submittal shall include a start date, time, and duration of diversion.
   5. Sewer plugging method and type of plug.
   6. Method of noise control for each pump and generator.
   7. Thrust and restraint block sizes and locations where space is limited.
   8. Temporary pipe supports and anchoring where required.
   9. Temporary creek crossing pipe supports and anchoring methods where required.
   10. Staffing Plan.

C. The WFMP shall include a Wastewater Discharge Emergency Response Plan indicating the procedures, personnel, equipment, and activities that will be implemented in the event of a wastewater discharge, spill or overflow to the environment, or diversion system failure. The Contractor shall be responsible for implementation of the Wastewater Discharge Emergency Response Plan in accordance with Section 02072.

D. The Contractor shall submit as part of the WFMP the monitoring procedure and frequency and shall continuously monitor the flow levels downstream and upstream of the flow diversion to detect any possible failure that may cause a wastewater discharge. The Contractor shall maintain a daily log of the monitoring and provide weekly copies to the Engineer in a manner acceptable to the Owner.

E. The Contractor shall observe and comply with all Federal, State, and local laws, ordinances, codes, orders, and regulations which in any manner affect the conduct of the work, specifically as they relate to wastewater discharges, spills, or overflows to the environment. The Contractor shall be fully responsible for preventing wastewater

discharges, spills or overflows, containing the wastewater, recovery and legal disposal of wastewater, any fines, penalties, claims and liability arising from negligent or willful discharge of wastewater, and violation of any law, ordinance, code, order, or regulation as a result of the discharge, spill or overflow. The Contractor shall be responsible for payment of any fines or penalties assessed against the Owner for such wastewater discharges, spills, or overflows, including any attorney fees and costs associated with defending any action against the Owner resulting from such discharges, spills or overflows.

F. For bypass systems that must cross over a creek or drainage way, the Contractor is responsible for designing a support system to elevate the piping above the water way's **2-year** flood elevation. The contractor shall submit the shop drawings to the Engineer for acceptance prior to installation. The bypass piping supports shall be installed within the water way, or in a location that will not impede flow during a storm event.

1.06 FLOW DATA

A. Thoroughbred PS: The average daily flow in the sewer pipe is 440 gallons per minute (gpm) and the peak flow is 1,100 gpm. Contractor to verify flows before bypass pumping commences.

PART 2 - PRODUCTS

2.01 TEMPORARY DIVERSION STRUCTURES

A. Contractor, at his/her discretion, may construct additional diversion structure(s) at the bypass pump set-up location to accommodate the incoming wastewater flows for pumping. The Contractor is responsible for providing pumps and temporary storage, if required, to handle the incoming flows.

2.02 BYPASS PUMPING EQUIPMENT

A. All bypass piping must be rigid pipe; flat piping (hose) is not acceptable.

B. The Contactor shall only use equipment inspected and found to be fully functional. The Contractor shall use pressure-rated piping materials in good working condition. Where five or more pipes will be used, provide one redundant, additional pipe of greater or equal size.

C. The Contractor shall provide a pumping system consisting of pumps, pipe and generators, if applicable, capable of handling an estimated peak flow of 1,100 gpm for the Thoroughbred EQ Basin and 1,285 gpm for the Schoolhouse Lift Station. Extra pumps and generators, if applicable, with a total capacity equal to 100% of the design flows must also be provided. A minimum of three pumps and generators, if applicable, shall be on site with no single pump and generator, if applicable, having less than 50% capacity of the design flows. The Contractor shall utilize the flow bypass system to perform the necessary maintenance and repairs on the flow bypass system, and exercise and ensure the operation of the backup pumps. The Contractor shall operate the backup pumps for a minimum of 25% of the total bypass time on a daily basis. All pumps shall be fully installed, operational, and ready for immediate use.

D. The influent flow rate into the bypass pumping diversion structure could be variable, and the flow rate could change from low flow to high flow over a short period of time. The bypass pumping system shall be capable of quickly adjusting to accommodate the variability in the influent flow rate.

E. Pumps and generators shall be equipped with devices such as (but not limited to) mufflers and/or plywood/Styrofoam noise panels enclosing the engines to keep the noise level down to a minimum. A maximum noise level of 50 decibel (dBA) is permitted.

2.03 TEMPORARY OR PERMANENT BYPASS PUMPING FACILITIY

A. Vacuum Inserted Sewer Clean-Out (As required by Engineer for sewer services expected to be out-of-service for more than 48 hours)
   1. The clean-out shall be a one-piece, molded PVC riser pipe and saddle. The riser pipe shall be solvent welded to the saddle boss. The saddle shall conform to the lateral pipe by a snap fit where the lateral pipe is either four (4") or six (6") in diameter. The riser pipe shall be SDR 35 or SDR 26 PVC. The resin will be a one-part marine grade adhesive/sealant designed for the specific designed for the application of a VAC-A-TEE saddle adhered to the lateral pipe by a chemical bond.
   2. Manufacturers:
      a. VAC-A-TEE by LMK Enterprises, Inc.
      b. Or Approved Equal
   3. Acceptable Installers
      a. C&L Water Solutions or approved equal by Engineer

PART 3 - EXECUTION

3.01 BYPASS PUMPING EQUIPMENT

A. The Contractor shall continuously monitor the flow levels downstream and upstream of the flow diversion to detect any possible failure that may cause a wastewater discharge. The Contractor shall maintain a daily log of the monitoring and provide weekly copies to the Owner in a manner acceptable to the Engineer.

B. The Contractor shall provide one dedicated fuel tank for every single pump/generator, if fuel/generator driven pumps are used. The Contractor shall provide a fuel level indicator outside each fuel tank. The Contractor shall continuously (while in use) monitor the fuel level in the tanks and ensure the fuel level does not drop below a level equivalent of 2 hours of continuous flow diversion system operation. The Contractor shall take the necessary measures to ensure the fuel supply is protected against contamination. This could include, but is not limited to, fuel line water traps, fuel line filters, and protecting fuel stores from precipitation. The Contractor shall also monitor all hoses and repair leaks immediately.

C. The Contractor shall provide fuel leak containment around all generators.

D. Drain residual wastewater from piping system to pipelines prior to disassembly, taking care to avoid wastewater spills.

E. All pumps, generators and other equipment shall be placed on a plastic tarp to protect against spills of petroleum products used by the equipment.

3.02 QUALITY CONTROL

A. The Contractor must provide 24-hour supervision of the bypass pumping system during operation.

B. The Contractor shall inspect the entire bypass pumping and piping system for leaks or spills on an hourly basis. The bypass system will have trained and qualified attendants around the clock whose only duty is to maintain the bypass pumping system until the bypassing of that specific pipeline is no longer required. The attendants shall be qualified to both operate and repair any and all problems that may occur. The attendants shall have a cellular phone for communication between the Owner and the site in the event of emergencies. No bypassing to the ground surface, receiving waters, storm drains, or bypassing which results in soil or groundwater contamination or any potential health hazards shall be permitted. In the event of any sewage spill, the Contractor shall be responsible for the prompt cleanup and disinfecting of the spill as outlined in Section 02072, Wastewater Discharge Emergency Response Plan. The Contractor shall compensate the Owner for the cost of any fines levied as the result of a spill or unauthorized discharge.

C. The Contractor shall inspect and maintain the bypass system daily, including the backup system. The Contractor shall maintain a log of all inspection, maintenance and repair records, and provide copies to the Engineer upon request.

D. The Contractor shall not damage existing public and private improvements, interrupt existing services and/or facility operations which may cause a wastewater discharge, spill or overflow. Any utility and/or improvement which is damaged by the Contractor shall immediately be repaired at the expense of the Contractor.

E. The Contractor is prohibited from discharging any groundwater, stormwater or hazardous waste encountered during the construction project.

3.03 HYDROSTATIC PRESSURE TESTING

A. The diversion system shall be hydrostatically pressure tested in the presence of the Owner or its representative using potable water prior to wastewater flow diversion. The Contractor shall demonstrate to the satisfaction of the Owner or its representative that both the primary and backup flow diversion systems are fully functional and adequate, and shall certify the same, in writing, to the Owner in a manner acceptable to the Engineer.

B. Hydrostatic Pressure Test:
   1. Prior to operation, test each section of discharge piping.
   2. Test pressure shall be 50% greater than maximum operating pressures, or 10 psi above maximum operating pressures, whichever is greater.
   3. The test shall run for a period of 2 hours in the presence of the Owner or its representative.
   4. The Contractor shall fill the line with water.
   5. The line shall be sealed on the discharge end.
   6. The line may be put in service if after the 2-hour period the pressure has been maintained and there are no observable leaks.
   7. Notify Engineer 24 hours prior to testing.

3.04 TEMPORARY OR PERMANENT BYPASS PUMPING FACILITIY

A. Vacuum Inserted Sewer Clean-Out
   1. Contractor shall notify Engineer that a specific sewer service is expected to be out-of-service for more than 48 hours. Contractor shall notify Engineer within 72 hours of required sewer service disruption.
   2. Engineer will determine whether temporary bypass pumping facility is required, and Engineer will report back to Contractor within 24 hours.
   3. Locate the lateral pipe.
   4. In grass areas, the sod shall be neatly cut and removed. In pavement areas, the pavement shall be straight-line marked, cut and removed.
   5. The vacuum excavated borehole shall be approximately twenty-inches (20") in diameter and all spoils shall be deposited in a vacuum truck.
   6. A riser pipe of an appropriate length is solvent welded to the saddle.
   7. The adhesive/sealant shall be applied to the underside of the saddle at no less than a ¼" thick layer.
   8. The saddle and riser pipe shall be carefully inserted into the bore hole, setting the saddle onto the pipe, applying a downward force causing the saddle to expand and snap onto the lateral pipe.
   9. Immediately after the saddle has been affixed to the lateral pipe, the riser pipe should be secured by backfilling the bore hole with sand or pea-gravel to within 6-inches of the original grade.
   10. An exfiltration test shall be performed by filling the riser pipe with a 6-foot column of water. The test shall be performed no less than 2-hours from the time of affixing the saddle to the pipe. The column of water shall be held for five minutes. The water level shall be measured from the top of the riser pipe. Zero leakage is allowed.
   11. A diamond core saw shall be introduced into the riser pipe, the crown of the pipe is cut and the coupon is removed.
   12. An approved cap or cover is installed at ground level or below ground level.

B. Should soil conditions reveal running sand or similar conditions that would prohibit the installation, the installation shall be terminated and the borehole filled with flowable grout. The surface area shall be restored to its original condition.

3.05 CLEAN-UP

A. The bypass pumping system shall be cleaned and drained prior to being dismantled and moved. The Contractor shall alternate pigging and purging of the system to remove all loose material. After the Contractor has cleaned the pipe, and prior to dismantling of the piping for removal from the Project site, the Contractor shall disinfect the pipe with 10% chlorine and water solution. Notify the appropriate governing agency of the downstream Wastewater Treatment Plant for chlorine added to sanitary sewer pipe larger than 24-inches in diameter.

B. Disturbed Areas: Upon completion of bypass pumping operation, clean disturbed areas, restoring to original condition, including, but not limited to, pavement restoration and landscaping, at least equal to that which existed prior to start of Work.

3.06 SCHEDULING

A. The bypassing system shall not be shut down between shifts, on holidays or weekends, or during work stoppages without written permission from the Engineer or Owner.

3.07 WASTEWATER DISCHARGE/DIVERSION SYSTEM FAILURE

A. In the event of a wastewater discharge, spill or overflow, or diversion/bypass system failure, immediately implement the Wastewater Discharge Emergency Response Plan (Section 02072).

B. The Contractor will be charged for all costs associated with the Owner's efforts if they are dispatched to the discharge, spill or overflow.

END OF SECTION

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SECTION 02072

WASTEWATER DISCHARGE EMERGENCY RESPONSE PLAN

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Development of a Wastewater Discharge Emergency Response Plan, to be implemented in the event of a wastewater discharge, spill or overflow to the environment.

1.02 SUBMITTALS

A. Emergency Response: Detailed implementation plan.

1.03 WASTEWATER DISCHARGE EMERGENCY RESPONSE PLAN DEVELOPMENT

A. The Contractor shall develop and submit to the Owner at least fifteen (15) working days prior to the start of construction, a written Wastewater Discharge Emergency Response Plan (WDERP) in a form similar to the attached sample at the end of this section. The WDERP shall be developed to respond to any construction related wastewater discharge, spill, or overflow to the environment. The Contractor's WDERP shall not rely on the Owner's personnel for emergency response, but they may be dispatched at the Owner's discretion, to provide additional assistance. If the Owner's personnel are utilized, the Contractor shall be responsible for all associated costs. The Contractor is prohibited from discharging any groundwater, stormwater, or hazardous waste encountered during the construction project.

B. The WDERP shall include at minimum, the following:
   1. Identification of environmentally-sensitive areas that could be affected by a wastewater discharge, spill, or overflow, including but not limited to, waterways, channels, catch basins, and entrances to existing underground storm drains.
   2. Development of an emergency notification procedure that complies with State and Federal requirements including but not limited to, Section 25-8-601(2), C.R.S. The Contractor shall designate primary and secondary representatives, their respective office telephone numbers, mobile phone numbers and e-mail addresses shall be provided. Owner contacts shall also be listed.
   3. Identification of personnel and equipment/tools that will be utilized in the event of a wastewater discharge, spill, or overflow to the environment. Include an emergency response team with arrangements for backup personnel and equipment. The emergency response team shall be able to dispatch to the site 24 hours a day 7 days a week including weekends and holidays to respond immediately to any wastewater discharge, spill, or overflow to the environment related to the Project work.
   4. Identification of downstream public water systems.
   5. Identify owners of stormwater inlets in immediate vicinity.
   6. Step-by-step procedures to contain, control, and minimize wastewater discharges, spills, or overflows to the environment.

C. At the pre-construction meeting, the Contractor will be provided with a list of Owner representatives to contact in case of a wastewater discharge, spill, or overflow to the environment. These contacts shall be added to the WDERP.

D. Contractor cannot begin work until the Engineer has accepted the WDERP in writing. The complete and final copy of the WDERP shall be available on the job site at all times.

E. It shall be the Contractor's responsibility to assure that all employees, including subcontractors, know and obey all emergency procedures included in the WDERP.

F. The emergency response plan shall comply with local regulations,

1.04 WASTEWATER DISCHARGE EVENT

A. In the event of a wastewater discharge, spill, or overflow to the environment, the Contractor shall:
   1. Immediately implement the WDERP without direction from the Owner or the Engineer, to control and contain the discharge, spill, or overflow to the environment.
   2. Contact the Owner's personnel immediately. Information to provide shall include at minimum, the following:
      a. Location of discharge, spill, or overflow to the environment
      b. Estimated volume
      c. Time discharge, spill, or overflow began
      d. Duration if already terminated, or expected duration if in progress
      e. Cause (if known)
      f. Control measures implemented
      g. Type of remedial and/or clean up measures taken
      h. Description of affected or potentially affected sensitive areas such as waterways, channels, catch basins, and entrances to existing underground storm drains.
   3. Based on this information, personnel will determine whether the discharge, spill, or overflow is contained, and whether or not the Owner's maintenance staff should be dispatched to the site. If dispatched, the Contractor shall be responsible for all costs incurred by the Owner's maintenance staff as associated with the discharge, spill, or overflow.
   4. Contact owner of stormwater inlets if discharge, spill, or overflow enters stormwater system.

B. The Contractor shall, within 2 working days of the wastewater discharge, spill, or overflow, submit to the Owner a written Wastewater Discharge Incident Report (Figure 1).

C. The Owner's representative will evaluate the suggested procedural changes to avoid further discharges, spills, or overflows and will instruct the Contractor through the Owner on changes. The Owner may institute further corrective actions, as deemed necessary.

D. The Contractor shall observe and comply with all federal, state, and local laws, ordinances, codes, orders, and regulations which in any manner affect the conduct of the work, specifically as they relate to wastewater discharges, spills, or overflows to the environment. The Contractor shall be fully responsible for preventing wastewater discharges, spills, or overflows to the environment, containing the sewage, recovery and legal disposal of sewage, any fines, penalties, claims and liability arising from negligent or willful discharge of

wastewater, and violation of any law, ordinance, code, order, or regulation as a result of the discharge, spill or overflow. The Contractor shall be responsible for payment of any fines or penalties assessed against the Owner for any such sewage discharge, spill, or overflow, including any attorney fees and costs associated with defending any action against the Owner resulting from such discharge, spill or overflow.

E. The Contractor shall not damage existing public and private improvements, or interrupt existing services and/or facility operations which may cause a wastewater discharge, spill, or overflow to the environment. Any utility and/or improvement which is damaged by the Contractor shall immediately be repaired at the expense of the Contractor.

F. Once the discharge, spill, or overflow has been contained and the situation causing the event has been stabilized, the Contractor shall restore the affected areas to original condition.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 02072-FIGURE 1

WASTEWATER DISCHARGE INCIDENT REPORT

Project Title:

Report Date:

Incident Date:

Discharge Location:

Time & Duration of Discharge:

Estimated Lost Wastewater Volume:

Notification to Owner/Engineer
Who/When Notified:

Description of the Incident:

Cause (if known):

Control Measures Implemented:

Remedial and/or Cleanup Measures Taken:

Recommended Procedural Changes:

REPORTED BY: [Contractor Representative]

_____
Signature Date

RECEIVED BY: [Owner Representative]

_____
Signature Date

[Engineer Representative]

_____
Signature Date

cc:

SECTION 02080

PRECAST CONCRETE SECTIONAL MANHOLES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Precast reinforced concrete cylindrical sectional manholes, complete with openings, inserts, ladder rungs (where specifically called for), hardware, drains, covers and frames.
   2. Precast reinforced concrete manhole bases and tops.

B. Related Sections:
   1. Section 02065: Controlled Low Strength Material
   2. Section 02301: Earthwork
   3. Section 03300: Cast-In-Place Concrete
   4. Section 09961: High Solids Epoxy Lining

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM), Standard Specifications:
   1. A36 Structural Steel
   2. A48 Gray Iron Castings
   3. C150 Portland Cement
   4. C478 Precast Reinforced Concrete Manhole Sections

B. American Association of State Highway and Transportation Officials (AASHTO), Standard Specifications for Highway Bridges.

C. Federal Specification: SS-S-210: Sealing Compound, Preformed Plastic, for Expansion Joints and Pipe Joints.

1.03 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Product Data:
   1. Descriptive details of the manufacturer's proposed standard products, including:
      a. Precast manhole sections.
      b. Precast roof slab or cone section.
      c. Precast base slab.
      d. Steps, ladder rungs and other hardware.
      e. Minimum concrete 28-day compressive strength.
      f. Cement certification.
      g. Manhole cover and frame.
   2. Shop drawings, including:
      a. Design criteria.
      b. Reinforcing steel location and concrete cover.

c. Layout of all inserts, attachments and openings.
d. Location and type of joints.

1.04 QUALITY ASSURANCE

A. Provide products of a manufacturer who has been regularly engaged in the design and manufacture of the product.

B. Demonstrate to the satisfaction of the Engineer that the quality is equal to the product made by those manufacturers specifically named herein, if an alternate product manufacturer is proposed.

PART 2 - PRODUCTS

2.01 DESIGN CRITERIA

A. General: ASTM C478, and also:
1. Roof slab live load: AASHTO Loading Class HS 20-44, 300 lb/sq. ft..
2. Backfill material: Structural backfill.
3. Buoyancy: Design manhole for groundwater up to 0 feet below grade.

2.02 PRECAST SECTIONS

A. General:
1. Manhole cone section: Eccentric taper.
2. Cement: ASTM C150, Type II, low alkali.
3. Roof slab opening: Size to support the manhole cover frame.
4. Lifting eyes: Provide for each section.
5. Lining: Refer to System No. 13, Section 09961.

B. Manufacturer: Jensen Precast, Inc., Fontana, CA; Oldcastle Precast. Inc., Fontana, CA; or equal.

2.03 SEALANT GASKETS

A. Type: Preformed, continuous rope form plastic material, protected by removable two-piece wrapper.

B. Sealing Compound: Reinforced hydrocarbon resins blended with plasticizing compounds and reinforced with inert mineral filler. No solvents, irritating fumes or obnoxious odors.

C. Adhesive and Cohesive Strength: Not dependent on oxidizing, evaporating, or chemical action.

D. Conform to Federal Specification SS-S-210.

E. Provide: RAM-NEK as manufactured by K. T. Snyder Company, Inc., Houston, TX; QUIKSEAL as supplied by Associated Concrete Products, Santa Ana, CA; or equal.

2.04 FRAMES AND COVERS

A. Material: Cast iron; ASTM A48, Class 30B.

B. Marking: In raised letters, as specified, on manhole cover.

C. Coating: Bituminous paint, black.

D. Size: 60-inch-diameter cover.

E. Pick Hole: Closed.

F. Seal: Provide continuous 1/4-inch-diameter neoprene “o” ring between frame and cover.

G. Manufacturer: South Bay Foundry, Hayward, CA.; Alhambra Foundry Company Ltd., Alhambra, CA; or equal.

2.05 LADDER RUNGS

A. General: ASTM C478.

B. Material: Copolymer polypropylene plastic molded on steel reinforcing bar

2.06 ACCESSORIES

A. Inlet Grates and Frames:
   1. Material: ASTM A48, Class 30B.
   2. Coating: Bituminous paint, black.
   3. Loading: 300 lb/sq. ft. [AASHTO Loading Class HS20-44]

2.07 SOURCE QUALITY CONTROL

A. Precast Sections:
   1. Verify concrete compressive strength test results are satisfactory for the sections supplied.
   2. State the curing method. Identify the start and end dates for the sections supplied.

B. Frames and Covers:
   1. Verify cast test bar tensile strengths are satisfactory.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Compact subgrade to 95% relative density for 6-inch minimum depth.

B. Provide a 6-inch gravel layer under the base slab and compact to 95% relative density prior to placement.

C. Set precast manhole sections in a concrete base joint groove, formed in the concrete base slab.

D. Apply primer to joint surfaces in accordance with manufacturer's instructions. Make all joints watertight with sealant gaskets.

E. Backfill around the manhole with Structural Backfill material. Compact the backfill material to 95% of relative density from the pipe bedding and base slab up to final finish grade, over an area defined as being within a distance of 4 feet from the exterior walls of the manhole.

F. Accurately locate and place the manhole frames to within 1/8-inch vertical elevation in paved areas and to 1/2-inch in other areas. Coordinate the activities of all trades so that this tolerance is achieved.

G. Install the manhole cover in the frame. Machine the cover if necessary to obtain a solid fit, without rattling under load.

H. Lining shall conform to Section 09961.

3.02 FIELD QUALITY CONTROL

A. Verify all precast sections are continuously sealed with gaskets.

B. Verify all manhole covers fit quietly in the frames.

3.03 TEST FOR MANHOLES

A. Furnish and dispose of water used for testing.

B. Hydraulically test all manholes installed.

C. After all pipe has been laid, backfilling has been completed, and after the testing of the pipes, plug the end of the pipe stubs in each manhole with flexible-joint caps, or acceptable alternate, securely fastened.

D. Fill the manhole with water and measure leakage over a period of not less than one hour.

E. Allowable Leakage: less than one (1) gallon per hour per 10-foot depth of manhole.

F. When leakage from the manhole exceeds the above amount, determine the source or sources of the leakage, and repair or replace defective materials and workmanship.

G. The completed pipe and manhole installation shall pass this test before the project can be accepted.

END OF SECTION

SECTION 02200

SITE PREPARATION

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Site preparation shall consist of all clearing, grubbing, stripping, (demolition), and related work necessary to prepare the project site for construction operations.
   2. No open burning of debris, lumber, or other scrap will be permitted.
   3. Trees and vegetation to be left standing shall be protected from damage incident to site preparation and construction operations by the erection of barriers or by such other means as the circumstances require.

B. Related Sections:
   1. Section 01140: Environmental Protection
   2. Section 02301: Earthwork
   3. Section 02050: Demolition

PART 2 – PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 DEMOLITION

A. Demolish and remove any fences, posts, poles, or other structures from within the project site, areas to be cut or areas to receive fill, and pipeline alignments. See Section 02050 for demolition specifics.

3.02 CLEARING

A. Clearing shall consist of the felling, trimming and cutting of trees, and the removal of downed timber, shrubs, grasses, debris and rubble from the project site which will obstruct or otherwise impede construction operations.

3.03 GRUBBING

A. Grubbing shall consist of the removal and disposal of stumps, roots larger than 3 inches in diameter, and matted roots from the construction area. This material, together with logs and other organic debris, shall be excavated and removed to a depth of not less than 18 inches below the original surface level of the ground in areas indicated as construction areas under this Contract, such as areas for structures, pavement, fills. Depressions made by grubbing shall be filled with structural backfill material and compacted to make the surface conform with the

original adjacent surface of the ground, unless further excavation is required. Grub borrow areas to the extent necessary to obtain material free of stumps and roots.

3.04 STRIPPING

A. Strip the upper 4 inches of soil containing vegetation and root matter from all areas to receive fill and from all areas to be excavated.

3.05 DISPOSAL

A. Felled Trees and Downed Timber: Cut up and stockpile where directed by the Engineer.

B. Strippings: Stockpile stripped material and use it to restore the site.

C. Dispose of remaining vegetation and debris in accordance with Section 01140.

END OF SECTION

SECTION 02301

EARTHWORK

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Perform all excavation, shoring, dewatering, backfilling, compaction and grading necessary or required for the construction of the work as covered by these Specifications and indicated on the Drawings. The excavation shall include, without classification, the removal and disposal of all materials of whatever nature encountered, including water and all other obstructions that would interfere with the proper construction and completion of the required work.

1.02 REFERENCES

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

1. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
2. ASTM D448 - Standard Classification for Sizes of Aggregate for Road and Bridge Construction
3. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft3).
4. ASTM D1556 - Standard Test Method for Density of Soil in Place by the Sand-Cone Method.
5. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (6,000 ft-lb/ft3).
6. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
7. ASTM D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).
8. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
9. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
10. ASTM D4253 - Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
11. ASTM D4254 - Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
12. ASTM D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

Standards listed below apply when no other more stringent standard is referenced. The order of precedence is as follows:

1. Agency Standards (Rainbow Municipal Water District)
2. Local Standards
3. Regional Standards
4. State Standards (Caltrans)

B. State of California, Department of Transportation, Standard Specifications, most current (Standard Specifications).

C. State of California, Department of Transportation, Manual of Test (California Test).

1.03 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Submit the following under the Product Review category.

1. Excavation Protection Plan *(if applicable)*: Identify location, extent, and type of excavation protection. Describe sheeting, shoring, and bracing materials and installation required to protect excavations and adjacent structures and property; include structural calculations for cuts 20 feet, or greater, to support plan. Structural calculations for cuts 20 feet, or greater, shall be done under the supervision of a Professional Engineer experienced in the design of this Work and licensed in the State of California haul routes, temporary storage, and disposal location. Refer to Section 02050.
2.
3. Potholing Report in accordance with Section 3.02 below.
4. Product Data: Submit gradation reports for bedding materials and import backfill materials. Submit product data for geotextile fabric indicating fabric and installation procedure.
5. Dewatering Plan: Describe methods for dewatering including power source, size of pumps, appurtenances, settlement monitoring program, and dewatering water disposal. Include any SWPPP and NPDES Permit information relevant to discharge of water from dewatering.
6. Samples and Test Results: Furnish, without additional cost to the Owner, such quantities of import materials as may be required by the Engineer for test purposes. Cooperate with the Engineer and furnish necessary facilities for sampling and testing of all materials and workmanship. Submit test results for import materials. Tests shall be performed within 60 days of the submission. All material furnished and all work performed shall be subject to rigid inspection, and no material shall be delivered to the site until it has been favorably reviewed by the Engineer, or used in the construction work until it has been inspected in the field by the Engineer.

1.04 DEFINITIONS

A. Fill: Earth used to fill holes, pits, or depressions necessary to bring the final grade up to the specified elevation or contours.

B. Pipe Bedding: The layer of material immediately below the bottom of the pipe and extending over the full trench width. Minimum thickness is 6 inches.

C. Pipe Zone: Full width of the trench from 6 inches below the bottom of the pipe to a horizontal level 12 inches about the top of pipe. The Pipe Zone is inclusive of Pipe Bedding.

D. Trench Zone: Includes the portion of the trench from the top of the pipe zone to the bottom of the pavement zone or to the existing surface in unpaved areas.

E. Definitions and materials for Pipe Bedding, Pipe Zone and Trench Zone for pipeline located within the Caltrans right-of-way shall be as shown in the Drawings.

F. Relative Compaction: In-place density divided by the maximum dry density laboratory compaction expressed as percentage.

G. Over excavation: Excavation beyond the limits shown in the Drawings.

H. Rock Excavation: Excavation of material that consists of boulders and pieces of concrete or masonry exceeding 1 cubic yard in dimension which, in the opinion of the Engineer, requires for its removal, drillings and blasting, wedging, sledging or barring, breaking up with a power operated hand tool, or hydraulic hammer attachment on a backhoe or excavator.
   1. Rock: Non-decomposed stone, that by demonstration cannot, in the Engineer's opinion, be reasonably excavated with a Caterpillar 345 DL with rock bucket or similar equipment approved by the Engineer and contains a volume of more than 1 cubic yard. The Engineer reserves the right to waive the demonstration of the material encountered as well-defined rock.
   2. The bedrock material encountered during field explorations typically was completely to highly weathered to the depths explored and is expected to be removable with typical earthmoving equipment. Special excavation equipment may be required at the lift station site and along portions of the alignment.
   3. Refer to Paragraph 3.11.

1.05 QUALITY ASSURANCE

A. Source Quality Control: Furnish all bedding material from a single source throughout the work unless otherwise approved. Test import materials proposed for use to demonstrate that the materials conform to the specified requirements. Tests shall be performed by an independent testing laboratory.

B. Field Quality Control:
   1. The Engineer will:
      a. Review materials proposed for use.
      b. Observe excavation and direct the contractor should excavation beyond the limits shown in the Drawings be required.
      c. Observe placement and compaction of fill and review compaction reports.
      d. Review results of independent testing laboratory tests and request additional testing at the Engineer's discretion. If the testing shows results that are not fully acceptable, the Contractor will be required to perform the additional tests to demonstrate that Contractor has met the specification requirements.
   2. The Contractor shall hire an independent soil testing laboratory approved by the Engineer to perform the following tasks:
      a. Test materials proposed for use and submit results to the Engineer. Imported/Borrow materials shall have a Particle Size Analysis and Laboratory Compaction Test (as indicated below) performed for every 5,000 cubic yards of materials delivered.
      b. Test soils during placement of fill to verify conformance with material and compaction requirements defined herein.
      c. Be responsible for costs of additional inspection, rework, and re-testing resulting from non-compliance.

C. Testing Methods:
   1. Durability Index: Manual of Test, State of California, Department of Transportation.
   2. Specific Gravity: ASTM D854
   3. Laboratory Compaction: ASTM D1557, Method A or C.
   4. In-place Density: ASTM D1556 or ASTM D2922.
   5. Particle Size Analysis of Soils: ASTM D422.

6. Plastic Limit and Plasticity Index: ASTM D4318.
7. Soil Classification: ASTM D2487.
8. In-place Moisture Content: ASTM D3017.
9. Sample backfill materials: ASTM D75
10. Relative Density of cohesion-less soils: ASTM D4253 and D4254

D. Samples: Contractor shall notify Engineer a minimum of 48 hours before obtaining samples. Engineer may choose to be present while samples are obtained. Contractor shall endeavor to collect samples from source stockpiles. Contractor shall notify Engineer prior to sample collection that samples will be collected from source stockpiles or will be provided in sacks from the source management in cases where access cannot be granted to Contractor and Engineer for sample collection directly from stockpiles. Contractor shall make available to Engineer the source(s) of all Crushed Aggregate and Import Fill materials a minimum of 30 days prior to bringing any materials onsite.

E. Contractor shall not excavate, construct embankments, or fill until all the required submittals have been reviewed and approved.

1.06 DELIVERY, STORAGE AND HANDLING

A. Scheduling of deliveries shall be coordinated with the Engineer prior to material arriving onsite so as not to interrupt existing plant/facility operation.

B. If access to private property is required, coordination with private owners is required prior to material arriving onsite.

C. Earthwork materials shall be stored in a location confirmed in writing by the Engineer. Written approval from the Engineer shall be provided if alternative storage locations are to be used.

D. Contractor shall protect stockpiled material so that it's not contaminated, does not become saturated and is identifiable.

1.07 EXPLOSIVES

A. Any construction procedure elected by the Contractor that involves the use of explosives shall conform to the requirements of Caltrans Specifications, Section 19-4. be performed in accordance with all applicable Federal, State, and local laws and regulations. Use of explosives shall be performed by an experienced, qualified, and equipped contractor with a minimum of ten (10) years professional experience in the design and application of explosive excavation plans. The Contractor shall obtain all permits required for such use of explosives and shall have complete responsibility for their transportation, storage, and use. Explosives shall not be used without specific authorization by the Owner.

1.08 SUBSURFACE INVESTIGATIONS

A. Geotechnical investigations for design purposes for this project were made for the Lift Station 1 Replacement Project by Leighton Consulting, Inc. in reports dated June 29th, 2016, October 21st, 2017, November 27th, 2017, November 30th 2018 (updated June 2, 2020), and an Addendum dated January 4, 2021.

B. These reports are available for examination by bidders. While the records of data obtained may be considered by the Contractor to be correct, any conclusions or recommendations made in the reports are for information to the Design Engineer and are not a part of the Contract Documents. Copies of the reports and boring

logs are in the Appendix of these Specifications and their locations are shown on the Drawings.

C. The bidders may make additional subsurface investigations at the site prior to the bidding of the project. Prior to making any drillings or excavations, the bidder shall secure permission from the Owner, and property owners if on private property.

1.09 ADDITIONAL SAFETY RESPONSIBILITIES

A. The Contractor shall select, install and maintain shoring, sheeting, bracing, and sloping as necessary to maintain safe excavations. The Contractor shall be responsible for ensuring such measures: (1) comply fully with 29 CFR Part 1926 OSHA Subpart P Excavations and Trenches requirements, (2) provide necessary support to the sides of excavations, (3) provide safe access to the Engineer's sampling and testing within the excavation, (4) provide safe access for backfill, compaction, and compaction testings, and (5) otherwise maintain excavations in a safe manner that shall not endanger property, life, health, or the project schedule. All earthwork shall be performed in strict accordance with applicable law, including local ordinances, applicable OSHA, CalOSHA, California Civil Code, and California Department of Industrial Safety requirements.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Trench Zone:
   1. Native soils: Native soils are generally considered suitable. Material shall be free of asbestos, organic matter, roots, debris, rocks larger than 4 inches in diameter, clods, clay balls, broken pavement, and other deleterious materials. Backfill material shall be have a gradation with at least 40 percent of material passing No. 4 sieve. The coarser materials shall be well distributed throughout.
   2. Import material: Import soils shall be granular in nature, free of organic material (los of ignition less than 2 percent), have an Expansion Index less than 20 with low to no corrosion impact to the proposed improvements. Representative soil samples of proposed import fills shall be approved by the Geotechnical Engineer prior to delivery.

B. Pipe Bedding and Pipe Zone Materials:
   1. Sand: Sand shall conform to the requirements of Caltrans Specifications, Paragraph 19-3.02F (2). Sand shall have a Sand Equivalent of 30 or greater.
   2. Imported Sand: Consist of natural or manufactured granular material, or combination thereof, free of deleterious material, mica, loam, clay or other substances. Material shall meet the gradation requirements of Sand.

C. 3/4-inch Crushed Rock Bedding: 3/4"-inch Crushed Rock Bedding shall be used for all pipelines at depths greater than 15 feet and under all structures unless otherwise indicated on the drawings.

1. Clean, crushed aggregate, conforming to ASTM D448, No. 67:

Sieve Size	Percent Passing
1 inch	100
3/4 inch	90 to 100
3/8 inch	20 to 55
No. 4	0 to 10
No. 8	0 to 5

D. Crushed Rock: Class 2, 3/4-inch maximum aggregate base, Standard Specifications Section 26.

E. Structural Backfill: Structural Backfill shall meet the following gradation:

Sieve Size	Percent Passing
3/4 inch	100
1/2 inch	95 to 100
3/8 inch	50 to 100
No. 4	20 to 65
No. 8	10 to 40
No. 40	0 to 20
No. 200	0 to 5

F. Native Backfill: Native soil prepared as necessary to be free from clods or rocks larger than 2 inches in greatest dimension. Wet, soft, or frozen material, organic matter, asphalt chunks, or other deleterious substances shall not be used as backfill.

G. Imported Backfill: Imported non-expansive soil with liquid limit no greater than 40 percent and a plasticity index no greater than 15 percent, free from clods or rocks larger than 2 inches in greatest dimension, and free from organic material. Representative soil samples of proposed import fills shall be approved by the Geotechnical Engineer prior to delivery.

H. Subgrade: Subgrade material may be native soil or imported soil and prepared to be non-yielding when proof-rolled by passing over all required areas with a loaded scraper, front-end loader with loaded bucket, or other heavy rubber-tired vehicle with high tire pressure, in the presence of the Engineer. If subgrade is unstable, wet, or soft and air-drying is not an option, Contractor shall coordinate with the Engineer for stabilization methods.

I. Flow Fill (Flowable Concrete Backfill)

1. Flow Fill shall be used for bedding and backfill only as directed by the engineer and as indicated on the drawings.
2. Flow Fill shall be Low Strength Concrete in accordance with Section 02065-Controlled Low Strength Material.

J. Landscape Fill: Imported or native backfill free from chemicals, salts or other materials harmful to plant growth.

K. Impervious Material: Clay with a minimum percentage of material passing the No. 200 sieve of 50 percent. The material shall be free of organics, rocks, or clods greater than 4 inches in diameter.

L. Water: The water used shall be reasonably free of objectionable quantities of silt, oil, organic matter, alkali, salts and other impurities. Water quality must be acceptable to the Engineer.

M. Aggregate Base: Refer to Section 02700.

N. Warning Tape: 3-inch-wide, inert, fade-resistant plastic film resistant to acids, alkalis, and other components likely to be encountered in soil. Tape shall be blue, Griffolyn Terra Tape; or equal.

PART 3 - EXECUTION

3.01 CONTROL OF WATER

A. All excavations shall be kept free from water and all construction shall be in the dry.
   1. It should be presumed that the presence of groundwater will require dewatering operations. Furnish, install, maintain, and operate all necessary pumping and other equipment for dewatering all excavations. At all times have on the project sufficient pumping equipment for immediate use, including standby pumps for use in case other pumps become inoperable.
   2. Provide a sufficient number of pumps so as to hold the groundwater level at an elevation of not less than 1 foot below the lowest elevation of the pipe, duct or other material or feature to be placed. Groundwater levels shall be kept to an elevation of not less than 3 feet below the excavation bottom for the wet wells and below grade vault.
   3. Dispose of water as required by State and local regulations, and in such a manner as to cause no injury or nuisance to public or private property, or be a menace to the public health. It is the Contractor's responsibility to obtain all necessary Storm Water Discharge Permits.
   4. The dewatering operation shall be continuous, so that the excavated areas shall be kept free from water during construction, while concrete is setting and achieves full strength, and until backfill has been placed to a sufficient height to anchor the work against possible flotation.
   5. Continue dewatering during backfilling operations such that the groundwater is at least 1 foot below the level of the compaction effort at all times. No compaction of saturated materials will be allowed.
   6. Dewatering devices must be adequately filtered to prevent the removal of fines from the soil.
   7. The Contractor shall be responsible for any damage to the foundations or any other parts of existing structures or of the new work caused by failure of any part of the Contractor's protective works. After temporary protective works are no longer needed for dewatering purposes, they shall be removed by the Contractor.
   8. If pumping is required on a 24-hour basis, requiring engine drives, then engines shall be equipped in a manner to keep noise to a minimum. Refer to Section 01140 for noise control requirements.
   9. Prevent disposal of sediments from the soils to adjacent lands or waterways by employing whatever methods are necessary, including settling basins.

B. The Contractor shall be responsible for furnishing temporary drainage facilities to convey and dispose of surface water falling on or passing over the site.

3.02 EXISTING UTILITIES

A. General: The known existing buried utilities and pipelines are shown on the Drawings in their approximate location. The Contractor shall exercise care in avoiding damage to all utilities as he will be held responsible for their repair if damaged. There is no guarantee that all utilities or obstructions are shown, or that locations indicated are accurate. Utilities are piping, conduits, wire, cable, ducts, manholes, pull boxes and the like, located at the project site and adjoining said site.

B. Check on Locations (Potholing):
   1. Contact all affected utility owners and request them to locate their respective utilities prior to the start of "potholing" procedures. The utility owner shall be given 7 days written notice prior to commencing potholing. If a utility owner is not equipped to locate its utility, the Contractor shall locate it.
   2. Clearly paint the location of all affected utility underground pipes, conduits and other utilities on the pavement or identify the location with suitable markers if not on pavement. In addition to the location of metallic pipes and conduits, non-metallic pipe, ducts and conduits shall also be similarly located using surface indicators and detection tape if present and shall then be similarly marked.
   3. After the utility survey is completed, commence "potholing" to determine the actual location and elevation of all utilities where crossings, interferences, or connections to new pipelines or other facilities are shown on the Drawings, marked by the utility companies, or indicated by surface signs. Prior to the preparation of piping shop drawings, or the excavating for any new pipelines or structures, the Contractor shall locate and uncover these existing utilities including services and laterals to a point 1 foot below the utility. Submit a report identifying each underground utility and its depth and location. Any variation in the actual elevations and the indicated elevations shall be brought to the Engineer's attention.
   4. Excavations around underground electrical ducts and conduits shall be performed using extreme caution to prevent injury to workmen or damage to electrical ducts or conduits. Similar precautions shall be exercised around gas lines, telephone and television cables.
   5. Excavations shall have a surface dimension of no more than 18" x 18". Air spades and vacuum excavators shall be used to limit the size of the excavation and damage to adjacent facilities. Backfill after completing potholing. In existing streets pave with 1 inch of cold mix asphalt concrete.

C. Interferences:
   1. If interferences occur at locations other than shown on the Drawings, the Contractor shall notify the Engineer, and a method for correcting said interferences shall be supplied by the Engineer. Payment for interferences that are not shown on the plans, nor which may be inferred from surface indications, shall be in accordance with the provisions of the General Conditions. If the Contractor does not expose all required utilities prior to shop drawing preparation, he shall not be entitled to additional compensation for work necessary to avoid interferences, nor for repair to damaged utilities.
   2. Any necessary relocations of utilities, whether shown on the Drawings or not, shall be coordinated with the affected utility. The Contractor shall perform the relocation only if instructed to do so in writing from the utility and the Engineer.

D. Shutdowns: Planned utility service shutdowns shall be accomplished during period of minimum use. In some cases this may require night or weekend work. Such work shall be at no additional cost to the Owner. Program work so that service will be restored in the minimum possible time, and shall cooperate with the utility companies in reducing shutdowns of utility systems to a minimum.

1. Disconnections: No utility shall be disconnected without prior written approval from the utility owner. When it is necessary to disconnect a utility, the Contractor shall give the utility owner not less than 72 hours' notice when requesting written approval. The Contractor shall program his work so that service will be restored in the minimum possible time.

E. Overhead Facilities: There are existing overhead electric and telephone transmission lines at the site. These overhead utilities are not shown on the Drawings. Extreme caution shall be used when working in the vicinity of overhead utilities so as to prevent injury to workmen or damage to the utilities. The Contractor shall be required to comply with the applicable provisions of the California Construction Safety Orders when working anywhere on this project.

F. Existing gas, water, sewer and telephone house laterals are not specifically shown on the Drawings but do exist along the pipeline routes. Protect all service laterals from damage due to construction operations. If any laterals are damaged, notify the Engineer and the affected utility immediately. The cost of repair shall be borne by the Contractor.

3.03 GENERAL CONSTRUCTION REQUIREMENTS

A. Site Access: Access to the site will be over public and private roads. Exercise care in the use of such roads and repair at own expense any damage thereto caused by Contractor's operations. Such repair shall be to the satisfaction of the Owner or agency having jurisdiction over the road. Take whatever means are necessary to prevent tracking of mud onto existing roads and shall keep roads free of debris.

B. Barriers: Barriers shall be placed at each end of all excavations and at such places along excavations as may be necessary to warn all pedestrian and vehicular traffic of such excavations. Lights shall also be placed along excavations from sunset each day to sunrise of the next day until such excavation is entirely restored.

C. Access: Free access must be maintained to all fire hydrants, water valves and meters, and private driveways.

D. Demolition of Pavement: Where trenching or excavation occurs in paved areas, the pavement shall be scored and broken ahead of the trenching or excavation operation. The extent of paving removed shall be limited to the minimum necessary for the excavation. All existing asphalt or concrete surfacing shall be saw cut vertically in a straight line, and removed from the jobsite prior to starting the trench excavation. This material shall not be used in any fill or backfill.

E. Dust Control: Take proper and efficient steps to control dust.

F. Permits: Refer to General Conditions

G. Storage of Materials: Excavated materials unsuitable for backfill shall not be stored on existing streets, and shall be disposed of immediately. Neatly place excavated materials far enough from the excavation to prevent stability problems.

Keep the materials shaped so as to cause the least possible interference with plant operations and drainage.

H. Temporary Pavement: Place temporary pavement on trenches in existing streets within 24 hours after the trench has been backfilled. Maintain temporary pavement until permanent pavement is to be placed.

I. Existing Facilities: Maintain access to existing facilities to permit continued operation. Maintain access for firefighting equipment and to fire hydrants.

3.04 TRENCH EXCAVATION

A. Excavation for pipe and other utilities such as duct banks shall be in open cut. The trench shall be as wide as necessary for sheeting and bracing and the proper performance of the work up to the maximum width permitted by the typical cross-sections shown on the Drawings. The sides of the trenches shall be vertical in paved areas. The bottom of the trench shall be constructed to the grades and shapes indicated on the Drawings. Should the Contractor desire to use other equivalent methods, he shall submit his method of construction to the Engineer for favorable review prior to its use.

B. Remove lumped subsoil and rock up to ½ cu yd., measured by volume. Remove larger material as specified in Paragraph 1.04.H.

C. Do not advance open trench more than 400 feet ahead of installed pipe. The trench shall not be backfilled until the Engineer reviews the pipe and bedding installation.

D. Accurately grade the bottom of the trenches to provide uniform bearing and support for each section of the pipe or conduit at every point along its entire length, except for the portions of the pipe sections where it is necessary to excavate for bell holes and for the proper sealing of pipe joints, and as hereinafter specified. Dig bell holes and depressions for joints after the trench bottom has been graded. In order that the pipe rest on the bedding for as nearly its full length as practicable, bell holes and depressions shall be only of such length, depth and width as required for properly making the joint. Remove stones as necessary to avoid point bearing.

E. There shall be no additional payment to the Contractor for excavations beyond the limits shown in the Drawings not directed by the Engineer. Remove unsatisfactory material encountered below the grades shown as directed by the Engineer and replace with Crushed Rock. Backfill and compact excavations, beyond the limits shown in the Drawings, in accordance with the requirements of Paragraph 3.10 with Crushed Rock. Payment for removal and replacement of such unsatisfactory material directed by the Engineer shall be made in accordance with the provisions of the General Conditions.

F. Grade trenches so that they are uniformly sloped between the pipe elevations shown on the Drawings. If no elevations are shown on the Drawings, provide 3 feet of minimum cover. Comply with the minimum and maximum trench widths shown on the Drawings. Notify the Engineer if the trench width exceeds the maximum allowable width for any reason.

G. For all piping or conduits to be placed in any excavated and backfilled area, such as at manholes or for building connections, the structural backfill shall be first

compacted to a level at least 3 feet from the top of the piping or conduit elevation and then retrenched to pipe grade.

H. Provide ladders for access to the trench by construction and inspection personnel.

3.05 EXCAVATION FOR STRUCTURES

A. All excavation for structures shall be done to the dimensions and levels indicated on the Drawings or specified herein. Excavate to such width outside the lines of the structure to be constructed as may be required for proper working methods, the erection of forms and the protection of the work.

B. Take care to preserve the foundation surfaces shown on the Drawings in an undisturbed condition. If the Contractor over excavates or disturbs the foundation surfaces shown on the Drawings or specified herein, without written authorization of the Engineer, he shall replace such foundations with concrete fill or other material approved by the Engineer in a manner that will show by test an equal bearing value with the undisturbed foundation material. No additional payment will be made for the added quantity of concrete fill or other material used because of over excavation.

C. Inspection of Excavation: Notify the Engineer when excavation for the structure is complete. No forms, reinforcing steel, concrete, or precast structure shall be placed until the excavation has been inspected by the Engineer.

3.06 FOUNDATIONS ON UNSTABLE SOILS

A. If the bottom of the excavation is soft or unstable, and in the opinion of the Engineer, cannot satisfactorily support the pipe or structure, the soft or unstable material shall be removed and replaced a minimum of 12 inches below grade with Structural Backfill or as otherwise specified by the Engineer. Payment for removal and replacement of such unsatisfactory material directed by the Engineer shall be made in accordance with the provisions of the General Conditions

3.07 SUPPORT OF EXCAVATIONS

A. Adequately support excavation for trenches and structures to meet all applicable requirements in the current rules, orders and regulations. Excavation shall be adequately shored, braced and sheeted so that the earth will not slide or settle and so that all existing structures and all new pipe and structures will be fully protected from damage. Keep vehicles, equipment, and materials far enough from the excavation to prevent instability.

B. Take all necessary measures to protect excavations and adjacent improvements from running, caving, boiling, settling, or sliding soil resulting from the high groundwater table and the nature of the soil excavated.

C. The support for excavation shall remain in place until the pipeline or structure has been completed. During the backfilling of the pipeline or structure, the shoring, sheeting and bracing shall be carefully removed so that there shall be no voids created and no caving, lateral movement or flowing of the subsoils.

3.08 BEDDING AND BACKFILL

A. Place bedding and backfill materials true to the lines, grades, and cross-sections indicated on the Drawings and compacted to the degree specified on the Drawings. Place bedding and backfill materials in horizontal lifts not to exceed 6 inches in

thickness measured before compaction. The difference in level on either side of a pipe shall not to exceed 4 inches.

B. Backfill material shall not be placed over the pipe or conduit until after the joints have been completed and inspected by the Engineer.

C. Do not place backfill material until the Engineer has inspected, testing to his or her satisfaction, and favorably reviewed the prepared subgrade.

D. It shall be incumbent upon the Contractor to protect the pipe or conduit from damage during the construction period. It shall be his responsibility to repair broken or damaged pipe at no extra cost to the Owner. Carefully place backfill around and over the pipe and do not allow it to fall directly upon the pipe. Tamping of backfill over the pipe shall be done with tampers, vibratory rollers and other machines that will not injure or disturb the pipe.

E. Do not allow construction traffic nor highway traffic over the pipe trench until the trench backfill has been brought back even with existing adjacent grade.

F. Import Backfill: The removal and replacement limits and quantity of import backfill material shall be coordinated and accepted by the Engineer and governing authority prior to proceeding with the installation.

3.09 STRUCTURAL BACKFILL

A. Compact materials in accordance with Paragraph 3.10 unless otherwise specified or shown on the Drawings.

B. Backfill Adjacent to Structures
   1. Do not place backfill against structures until the concrete has been patched and cured.
   2. Do not place backfill against structures until at least 28 days after the concrete was placed, or until the concrete has achieved a strength of at least 2,500 psi, whichever is earlier. Concrete strength shall be demonstrated by field cured cylinders tested at the Contractor's cost, prepared and tested in accordance with ASTM C31 and ASTM C39.
   3. Do not place backfill against hydraulic structures until the structure has passed the specified leakage tests.
   4. Place Structural Backfill within 2 feet of a structure or as shown on the Drawings.
   5. Place structural backfill in uniform, level layers, not exceeding 6 inches thick measured before compaction. Bring backfill up uniformly on all sides of the structure, and on both sides of buried walls.

C. Backfill for Walls Below Grade
   1. Backfill should be placed in horizontal lifts not exceeding 6 inches in loose thickness. Only light, hand-operated compaction equipment (e.g., jumping jack, walk-behind vibratory plate compactor) shall be used within 5 feet of walls below grade.

3.10 COMPACTION

A. Add water to the backfill material or dry the material as necessary to obtain moisture content within 2 percent of optimum. Employ such means as may be necessary to secure a uniform moisture content throughout the material of each layer being compacted.

B. After the material has been moisture conditioned, compact it with compaction equipment appropriate for the use to achieve specified compaction.

C. If the backfill material becomes saturated from rains or any other source because it was not compacted to the specified density or was not backfilled and compacted to surface grade, through negligence or otherwise, remove the faulty material and replace it with suitable material compacted to the specified density. No additional payment will be made for doing such work or removal and replacement.

D. Compact materials in accordance with ASTM D1557 (Modified Proctor) unless otherwise specified.

E. Compaction of embankment and backfill materials by flooding, ponding or jetting is not permitted.

F. When densities of compacted materials do not meet the requirements, remove and/or recompact the material until the requirements are met. If the Engineer determines that the nature of the ground in which the trench lies precludes compaction of the backfill to the specified density, compact the backfill to the maximum practicable density. The Contractor will be back charged the cost of retesting all failing tests, including the initial retest. Such back charges will be deducted from the Contractor's Progress Payments.

G. Material Requirements

	Material	**Minimum Relative Compaction[1]**
1.	Native Soil Import Soil	90 percent 95 percent
2.	Pipe Zone Backfill	90 percent
3.	Trench Zone Backfill	90 percent 95 percent in top two feet of trench
4.	Pipe Bedding	90 percent
5.	3/4-inch Crushed Rock Bedding	90 percent
6.	Crushed Rock	95 percent
7.	Subgrade	95 percent
9.	Structure Backfill	95 percent
10.	Landscape Fill	85 percent
13.	Impermeable Material	90 percent

[1]Modified Proctor Test

H. Testing Frequency:
1. Trench Backfill: Test every 200 feet of trench.
2. Earthwork: Test every 500 square feet for each 2 feet of fill.
3. Structural Backfill:
   a. Sub-base: Test every 200 square feet.
   b. Base:
      1) Test every 200 square feet of building footprint, with no less than 2 tests per structure.
      2) Test every 200 cubic yards of material placed within 10 feet around the building.

3.11 ROCK EXCAVATION

A. No payment will be made under “Rock Excavation” for any method of rock removal other than systematic drilling and blasting. If the Contractor elects to mechanically remove material classified as “Rock Excavation” by the above definition with other equipment, including excavating equipment of a larger size than specified above, it shall be understood that payment for the removal of the material by this method shall be included in the bid price for installing the pipe or excavation at the lift station site.

B. No soft or disintegrated rock which can be removed with a hand pick or power operated excavator or shovel; no loose, shaken, or previously blasted rock or broken stone in rock fillings, or elsewhere; and no rock exterior to the minimum limits of measurement allowed, which may fall into the excavation, will be measured or allowed.

C. Any rock excavation shall be paid by the Owner based on the actual quantities removed per the requirements of Specification 01025. Prior to removal, the rock shall be completely stripped of all overburden over at least 50 feet or the length of the area requiring blasting whichever is less. The Engineer will then make the necessary measurements and take elevations on the rock to determine the volume of rock to be removed. Rock excavation shall be approved and measured by the Engineer. Rock quantities will be measured based on the depth and width of rock removed from within the designed pipeline or conduit trench area as required per the Contract Documents or for the water storage tank structures or vaults on the tank site. Rock excavation beyond the limits approved by the Engineer shall be exempt from payment. Rock excavation is anticipated for this Work.

D. Rock Excavation within the Caltrans right-of-way shall be per Caltrans Standard Specification Section 19-4.

3.12 SITE GRADING

A. Rough Grading: After completion of stripping, rough grade cut areas to the lines, grades and contours shown on the Drawings.

B. Compact all fills in accordance with the requirements of Section 3.10 unless otherwise specified or shown on the Drawings.

C. Proof-Rolling: After rough grading, proof-roll the areas where roads, fills, and on-grade structures are to be constructed in order to detect soft zones. Proof-roll by passing over all required areas with a loaded scraper, front-end loader with loaded bucket, or other heavy rubber-tired vehicle with high tire pressure, in the presence of the Engineer. The Engineer will determine what areas tested by proof-rolling are soft zones that require corrective work.

1. Soft Zone Corrective Work: Remove all soft material as indicated by the Engineer from all soft zones exposed by proof-rolling. Properly dispose of unsuitable material off site.
2. Fill the resulting voids with moisture-conditioned imported backfill, in level 6-inch uniform layers measured before compaction. Compact with appropriate equipment in accordance with the requirements of Section 3.10 unless otherwise specified or shown on the Drawings.
3. Soft zone corrective work will be considered a change in the scope of project work and will be paid for as extra work by a Change Order, per the General Conditions.

D. Scarifying: Scarify to a minimum 6-inch depth all areas where fills are required. Moisture condition the scarified surface to within 2 percent of optimum water content, and compact in accordance with the requirements of Section 3.10 unless otherwise specified or shown on the Drawings.

E. Fills:
   1. Do not place any fill until the Engineer has inspected, tested to his satisfaction, and favorably reviewed the prepared subgrade.
   2. Construct fills as shown on the Drawings, true to line, grade and cross-section. Construct fills of imported backfill. Place material in approximately 6 inch-thick horizontal layers measured before compaction and carried across the entire width to the required slopes.

F. Ditches: Cut ditches accurately to the cross sections and grades shown. Take care not to excavate beyond the limits shown ditches, and backfill excessive excavation to grade. Compact the surfaces of ditch slopes and bottom.

G. Landscaped Areas: Use Landscape Fill in the top 2 feet of areas to be landscaped.

3.13 FINISH GRADING

A. Finish grade the site to the elevations shown on the Drawings. Finish grading shall be uniform and pleasing and shall provide drainage from all areas to collection points. The finished surfaces shall be smooth and compacted.

3.14 DISPOSAL OF EXCAVATED MATERIAL

A. Dispose of unsuitable material or excavated material in excess of that needed for backfill or fill offsite in accordance with the requirements of Section 01140.

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SECTION 02441

MICROTUNNELING

PART 1 - GENERAL

1.01 SCOPE

A. Perform all Work to provide buried piping, specials, and appurtenances shown, specified, and required for the construction of complete and operable pipelines using the microtunneling method of installation.

B. The Work of this Section shall include the construction of sanitary sewer pipelines to the alignments and grades shown on the drawings by a two-pass pipe jacking method where the carrier pipe is installed following the installation of a jacked casing by microtunneling boring machine (MTBM).

C. The Contractor shall have sole responsibility for the means and methods utilized to install the sewer pipeline to the lines and grades shown and for preventing settlement or heave, all within the tolerances specified herein and subject to review by the Engineer. In such case, the Contractor shall demonstrate to the Engineer that the proposed means and methods shall complete the Work in accordance with the Specifications, this Section, Applicable Codes, and the Construction Schedule.

D. Provide all items required to complete the Work by microtunneling including, but not limited to, the microtunneling/jacking system, spoil transportation and separation, hoisting, lifting, safety and control equipment.

E. Jacking and Receiving shafts have been sited and sized on the Plans considering overhead and underground utility conflicts, driveway access, and traffic impacts. Alternate shaft construction locations may be allowed as specified herein and in Section 02442 Microtunneling Shafts.

F. The drawings are marked with locations of Jacking Shafts. The Jacking Shaft locations have been shown on the drawings. A Support Area may also be required on all ends of the jacking shaft. The dimensional limits shown on the drawings shall be accommodated by the contractor in planning the microtunnel work.

G. Section 01570 includes requirements for traffic control. Comply with these requirements.

1.02 DEFINITIONS

A. Annular Space: The radial measure for the void created between the outside radiuses of the jacking pipe to the outermost excavation along the entire pipeline. The distance includes the MTBM’s overcut.

B. Carrier Pipe: As it relates to this work, a pipe for conveyance of sewage. See also Product Pipe.

C. Casing (pipe): A pipe, typically made of steel, used to support a tunnel in which the product or carrier pipe is later inserted.

D. Compression Ring/Packer: An engineered material designed as a ring and fitted between the bell and spigot jacking pipe ends to help distribute the jacking forces more uniformly over the entire bearing surface. The packer compensates for steering, misalignment, and pipe end irregularities during the jacking process.

E. Controls: The system that synchronizes excavation, removal of excavated material, and jacking of pipe to maintain overall balance to provide complete and adequate ground support at all times.

F. Cutterhead: Any rotating tool or system of tools on a common support, which excavates at the face of a bore.

G. Earth Pressure Balance: The process by which mechanical and passive earth or slurry pressure is applied to the tunnel face equal and opposite to the pressure of the earth and groundwater against the tunnel face. Excavation is controlled to maintain the opposing pressure to prevent heave or subsidence.

H. Emergency Recovery Shaft: A vertical excavation required for the removal of an obstruction or the trenchless construction equipment is retrieved or repaired. The location of an emergency shaft is determined by construction necessity and typically will not have a manhole constructed in the shaft.

I. Face: The location where excavation takes place; the head of the tunnel excavation; typically vertical or near vertical.

J. Full Face Control: Complete mechanical support of the excavated face at all times.

K. Geologic Contact: An interface between two geological strata.

L. Guidance System: A system that relates the actual position of the MTBM to a design reference, often a laser beam transmitted from the jacking shaft along the centerline of the pipe to a target mounted in the shield.

M. Intermediate Jacking Station(s) (IJS): A steel cylinder, fitted with hydraulic jacking cylinders, which is incorporated into a pipeline between two pipe segments. Its function is to distribute the jacking forces over the pipe string on long drives.

N. Intermediate Shaft Location: A vertical excavation where a manhole will be placed before or after the tunnel is constructed. The locations are predetermined so the maximum distance between manholes is never exceeded.

O. Jacking Frame: A structural component, fitted with hydraulic cylinders, which is used to push the shield and pipe string into the ground. The jacking frame serves to distribute the thrust load to the pipe string and the reaction load to the shaft wall or thrust wall.

P. Jacking Pipe: A specialty pipe that is engineered and manufactured with a smooth outer wall and watertight joints. The pipe is specifically designed to be jacked through the ground.

Q. Jacking Shaft: A vertical excavation from which trenchless technology equipment and pipe are launched and driven.

R. Jacking Shield: A fabricated steel cylinder from within which the excavation is carried out either by hand or machine. Incorporated within the shield are facilities that allow it to be adjusted to control line and grade.

S. Laser: An optical system projecting a beam onto a target to provide guidance reference during the tunnel excavation.

T. Lubricant (Lubrication): A fluid, normally bentonite and/or polymers, used to reduce frictional jacking loads on the jacking pipe and fill the annular space.

U. Microtunneling: A remotely controlled, guided pipe-jacking process that provides continuous support to the excavation face and tunnel. The microtunneling process provides the ability to control excavation face stability by applying mechanical and fluid pressure to counterbalance the earth and naturally occurring hydrostatic pressure.

V. Microtunnel Boring Machine (MTBM): A remotely controlled, steerable, laser guided tunnel boring machine consisting of an articulated boring machine shield and a rotating cutting head. Personnel entry is not required for the routine operation of the MTBM.

W. Obstruction: An object, other than conditions anticipated in Section 02441 Microtunneling 1.09 Project Conditions, that lies either fully or partially in the direct path of the MTBM and prevents its progress. A small hard object whose principal dimension is less than or equal to 9.0 inches and greater than unconfined compressive strength (UCS) of 30,000 psi, or a large hard object whose principal dimension is greater then 9.0 inches and greater than UCS of 3,000 psi.

X. Overcut: The radial distance between the excavated hole and the outside radius of the MTBM; may also be described as the radial distance beyond the shield that the gauge cutter, the cutter that creates the greatest outside diameter, excavates.

Y. Packer: High quality fiberboard, which may contain other cushioning materials and is used to protect adjacent jacking surfaces from coming in direct contact with each other, distributing jacking loads, and helping to prevent pipe damage from microscopic pipe end imperfections.

Z. Pipe Jacking: Constructing a pipeline by hydraulically jacking consecutive sections of jacking pipe through the ground behind a shield or TBM.

AA. Pipe String: The succession of joined individual pipes being used to advance the excavation equipment and support the tunnel.

BB. Principal Dimension: The largest of the three dimensions of an object.

CC. Product Pipe: As it relates to this Work, a pipe for conveyance of sewage. See Carrier Pipe.

DD. Receiving/Exit Shaft: A vertical excavation toward and into which the tunnel is driven.

EE. Shield: A fabricated steel cylinder from within which excavation is carried out either by hand or machine. Incorporated within the shield are facilities that allow it to be adjusted to control line and grade.

FF. Slurry: A fluid, normally water or a water/bentonite medium, used in a closed loop system for the removal of spoil and to balance the naturally occurring hydrostatic pressure during microtunneling.

GG. Slurry Chamber: Located behind the cutting head of a slurry microtunneling machine. Excavated material is mixed with slurry in the chamber for transport to the surface.

HH. Slurry Line: A series of hoses or pipes that transports tunnel muck and slurry from the face of a slurry microtunneling machine to the ground surface for separation and then returns it to the cutter face.

II. Slurry Pressure Balance Machine: A microtunneling system, which uses a low pressure fluid to stabilize the ground and balance hydrostatic water pressure at the face of the tunnel and to transport the excavated spoil to the surface.

JJ. Slurry Separation: A process that separates excavated material from the circulating slurry.

KK. Specials: The pipe immediately in front and behind an IJS that require the manufacturing process to accommodate the IJS design requirements. The Special "A" is the pipe leading an IJS and the Special "B" is the pipe trailing an IJS during the jacking process.

LL. Spoil: Earth, rock, and other materials removed during tunneling.

MM. Surface Monitoring Points: Survey Control Points to be established at the ground surface, below the ground surface, or on manmade structures along the pipe alignment and to be used for monitoring ground deformation due to subsurface excavation.

OO. Thrust Block: An engineered structure located between the jacking frame and the shaft wall intended to spread the jacking force developed by the hydraulic cylinders over a larger surface area.

PP. Thrust Ring: A fabricated ring that is mounted on the face of the jacking frame intended to transfer the jacking load from the jacking frame to the thrust bearing area of the pipe section being jacked.

QQ. Trenchless Technology Equipment: Equipment used to install the product pipe from the point of origin to the destination without the use of a trench cut. The equipment includes, but is not limited to, tunneling and drilling.

RR. Water Jetting: Cleansing mechanism of the cutterhead where high-pressure water is sprayed from nozzles in the cutterhead to help remove cohesive soils. Not permitted without prior written consent of the Engineer.

1.03 RELATED SECTIONS

A. Section 01300, Submittals

B. Section 02301, Earthwork

C. Section 02442, Microtunneling Shafts

D. Section 02443, Microtunneling Instrumentation

1.04 QUALITY ASSURANCE: EXPERIENCE REQUIREMENTS

A. Contractor: Possess a valid California Contractor's Class "A" license and a minimum of five years experience in the installation of pipelines using microtunneling as the method of installation. Experience requirements are the construction and completion of at least three (3) pipeline projects, each with a minimum of 200 L.F. of installed pipe between 8 inches inside diameter and 30 inches outside diameter using microtunneling as the method of installation. Projects must have been completed by the Contractor, or by a subcontractor under the direct supervision of, and with a written legal agreement with, the Contractor or Joint Venture. Projects must have been completed since January 1, 2014. The three referenced projects shall also have the following characteristics:
   1. One of the referenced projects shall have utilized jacking pipe material similar to the type used in this Work.
   2. One of the referenced projects shall have been in similar ground conditions to those anticipated in this Project.
   3. One of the referenced projects shall have had a successfully completed microtunnel drive length of at least 300 feet.

B. MTBM Operator: The Contractor's or subcontractor's MTBM operator(s) shall have at least five years experience in the installation of pipelines using microtunneling as the method of installation. The MTBM operator shall have successfully completed a minimum of three pipeline projects each with a minimum of 200 L.F. of installed pipe between 24 inches inside diameter and 90 inches outside diameter using microtunneling as the method of installation. The MTBM operator shall also have:
   1. Operated an MTBM of the manufacturer proposed for this Work.
   2. Utilized the same type of jacked pipe material as used in this Work.
   3. Successfully completed a project in similar ground conditions to those anticipated in this Project.
   4. Successfully completed a microtunnel drive length of at least 300 feet.

C. Microtunneling Crew: The microtunneling crew is required to have current Hazmat certifications maintained through the end of this project.

1.05 ALLOWABLE SETTLEMENT HEAVE

A. Allowable Settlement/Heave: Unless otherwise specified in Section 02443 Microtunneling Instrumentation, ground deformation during and after construction shall not exceed 13 millimeters (0.5 inches) as measured above and along the centerline of the tunnel being installed. Unless otherwise noted all surface

improvements are to be restored to original condition at no additional cost to Owner.

B. Annular Space Grouting: Fill the annular space with an approved grout upon completion of the drive. When grouting is required to control subsidence, pressure-injected grout shall fill voids outside the limits of the excavation created by caving or collapse of earth cover over the excavation.

1.06 SURVEYS

A. A professional surveyor licensed by the State of California and employed by the Contractor shall provide location survey markers. Attend a survey coordination meeting and adhere to the schedule established at that meeting.

B. The surveyor shall provide layout using the coordinates shown on the drawings and shall inverse those coordinates to obtain bearing and distance from one manhole location to the next.

1.07 REFERENCE CODES AND STANDARDS

A. CalOSHA, California Code of Regulations, Title 8, Industrial Relations, Chapter 4, Division of Industrial Safety, Subchapter 4, Construction Safety Orders; and Subchapter 20, Tunnel Safety Orders.

B. Occupational Safety and Health Administration (OSHA) Regulations and Standards for Underground Construction (29 CFR Part 1926, Subpart Section 1926.800, final rule dated June 9, 1989).

1.08 SUBMITTALS

Submit the following in accordance with Section 01300, Submittals. These submittals, 02441-1 through 02441-14, must be completed, reviewed, and accepted by the Owner prior to starting MT operations:

A. Construction Method and Sequence of Operations (Submittal 02441-1):
Provide a description of the proposed method of construction and the sequence of operations to be performed during construction. This submittal shall include the following:
   1. A general description and schedule of the microtunneling procedure, including, but not limited to: shaft construction, set-up of microtunneling equipment, method of spoil removal, spoil disposal, disposal location, methods of protection and maintenance of project site, and dewatering methods.
   2. Preprinted machine specifications identifying all the requirements as outlined in Section 2.04 Equipment and showing the jacking force the machine is capable of achieving and the type of head with which the machine is equipped.

3. Preprinted MTBM data sheets and specifications or a letter from the MTBM manufacturer, in English, demonstrating that the selected machine(s) is capable of progressing through the anticipated ground conditions, including, but not limited to: soil type, soil gradation characteristics, soil strength, as measured by “N” values, and hydrostatic head.

4. Preprinted machine specifications for remote control and active direction control of the MTBM.

B. Working Drawings/Work Plan (Submittal 02441-2):
   1. Layout of jacking and receiving shafts; including jacking equipment within the shaft and above ground equipment at each shaft location. Orientation of the manhole within the shaft shall be included.
   2. Shop drawings of tunnel machine, including configuration of cutter head and overcut tolerances. Cutterhead drawing shall confirm that the machine is capable of ingesting an obstruction as defined by its principal dimension. Provide details of casing pipe to MTBM interface, casing pipe to IJS interface and casing pipe joint details including joint packing material.
   3. Shaft ventilation system details.
   4. Pipe lubrication system details.
   5. Electrical system, lighting system, and onsite power generation.
   6. Grade and alignment control system details.
   7. Groundwater control provisions of tunneling machine.

C. Calculations signed and sealed by a Professional Engineer (PE) registered in the State of California who is experienced in the following calculations (Submittal 02441-3):
   1. Buoyancy calculations for the pipe and for the MTBM.
   2. Bearing capacity calculations for the pipe and for the MTBM.
   3. Buoyancy for the pipe after installation.

D. Details of slurry system and soil separation methods, including proposed slurry formulations by soil type, and calculations of the system capacity to handle flows at all proposed distances and changes of elevations to and from the tunneling machine (Submittal 02441-4).
   1. Submit Material Safety Data Sheet (MSDS) for slurry additives.
   2. Use NSF 060 or equal, Clean Water-approved materials only.
   3. Sample log sheet including time, date, sampler, shaft location, pipe number, slurry additives type, quantity added, soil type, viscosity, specific gravity, and water added.
   4. Submit a daily graph of specific gravity on a one daily trailing basis. The Contractor shall monitor the specific gravity to assure that no silt is being built up in the slurry that could indicate overcut by the microtunneling machine resulting in surface subsidence.

E. Jacking system details, including intermediate jacking stations and their proposed spacing, method of operation, thrust capacity, and sleeve details, plus method of control to prevent the jacking force from exceeding the axial capacity of the pipe (Submittal 02441-5).

F. Description of lubrication mix equipment and procedure for lubricating the pipe during jacking operations, including estimated volume for the anticipated soils (Submittal 02441-6).
   1. Submit materials to be used for lubrication, including materials if saline water is encountered.
   2. Submit Material Safety Data Sheet (MSDS) for lubricant additives.
   3. Use NSF 060 or equal, Clean Water-approved materials only.

G. Description of annular space grout mix equipment and procedure for grouting the annular space after jacking operations, including estimated volume for the anticipated soils (Submittal 02441-7).
   1. Submit Material Safety Data Sheet (MSDS) for grout mix additives.
   2. Submit grout mix.

H. Theoretical jacking force calculations and pipe material calculations shall be prepared and submitted (Submittal 02441-8).
   1. Jacking force calculations provided to the Engineer shall be stamped and signed by a licensed California professional engineer (PE).
   2. Contractor shall determine the maximum anticipated construction loads, including jacking forces, and ensure that the anticipated loads are implemented in the manufacturer's design of the pipe, subject to Engineer's review. The pipe manufacturer's submittal shall be signed and stamped by a PE. The PE signing and stamping for the pipe manufacturer shall be registered in California. The submittal shall include calculations showing maximum allowable jacking force. Submit drawing(s) of jacking pipe with lubrication/grout ports shown.
   3. Jacking pipe packer details shall be submitted to the Engineer for approval.
   4. Calculations which clearly state the relationship between hydraulic jacking pressure and jacking force for the main jacks and the IJS's. Provide the number and spacing of IJS's used for each drive based on the Maximum Anticipated Jacking Force. Provide method of control to prevent the Maximum Allowable Jacking Force from being exceeded. State "not used" if no IJS is used.
   5. Maximum jacking capacity of the thrust block and shaft wall.

I. Pipe Lay Schedule for each drive noting the following requirements (Submittal 02441-9):
   1. Any pipe that has a special manufacturing property e.g. pipe stiffness or jacking capacity, shall have a different colored stripe (red, blue, green) marking for each non-standard property on the inside and outside at the quarter points (4 each pipe) such that the pipe that can be readily identified on the surface or when placed in the ground. Standard shall be the most prevalent pipe ordered as measured by pipe ID.
   2. Each pipe on every drive is to be marked with consecutive numbers inside and outside as it is placed for jacking (beginning with 1).
   3. The Special A shall be marked with a number followed by the letter "A" and the Special "B" shall be marked with the next number followed by the letter "B" (e.g., if the IJS is to be located between pipes 18 and 19, the Special "A" shall be numbered 18-A and the Special "B" 19-B.).
   4. Markings shall be clear and permanent in nature.

J. Procedures (Submittal 02441-10):
   1. Complete launch procedure beginning with any modification to the approved shoring through first pipe in ground. Procedure is to include contingency plans for; loss of ground; inflow of water; loss of seal at entrance as evidenced by leaking water, lubricant, or soil; inability to inject lubricant; and procedure to prevent machine from dropping upon entrance into ground.
   2. Complete retrieval procedure beginning when the MTBM is approximately 10 feet outside of shaft or before the approved shoring is modified to receive the MTBM. The procedure is to continue through pipe in seal and with ground stabilized. Procedure is to include contingency plans for loss of ground; and loss of seal at exit as evidenced by leaking water, lubricant, or soil.
   3. Procedure for detecting the potential encounter of hazardous materials and subsequent actions to ensure safety.
   4. Procedure to accurately measure the volume of excavated material per pipe segment. Include a determination of the theoretical volume of excavated material per pipe segment and allowable tolerances on this volume.

K. A proposed contingency plan for potential situations that may occur during tunneling operations shall be provided for the following scenarios (Submittal 02441-11).
   1. Spoils do not settle/separate with the equipment on site including at minimum slurry sampling frequency, sand content, and viscosity limits by soil type.
   2. The MTBM hits an obstruction. The MTBM hits an obstruction under the Bonsall Creek Bridge.
   3. The laser and/or target is distorted by heat and/or humidity or has been knocked out of alignment. The Contractor shall describe which operational parameters are observed/measured/recorded to determine the above.
   4. The jacking pressures start to increase rapidly and reasonable concern exists for completing jacking operations to the receiving shaft.
   5. The MTBM “freezes” within a typical pipe reach during jacking operations.
   6. Inadvertent return plan with cleanup methods; emergency telephone numbers; sources of equipment and materials needed for containment and clean-up; and corrective actions for reducing operating pressures and modifying the slurry and/or lubricant. Slurry and lubrication inadvertent return plan shall include operating parameters that are controlled with the intent of preventing an inadvertent return. The Plan should include, as a minimum the following measures:
      a. A monitor to attend microtunneling to look for observable inadvertent fluid returns and lowered pressure readings on microtunneling equipment indicative of a frac-out.
      b. If a frac-out is identified, all microtunnel excavation shall stop for at least 4 hours, including the pumping of slurry and lubrication into the excavation. The location and extent of the frac-out will be monitored for 4 hours after the resumption of microtunneling to ensure the frac-out has ceased.
      c. If the slurry congeals, no other action will be taken that would potentially suspend sediments into water column.
      d. Surface releases of slurry, lubricant and bentonite shall be removed and original condition restored.
      e. The contingency plan shall identify additional measures to be taken to contain and remove the slurry or drilling lubricant if it does not congeal.

7. Line and grade control plan with operational parameters observed, measured, and recorded to determine if the MTBM is off line and/or grade. The plan shall include a return to the design line and/or grade over the remaining portion of the drive and at a rate of not more than 1.0 inch per 25 feet.
8. Adverse soils operational plan with operational parameters observed, measured, and recorded to determine that such soils have been encountered and vary substantially from those anticipated based on geotechnical data provided and experience on similar projects. The plan shall include replacing operators, slurry modifications, and other operational modifications deemed important and acceptable to the Engineer. Such adverse soils include:
    a. Flowing ground conditions;
    b. Soils consisting of gravels and cobbles;
    c. Abrasive soils;
    d. Mixed-face ground conditions, that consist of variable and/or abrupt changes in strength, consistency and/or gradation of the soils at the tunnel face.
9. Excessive ground movement plan including means and methods of expeditiously restoring any excessive ground settlement.
10. Excavated ground volume exceeds tolerances on theoretical volume.
11. Noticeable hydrocarbon smell is detected in the MTBM, microtunnel or shaft.
12. Thrust block deforms excessively under jacking loads, shows signs of structural damage, or provides insufficient capacity to advance pipe.

L. A Project Safety Plan for personnel conducting the tunneling or jacking operations and appurtenance installation including a section discussing shaft ventilation (Submittal 02441-12). The Project Safety Plan shall have a procedure that is practiced for removing injured staff from tunneling or shafts as Emergency Response organizations may not perform these removals as they would not be trained in how to accomplish these type removals.

M. Jacking Operations Log (Submittal 02441-13):
1. Provide a sample of logging reports and daily reports prior to beginning microtunneling.
2. Transcribe to paper and submit to the Engineer at the end of each shift the jacking operations log. The jacking operations log shall provide three recording points of measurements for each pipe segment up to and including 10 feet long. Provide the first recording point within one foot of the start, second recording point near the midpoint, and third recording point within one foot of the end. For pipe segments longer than 10 feet add one recording point at the midpoint between the first and second recording points and add one recording point at the midpoint between the second and third recording points for a total of five recording points. For each of the recording points, record the following measurements and provide unit of measure:
    a. Printed name of operator and signature.
    b. Time of measurement.
    c. Position of the tunneling machine in relation to design line and grade.
    d. Number of each pipe installed and length of pipe.
    e. Position of IJS in the installed pipeline including exerted jacking force.
    f. Maximum jacking forces exerted on the pipe at each section.
    g. Starting and finish times for each crew shift each day.
    h. Position of steering jacks.

i. Inclination and roll of cutter head.
j. Torque of the cutter head.
k. Earth pressure.
l. Slurry flow rates and pressures.
m. Face pressure of slurry.
n. Slurry density and viscosity.
o. Hydraulic pressure.
p. Volume of pipe lubricant used, viscosity, and pumping pressure.
q. Observations of settlement or heaving.
r. Any problems encountered since last recording point.

3. If an automated data recording system is available on the microtunneling system supplied, it is to be operational and the Contractor is to submit a sample of all information available for recording, variations in sampling frequency, and available formats. All automated data is to be provided to Owner on a daily basis in the requested format(s) at no additional charge to the Owner.

N. Contractor and Contractor's MTBM Operator(s) Qualifications (Submittal 02441-14): Submit resumes of the MTBM Operator(s) proposed for this project. The Contractor agrees that no changes will be made to personnel for this project without the express written consent of the Owner. The qualifications shall be in accordance with Section 02441 Microtunneling, 1.04 Quality Assurance: Experience Requirements.

O. Survey data (Submittal 02441-14):
1. Survey of line and grade for MTBM operations.
2. Submit readings to the Engineer on the same work day the readings are taken.
3. Provide interpretation of survey results to the Engineer on the following working day.
4. Provide contemporaneous written log of all laser set-ups and adjustments.
5. Provide copies of field forms used to establish all lines and grades.
6. Provide as-built survey of the casing pipe including one point taken at each joint and from each end of the pipe string. Mark survey locations so results can be replicated. Provide results in both tabular format and AutoCAD format acceptable to the Engineer. Scale to be acceptable to the Engineer. Survey shall confirm that carrier pipe can be installed within design tolerances.

1.09 PROJECT CONDITIONS

A. Contractor shall refer to the subsurface information described in Section 02301, Earthwork.

B. The plans show the locations of the soil borings and other geotechnical sites that are part of the various reports.

C. Reports are available from the Owner.

D. The Contractor shall provide adequate ventilation in the tunnel and shafts at all times. Air quality shall be tested in the shaft and tunnel immediately prior to each change in shift as well as prior to any personnel entry, and periodically thereafter as required by law.

E. The Contractor shall provide adequate lighting in the tunnel shaft and around equipment being utilized and shall thoroughly insulate any separate power and lighting circuits.

1.10 SAFETY

A. The Contractor shall obtain a State of California, Department of Industrial Relations, Division of Occupational Safety and Health Administration (Cal/OSHA) underground classification for these tunnels. The Contractor shall conform to the Cal/OSHA Permit requirements and perform Work in conformance with all applicable laws and regulations.

B. The Contractor shall submit a safety plan for the Engineer's information only (Submittal 02441-16). The Contractor is solely responsible for safety on the project site; therefore, the submitted plan shall not be subject to approval by the Engineer. At a minimum, the plan shall include:
   1. Safety plan for shaft access and exit, including ladders, stairs, walkways, removal of injured personnel, and hoists.
   2. Protection against improper electrical, mechanical, and hydraulic equipment operations.
   3. Protection against improper and unsafe lifting and hoisting equipment, practices, and operation.
   4. Ventilation and lighting details.
   5. Monitoring for hazardous gases.
   6. Protection against flooding and means for emergency evacuation.
   7. Protection of shaft including traffic barriers, accidental or unauthorized entry, and falling objects.
   8. Safety supervision responsibilities.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Steel pipe shall be specifically designed for microtunneling, conforming to paragraph B below.
   1. Use of other pipe types will require prior approval of the Engineer.

B. Pipe Specification
   1. Provide casing with minimum inside diameter as shown on the drawings and plate thickness, as determined by the calculations performed for paragraph 1.08.H above, unless the Contractor elects to adjust the excavated diameter to fit their means and methods, subject to acceptance by the Engineer.
   2. Provide casing that is specifically manufactured for microtunneling with a smooth outer wall and is manufactured to the following dimensional criteria:
      a. Circumference < 0.5 percent
      b. Exterior Roundness < 0.5 percent

c. End Squareness +/- 1.5 mm
d. Straightness < 3 mm
e. Pipe Length +/- 6 mm

3. The pipe shall be round, smooth, and with flush-jointed outer surfaces.
4. Pipe ends shall be square and smooth so that jacking loads are evenly distributed against the pipe end faces without point loads when the pipe is jacked. Pipe used for microtunneling shall be capable of withstanding the jacking forces imposed by the process of installation, as well as the final in-place loading conditions.
5. The driving ends of the pipe and intermediate joints shall be protected against damage.
6. Provide contact grout and lubrication ports on casing pipes manufactured for microtunneling. Provide at least one port per 7 feet of casing pipe. Ports to be rotated at least 120 degrees from previous port.

2.02 LUBRICATION

A. Lubrication shall consist of bentonite and/or polymers and water. Contractor shall bear the expense of obtaining water from a potable and/or recycled water source. Polymers shall be non-toxic and shall not be used until the MSDS is submitted and approved. (Submittal 02441-6)

2.03 ANNULAR SPACE GROUT

A. Grout shall consist of a cementitious mix containing sand and water. Contractor shall bear expense of obtaining water from a potable water source.

2.04 EQUIPMENT

The Contractor shall be responsible for compliance with the following requirements.

A. General: The microtunneling system selected shall be specifically designed for excavating, transporting, and separating the soil materials that routinely could be encountered or expected along the alignment of the proposed sewer.

B. Microtunnel Boring Machine (MTBM): Use MTBM equipment that is capable of handling the anticipated subsurface conditions. Only slurry MTBMs are permitted. In addition, the MTBM shall:
1. Be capable of maintaining the tunnel face under wet, dry, and adverse soil conditions and preventing loss of ground through the machine. The MTBM must provide satisfactory support of the excavated face at all time.
2. Be articulated to allow steering.
3. Incorporate a suitable seal between the MTBM and the leading pipe.
4. Provide protection to the electric and hydraulic motors and operating controls against water damage.
5. Use bi-directional drive on the cutter head wheel, and/or adjustable fins or other means, to control roll.
6. Exert a controllable pressure against the face, during both excavation and shutdown periods, to support the excavation face, prevent groundwater inflows, and prevent loss or heave of ground. A closed-face cutterhead designed to minimize loss of ground shall be provided. Control the volume of

excavated material removed at the tunnel face and the machine advance rate to avoid over-excavation.

7. Have sufficient cutting power to bore through the anticipated subsurface conditions.

8. Hydraulic fluids used in the MTBM shall be fire resistant, in accordance with NFPA 241.

C. Automated Spoil Transportation: Provide a MTBM that includes an automated spoil transportation slurry system that balances the groundwater pressures by the use of a slurry pressure balance system. System shall be capable of adjustment required to maintain face stability for the particular soil condition encountered on the Work and shall monitor and continuously balance the groundwater pressure to prevent loss of slurry or uncontrolled groundwater inflow. Contractor shall:
   1. Manage the pressure at the excavation face by use of the slurry pumps (which may operate at variable speeds), pressure control valves, and a flow meter.
   2. Include a slurry bypass unit in the system to allow the direction of flow to be changed and isolated, as necessary.
   3. Have a spoil transportation system that has the capability for removal of soil in balance with excavation and advance.

D. Slurry Separation Equipment: Provide a slurry separation system that is capable of the following:
   1. Provide adequate separation of the spoil from the slurry so that slurry with sediment content within the limits set by the Contractor's Work Plan can be returned to the cutting face for reuse. Use a mechanical separation plant, including scalping screens, shaker screens, de-sanding and de-silting cones, and centrifuge as deemed necessary by the project plan. Appropriately contain spoil at the site prior to disposal.
   2. Use the type of separation process suited to the size of the tunnel being constructed, the soil type being excavated, and the workspace available at each jacking shaft location for operating the plant.
   3. Carefully monitor the composition of the slurry to maintain the slurry weight, gel strength, and viscosity limits defined by the Contractor's Work Plan.

E. Pipe Jacking Equipment: Provide a MTBM operation that includes a pipe jacking system with the following features:
   1. Main hydraulic cylinders mounted in a jacking frame located in the jacking shaft used to push the MTBM and pipe through the ground.
   2. Jacking system that successively pushes the MTBM along with a string of connected pipes towards a receiving shaft.
   3. Sufficient jacking capacity to push the MTBM and the pipe string between the shaft locations identified on the Shop Drawings.
   4. Hydraulic cylinder extension rates which are synchronized with the excavation rate of the MTBM, as determined by the soil conditions.
   5. Uniform distribution of jacking forces on the end of the pipe by use of thrust ring and packers.
   6. A pipe lubrication system that at all times lowers the friction developed on the surface of the pipe during jacking.

7. Furnish and operate annular space grout system suitable for any required grouting operations depending on the condition of the application. The grouting operation shall not damage adjacent utilities or other properties. Grout shall be injected at a pressure that will not distort or imperil any portion of the Work or existing installations or structures.

F. Remote Control System: Provide a MTBM that includes a remote control system with the following features:
   1. Allows for operation of the system without the need for personnel to enter the tunnel. Has a display available to the operator, showing the position of the shield in relation to a design reference together with other information such as roll, pitch, complete guidance system, valve positions, thrust force, cutter head torque, rate of advance and installed length.
   2. Integrates the system of excavation and removal of spoil and its simultaneous replacement by pipe. As each pipe section is jacked forward, the control system synchronizes all of the operational functions of the system.

G. Active Direction Control: Provide a MTBM that includes an active direction control system with the following features:
   1. Controls line and grade by a guidance system.
   2. Is equipped with a high intensity laser (maximum legal limit) or newer systems which could include gyroscopic control sensors coupled to the laser sensing system.
   3. Is capable of maintaining line and grade as specified in 3.03.B.1.
   4. Provides active steering information that is monitored and transmitted to the operating console. As a minimum, this information shall include location of the laser beam on the target and location of the cutter head.
   5. Provides positioning and operation information to the operator on the control console.
   6. Provides a reference laser, or other approved device that indicates visually in the jacking shaft that the directional control laser has not been accidentally moved.

H. Safety Equipment: Provide all appropriate safety equipment as necessary for the Contractor's method and operation of construction and as required by all applicable Laws and Regulations.

PART 3 - EXECUTION

3.01 JACKING AND RECEIVING SHAFTS

A. The Contractor shall be responsible for constructing jacking and receiving shafts for microtunneling in accordance with the requirements of Section 02442, Microtunneling Shafts.

3.02 WORK AREA PREPARATION AND MAINTENANCE

A. The Contractor shall be responsible for the following conditions:
   1. Means and methods of tunneling and pipe jacking operations and safety of the Work, the Contractor's employees, the public and adjacent property, whether public or private.

2. Clean working conditions inside the jacking operation area, including removal of spoil, debris, equipment, and other material not required for operations. Contractor shall not store pipe on any City streets unless the Owner grants permission in writing. Contractor shall see that streets are cleaned each day with a street sweeper. Cleaning with a water truck shall not be allowed.
3. Organization of microtunneling surface equipment for each drive in such a manner as to enable proper operation at all times, to minimize impacts to property owners, and to maintain traffic control patterns as specified in the Traffic Control Plan.
4. Power generation equipment and any other equipment operating on or with fuel or lubrication oils shall be provided with suitable oil and gas containment basins made of plastic lining and sand bags to ensure no loss of oil to drains or water courses or to contaminate the ground.

3.03 INSTALLATION

A. Alignment Establishment: The Contractor shall be responsible for adherence to the following requirements and conditions:
1. Retain a Professional Surveyor licensed in the State of California to survey the control points identified in the Contract Documents. Surveyor shall check baseline and benchmarks at the beginning of the Work and report any errors or discrepancies to the Engineer. Sheet G-5 shows the survey monuments used by the design surveyor and may be used by the contractor's surveyor. The Contractor's surveyor shall verify all survey monuments that are used.
2. Use the baseline and benchmarks shown on the Plans to furnish and maintain reference control lines and grades for the sewer pipe construction. Use these lines and grades to establish the exact location of the pipeline excavation, and structures.
3. Establish and be responsible for accuracy of control for the construction of the entire Work, including Access Shaft locations, structures, excavation, pipe alignment, and grade.
4. Establish control points sufficiently far from the tunnel operation not to be affected by ground movement.
5. Check the primary control for the microtunneling system against an above ground undisturbed reference at least once each week or not greater than 250-foot intervals of pipeline constructed.

B. Tolerances: The Contractor shall adhere to the following requirement and conditions:
1. Pipe installation shall not vary by more than 0.2 feet in horizontal alignment or 0.1 feet in vertical elevation from any design point between, and including, shafts.
2. Record the exact position of the MTBM at 50-foot intervals or a minimum of once per shift to ensure the alignment is within the specified tolerances. Make the survey at the MTBM to allow immediate correction of misalignment before allowable tolerances are exceeded. The tunnel guidance system may be used; however, select times to measure and record this information after the air temperatures have stabilized throughout the pipe to ensure accurate readings.
3. When the excavation is off line or grade, return to the design line and/or grade over the remaining portion of the drive and at a rate of not more than 1-inch per 25 feet.

4. If allowable tolerances are exceeded, Contractor shall make all necessary adjustments to the installed casing at their own cost so that the carrier pipes can be installed to the correct line and grade.
5. Perform a verification survey with a transit or total station of the installed casing from shaft to shaft after removal of the MTBM. Document measured conformance to design line and grade of the casing together with locations and deviation (distance and direction) of any out-of-tolerance locations. Comply with the requirements of Section 02441 Microtunneling – 3.03.A.

C. Tunneling and Jacking of Pipe: The Contractor shall adhere to the following requirements and conditions:
1. Conduct tunneling operations in accordance with applicable safety rules and regulations and use methods that include due regard for safety of workers, and protection for adjacent structures, utilities, and the public.
2. Keep tunnel excavation within the rights-of-way indicated on the Contract Drawings, within the lines and grades designated on the Contract Drawings, and within tolerances specified in the Contract Documents.
3. Locate equipment powered by combustible fuels at suitable distances from shafts and protect equipment to prevent the possibility of explosion and fire in shafts or the pipe.
4. Synchronize the rate of advance of the MTBM with the rate of spoil removed to avoid over-excavating.
5. Make the excavation of a minimum sufficient size to permit pipe installation by jacking with allowance for injection of the lubricant.
6. Maintain an envelope of lubricant around the exterior of the pipe during jacking and excavation operation to reduce the exterior friction and possibility of the pipe seizing in place.
7. Contractor shall not employ water jetting of the ground to advance the pipe without prior written approval of the Engineer.
8. If the pipe “freezes” and the MTBM and/or pipeline are unable to be moved, a recovery access shaft may be permitted with the location subject to review by the Engineer. The bid price shall include all costs associated with recovery of the MTBM, including but not limited to permits, shaft construction, demolition and replacement, and utility relocation. Recovery shaft construction shall be performed in accordance with the requirements of Section 02442 Microtunneling Shafts.
9. In the event a section of pipe should be damaged during the jacking operation or joint failure occurs, as evidenced by visible ground water inflow or other observations, use one of the following procedures to correct the damage, as directed by the Engineer, and at no additional cost to the Owner:
    a. Slightly damaged pipe that passes leakage test and maintains pipe barrel and joint structural integrity, may, if access is possible, be repaired in place with a method approved by the pipe supplier and if the proposed technique is accepted by the Engineer.
    b. Severely damaged pipe, or pipe where joint failure is evident, shall be removed from the excavation by surface excavation, except as noted above, or by jacking it through the excavation and removing it at the receiving shaft. The removed pipe, after inspection is found to be without defect, may be jacked a second time by being placed into the same pipe string at the jacking shaft.

c. Damaged pipe may be repaired in place subject to approval by the engineer.

10. Perform annular space grouting as required to fill annular space and/or to control settlement.

D. Intermediate/Emergency Rescue Shafts. If an Intermediate/Emergency Rescue Shaft is requested, the Contractor shall obtain a written approval from the Engineer. The Intermediate/Emergency Rescue Shaft shall not be located in areas prohibited by the Contract Documents. The Contractor's request shall include all necessary permits and approvals, minimize public inconvenience and minimize impacting existing facilities. Additional ground monitoring instrumentation may be required.

E. Obstructions During Microtunneling:

1. Remove, clear, or otherwise make it possible for the microtunneling system and pipe to progress past or through objects in accordance with the Contractor’s submitted contingency plan.
2. No additional compensation for removing, clearing, or otherwise making it possible for the MTBM to progress past objects that are not obstructions will be paid.
3. Payment for obstruction removal shafts, which includes the removal of the obstruction, shall be paid in accordance with the Bid Schedule, if the object meets the definition of an obstruction, and subject to the following requirements:
   a. Notify the Engineer immediately upon encountering an object that stops the forward progress of the Work.
   b. Upon written authorization by the Engineer, proceed with removal of the object by means of obstruction removal procedures in accordance with the Contractor’s approved submittals and Section 02442 Microtunneling Shafts.
   c. No excavation within 5 feet of the front of the MTBM head is to be completed without the Engineer’s knowledge.
4. The proposal of alternative methods for removing, clearing or otherwise making it possible for the microtunneling system to progress past objects that does not allow for the visual observation and measurement of the nature of the object to be made shall not be considered for additional payment.

3.04 NOISE MONITORING AND ABATEMENT

A. Implement measures necessary to mitigate noise impacts caused by the Work. The following noise monitoring and abatement requirements are specific to the microtunneling operation when the Contractor’s power generation and slurry separation equipment are operating. Shaft construction shall be exempt from the following requirements:

1. Monitor the ambient noise at the corner of the occupied building closest to the generator and slurry separation equipment.
2. Provide equipment with enclosures or construct portable sound barriers to minimize noise impact.
   a. Provide a generator with a “residential” silencer and acoustic enclosure. Provide a unit that meets the noise requirements of the County of San Diego.

b. Provide equipment with equipment mufflers, as needed, to mitigate the noise produced from construction.
c. Contractor may be required to rearrange equipment to minimize noise impact.

3.05 DISPOSAL OF MUCK AND EXCESS MATERIAL

A. Remove muck and excavated material from the project site in accordance with the requirements of Green Book Section “Construction and Final Cleaning.”

B. Locate and acquire a site for the legal disposal of muck and excess excavated material and dispose of same in accordance with all applicable Laws and Regulations. Defend, indemnify, hold harmless the Owner, Design Engineer, Engineer, and all Subcontractors for all claims, demands, penalties, fines, damage, loss, causes of action, proceedings, liability, costs, and expense including attorney’s fees for failure to dispose of same in accordance with all applicable Laws and Regulations.

3.06 SITE CLEANUP

A. Unless otherwise shown or specified, Contractor shall restore to their original condition all existing surface improvements damaged or removed as a result of microtunneling operations.

3.07 QUALITY CONTROL

A. Perform a CCTV inspection of the completed pipeline. Provide two copies of DVD’s or Thumb Drives for viewing by the Engineer.

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SECTION 02442

MICROTUNNELING SHAFTS

PART 1 – GENERAL

1.01 SCOPE

A. Perform all work necessary for excavating, sheeting, shoring and supports shown, specified and required to construct jacking and receiving shafts, and other shafts as needed to complete the Work.

B. Maintain water tightness of all shafts as required for proper operation of the tunneling equipment and its effects on the tunneling system. Exterior dewatering to lower the groundwater is not permitted.

C. Design, furnish, install, and maintain support systems, including all bracing and associated items necessary to retain safe excavations and to control ground movements within specified limits. Upon completion of required tunnel construction, completely remove support systems as specified, and restore shafts and staging sites. Relocate utility lines as required to construct shafts. Provide sanitary sewer bypasses for lines that will be connected to manholes at shaft locations until connection to the new Trunk Sewers can be accomplished.

D. Sawcut and remove pavement; provide fences and signs for construction staging areas; design and construct shaft excavations and excavation support systems; dispose of materials; control and dispose surface water, ground water, and construction water; and restore site.

E. Assume sole responsibility for sizing the shaft excavations and construct shafts adequate for all structures required. Further, the allowable work area shall meet specifications of the Traffic Control Plan, and shaft excavations shall conform to right-of-way requirements and width limitations.

F. Construct shafts as sited on the Contract Drawings unless the Engineer approves otherwise. The Contractor shall be responsible for all costs associated with relocation of shafts.

G. Relocate, support, or bypass all identified utilities required in the performance of the work at no additional cost to the Owner.

1.02 RELATED SECTIONS

A. Section 01300, Submittals

B. Section 02301, Earthwork

C. Section 02441, Microtunneling

D. Section 02443, Microtunneling Instrumentation

1.03 QUALITY ASSURANCE

A. Permits and Regulations: Contractor shall:

1. Obtain all applicable permits for earthwork, work in roads, right-of-way, etc., as required by local, state, and federal agencies.

2. Comply with all construction discharge requirements specified herein.

3. Perform excavation work in compliance with applicable requirements of governing authorities having jurisdiction.

B. Reference Standards and Codes:

1. ASTM A 36, Specification for Structural Steel.

2. OSHA Standard, Title 29, Code of Federal Regulations, Part 1926, Section 650 (Subpart P - Excavations).

3. CAL/OSHA State of California Administrative Code, Title 8, Industrial Relations, Chapter 4, Subchapter 4, Construction Safety Orders.

C. Survey Requirements: Replace all monuments damaged by installation of shafts to the standard of the owning agency.

1.04 SUBMITTALS

Contractor shall submit all Shop Drawings and calculations for excavation support systems, and other related information for completion of the Work as requested by the Engineer. Where reference is made to a California PE, it shall mean that a Professional Engineer registered in the State of California who has a minimum of five years experience in earth retaining structures shall prepare and seal the Shop Drawings. Where reference is made to a California SE it shall mean that a Structural Engineer registered in the State of California who has a minimum of five years experience in similar work shall prepare and seal the Shop Drawings.

It shall be evident that the trenchless contractor was consulted during the preparation of the pre-construction submittals to establish dimensions of the jacking and receiving shafts and top of working slabs, based on the required casing elevations, casing segment lengths, dimensions of the trenchless contractor’s jacking frame and other tunneling equipment, eye entry and exit seals, and machine retrieval requirements.

In accordance with the requirements of Section 01300, Submittals, submit the following:

A. Name and qualifications of Contractor's PE responsible for excavation support system design.

B. Shop drawings and design calculations, indicating arrangements of supports and construction sequence for proposed support system(s), and: Show the elevation of struts, braces, or other supports as related to the depth of excavation at intermediate stages of construction. Provide details of working slab, drains, and sump construction. Indicate sizes, shapes, and material specifications for all support elements including lagging, if used. Show calculations that shall include estimates of likely deflections or deformations of the support system and shaft bottom, along with maximum tolerable values. Include design drawings and calculations signed by PE that meet the no dewatering requirement and the loads imposed by the construction method.

C. Sheet Pile Drivability Calculation: Provide sheet pile drivability calculation where driven interlocking sheet piles are used for shaft excavation support. At minimum, indicate required sheet pile type, dimensions, properties and required installation equipment.

D. Break-in and break-out plans that indicate support installed to transfer loads and maintain excavation support and stability of the excavation when commencing tunneling operations and when holing out in receiving or intermediate shafts.

E. Integrated thrust block design and details, including jacking force capacity and effects on shoring design by PE.

F. Contingency Plan: Describe the steps and actions needed to stabilize the excavation and excavation support systems if the excavation becomes unstable or the monitoring data indicate movements exceed the allowable limits. Include a list of contingency materials and equipment to be kept available on site for installation.

G. Shaft field inspection data on the same date as taken and interpretation by noon the following work day.

H. Daily installation logs, including: dimensions of the top and bottom of the shaft; elevations of top of ground, top of shoring elements, and bottom of shoring elements; and results of all tests and observations.

I. Daily driving record of each sheet pile, including pile type, location, number, batter, pile length before cutoff, location of splice, existing ground elevation, final tip elevation, starting and finishing driving times, number of blows per each foot of penetration including number of blows per inch for the last six inches, actual rate of hammer operation in blows per minute, and deviation from plumb and from indicated location, and cause and extent of interruption of pile driving.

J. Driving record for each pile, pile type, location, plumbness, batter, pile length before and after cutoff and final tip elevation.

1.05 DESIGN CRITERIA

A. The Contractor's Engineer shall comply with the following design criteria:

1. Construct the shaft using water-tight construction shoring methods that limit water inflow to less than 5 gallons per minute from all sources before and during tunneling operations except as specifically specified otherwise. Shaft shall also limit loss of ground and piping of soils into excavation. No soldier pile and lagging or trench boxes/shields shall be permitted for shaft construction. Limit groundwater inflow before microtunneling commences.

2. The Contractor shall properly support all excavations and prevent all movement of the soil, utilities, or structures outside of the excavation. All shafts and shoring systems shall conform with applicable federal, state and local safety standards, Cal/OSHA Standards, U.S. Bureau of Mines Standards, and the, trenching and shoring standards that are contained in the California Code of Regulations. Shoring deflection is limited to a maximum of one (1) inch of horizontal or vertical movement. All measured deflection values are relative to the baseline value identified at the start of construction.

3. Dewatering shall not be used to lower the groundwater at any time during microtunneling.

4. Shaft shall be designed and constructed utilizing watertight construction methods.

5. Design shaft excavation support systems and working slabs to withstand earth pressures, unrelieved hydrostatic pressures, bottom heave, equipment loads, applicable traffic and construction loads, and other surcharge loads to allow for the safe construction of microtunnel without ground deformation beyond specified tolerances, and to prevent damage to, or movement of, adjacent structures, streets, and utilities.

6. Design the support system to minimize horizontal and vertical movements, and to protect adjacent utilities from damage. Design support system to maintain the stability of the excavation and to provide a factor of safety of at least 1.5 against sliding and against bottom heave.

7. Design a working slab for each jacking shaft bottom to provide stable support for guide rails, thrust blocks, and other construction operations.

8. Provide temporary safety railing, concrete K-Rail barriers, and fencing around shaft excavations. Provide traffic control around working areas and shafts as shown on the Traffic Control Plans.

9. Engineer's review of the Contractor's plans and methods of construction shall not relieve the Contractor of the responsibility to provide and to maintain an adequate support system achieving the specified requirements.

10. Locate shafts approximately where indicated on the Contract Drawings unless otherwise approved by the Engineer.
11. For Subsurface Ground Information see Paragraph 1.06 below.

1.06 SUBSURFACE INVESTIGATIONS

A. Geotechnical investigations for design purposes for this project were made for Kennedy Jenks Consultants by Leighton Consultants in two reports entitled: Geotechnical Investigation Lift Station 1A Pipeline/Improvements Project, Rainbow Municipal Water District, Bonsall, California, dated November 27, 2017; and Geotechnical Investigation Lift Station 1A Pipeline/Improvements Project, Rainbow Municipal Water District, Bonsall, California, dated November 30, 2018 and updated on June 2, 2020 with an attached Addendum #1 dated January 4th 2021.

B. This report is available for examination by bidders from the Owner. While the records of data obtained may be considered by the Contractor to be correct, any conclusions or recommendations made in the reports are for information to the Design Engineer and are not a part of the Contract Documents. Copies of the boring logs are in the Appendix of these Specifications and their locations are shown on the Drawings. The bidders may make additional subsurface investigations at the site prior to the bidding of the project. Prior to making any drillings or excavations, the bidder shall secure permission from the Agency, City, County of San Diego and property owners if on private property.

1.07 MATERIALS TRANSPORTATION, HANDLING, AND STORAGE

A. Material Storage: Stockpile satisfactory excavated materials at locations approved by the Engineer, until required for backfill or fill. Place, grade, and shape stockpiles for proper drainage.

B. Disposal: Dispose of excess soil material and waste materials at an approved disposal site

PART 2 – PRODUCTS

2.01 MATERIALS

A. General: All timber and structural steel elements used for the supporting systems, whether new or used shall be sound and free from defects, which may impair their strength.

B. Structural Steel: Structural steel shall conform to ASTM A36 or higher strength, unless approved otherwise.

C. Sheet Piling: Z sections designed to withstand the external earth pressure and having a new edge sealing method such as used by Arcelor RPS sheets.

D. Timber: All timber shall be of structural grade with a minimum allowable flexural strength of 1,500 pounds per square inch (psi).

E. Shotcrete: Shotcrete shall conform to the requirements of ACI 506.2. Minimum design compressive strength shall be as required but not less than 4,000 psi.

PART 3 - EXECUTION

3.01 SHAFT SIZE AND LOCATION

A. Shaft Location: The shaft location and function shall be as shown on the Plans, unless otherwise approved by the Engineer. Proposed shafts at locations other than shown on the Plans shall comply with the following conditions:

1. Alternate or additional shaft locations shall be defined as alternate jacking/receiving shaft locations proposed by the Contractor. Intermediate shafts, recovery shafts, and obstruction removal shafts shall be as defined in Section 02441 Microtunneling.

B. Shaft Size: The Contractor shall be solely responsible for sizing the shafts. Shaft size shall be adequate for construction of any permanent structures indicated on the Plans and shall provide adequate room to meet the Contractor's operational requirements for tunnel construction and for backfill. Contain shaft excavations within the public right-of-way or permanent easement and limit width by the allowable work area shown by the Contract Drawings. Shafts are shown on the Drawings.

C. Permits: The Contractor shall obtain all approvals, permits and bear all costs related to constructing and using revised shaft locations or sizes (other than indicated by the contract drawing) including, but not limited to surveying, redesign and approval of the AutoCAD 2014 or later drawings, utility relocation, construction, and restoration.

D. Traffic Control: A licensed Civil Engineer in the State of California shall sign and submit to the Engineer for approval revised traffic control drawings approved by the Caltrans' Traffic Engineer and San Diego County's Traffic Engineer, if necessary.

3.02 UNAUTHORIZED EXCAVATION

A. All excavations outside the lines and grades shown, together with the removal and disposal of the associated material, shall be at Contractor's expense.

B. Fill and compact to at least 95% relative compaction with select backfill or approved slurry backfill all unauthorized excavations at Contractor's expense.

3.03 UTILITY CONFLICTS / RELOCATION

A. The Contractor shall be ultimately responsible for determining a plan of action, subject to the approval of the Engineer, for protecting and relocating, bypassing or supporting all identified and unidentified utilities required to construct the jacking and receiving shafts necessary to complete the work and deal with identified utilities at no additional cost to the Owner. Shaft locations are in highly congested utility crossings. The shafts may be altered slightly from their planned locations dependent on the Contractor's plan to sink the shafts and as allowed by the permits.

3.04 SHAFT CONSTRUCTION: GENERAL

A. All shafts shall be constructed utilizing methods that minimize groundwater impact. Construction shall be completed without an external dewatering system in-place and shall be constructed of materials that prevent water inflow. Develop a confined space entry procedure for entering the shafts to protect those that enter for work and inspection purposes. Develop a log to show that a safety briefing was performed for each such entry.

B. Shaft construction methods shall always ensure the safety of the work, Contractor's employees, Engineer's and Owner's employees, inspectors, public, and adjacent property and improvements, whether public or private.

C. Provide shaft excavations with a gravel base and a concrete working slab equipped with a sump to pump out construction water and stormwater.

D. Before beginning construction at any location of this project, adequately protect existing structures, utilities, trees, shrubs, and other existing facilities. Design excavation support systems to limit deformations that could damage adjacent facilities including utilities and structures. The repair of, or compensation for, damage to existing facilities, shall be at no additional cost to Owner.

E. All welding shall conform to the applicable provisions of ANSI/AWS D1.1.

F. Implement support system monitoring provisions in accordance with Section 02443, Microtunneling Instrumentation.

G. Install excavation support systems in accordance with approved Shop Drawings.

1. If settlement or deflections of supports or shaft bottom indicate the support system requires modification to prevent excessive movements, the Contractor's PE shall redesign and resubmit revised shop drawings and calculations to the Engineer at no additional cost.

2. Stockpiling of excavated material within the public right-of-way shall not be permitted.

H. Jacking Shafts shall be constructed with the shoring extending not more than 4 feet above the ground surface.

I. Install the internal bracing support system sequentially during shaft development as required by the approved Contractor's Engineer calculations.

3.05 SHAFT CONSTRUCTION: SPECIFIC TO LOCATION

A. Emergency Shaft Construction. Groundwater shall be anticipated above pipe invert. Vertical shaft boring with a CMP liner is an acceptable construction method.

3.06 SHAFT CONSTRUCTION: INTERNAL BRACING SUPPORT SYSTEM

A. The internal bracing support system shall include walers, struts, and/or shores.

B. Provide struts with intermediate bracing as needed to enable them to carry the maximum design load without distortion or buckling.

C. Include web stiffeners, plates, or angles as needed to prevent rotation, crippling, or buckling of connections and points of bearing between structural steel members. Allow for eccentricities caused by field fabrication and assembly.

D. Install and maintain all bracing support members in tight contact with each other and with the surface being supported.

E. Preload bracing members by jacking struts to 50 percent of the design load if necessary to control shoring movement.

F. Preload bracing members in accordance with methods, procedures, and sequence as described on the Shop Drawings. Coordinate excavation work with installation of bracing and preloading. Use steel shims and steel wedges welded or bolted in place to maintain the preloading force in the bracing after release of the jacking equipment pressure. Install support and preload immediately after installation and prior to continuing excavation.

G. Use procedures that produce uniform loading of bracing members without eccentricities or over-stressing and distortion of members of system.

3.07 SHAFT CONSTRUCTION: METHODS

A. Metal Pipe (MP) in Drilled Shaft

1. MP shall be placed in vertical drilled hole. The drilled hole shall be within design tolerances of vertical alignment, diameter, and designed depth. Drilled hole shall be of sufficient size to allow placing of MP without damaging the MP.

2. MP shall be true and round within design tolerances and of sufficient length to line entire hole. Installed MP shall be flush with ground surface or shall not extend more than 4 feet above ground surface without prior written permission of engineer.

3. Annular space shall be filled with grout of sufficient strength and flowability to provide 100% contact to ground and MP. Grout shall be within design tolerances for strength and flowability and compatible with subsurface conditions described in Section 02301.

4. Temporary ground support shall be provided in design and may include pilot hole, collaring hole with steel, and flooding of drilled hole with engineered driller's mud.

5. The shaft bottom is to be an integral part of the entire shaft design. Shaft shall not be drained until annular grout and bottom plug have reached required strength.

6. Following completion of construction, at a minimum the MP shall be removed for the first 6 feet below the final surface grade.

B. Interlocking Sheet Piles

1. Interlocking sheet pile shafts are to have interlocking grooves that are demonstrated to sufficiently seal the shaft to inflowing ground conditions.

2. The shaft bottom is to be an integral part of the entire shaft design. Shaft shall not be drained until grout and bottom plug have reached required strength.

3. All steel subsurface ground support materials shall be removed except for those lying directly below the installed jacked pipe.

4. Before placing any steel sheet piles, mark layout. Contact subsurface utilities and request they mark their adjacent facilities. Where utilities are within two feet of steel sheet piles, expose existing utility by hand excavation. Protect existing utilities during the pile installation.

5. If possible, place piles without interruption from first blow until average final set in or with a vibratory hammer which will force pile to penetrate by its own weight and weight of engines bearing on top. Vibrate the piles into place; do not drive.

6. Cut piles in plane as indicated. Fill space around piles with dry sand or crushed stone. Cutoff portions of piles remain property of Contractor. Transport portions from Worksite except if of a type and length which could be used for other piles on Worksite; cut off portions may be incorporated as a part of other piles.
7. Provide electrical continuity between metal elements of structure, including top channel by welding two reinforcing bars across each joint. Weld in accordance with AWS D1.1.
8. Weld on channel cap in accordance with AWS D1.1, and fill space around pile with dry loose sand within one hour after pile has been driven.
9. Splice steel piles with full penetration butt welds over entire cross Section. Align adjacent sections so axes of piles are straight. Limit number of splices in length of pile to two. Splices in top ten feet of pile - not permitted. Locations of pile lugs, when used. Welding by qualified welding operators only.
10. Noise and Vibration Limits - In accordance with the County of San Diego Municipal Code.
11. Design and construct the shaft bottom as an integral part of the entire shaft.
12. Remove all steel subsurface ground support materials, except for those lying directly below the installed jacked pipe.
13. Piles shall be guided and held in position by temporary gates with each pile properly interlocked with its neighbor.
14. Pre-drill at installation locations of sheet piles as required to maintain pile verticality and to avoid damage.
15. Drive to position and line indicated or as directed, based on required penetrations as determined by Contractor's accepted design. Piles materially out of line will be rejected. Remove rejected piles which interfere with work at no additional cost to the City.
16. Utilize sheet piles and installation equipment as indicated by the Sheet Pile Drivability Calculation.

C. Other Construction Methods

1. Contractor shall submit other construction method or combination of construction methods required for completion of the shafts.

3.08 BACKFILL

A. Refer to Section 02301.

B. Place backfill in shafts in 12-inch compacted layers.

C. Keep excavations dry during backfilling operations. Compact and raise backfill around pipelines and manholes evenly on all sides.

D. Jetting and flooding backfill shall not be allowed.

E. Flowable fill shall be permitted with written permission of the Engineer.

3.09 REMOVAL OF SUPPORT SYSTEM

A. Remove sheeting and bracing from excavations when complete. Perform removal in a manner that avoids injury to the work, existing street, adjacent utilities, or structures. Removal shall be equal on both sides of excavation to ensure equal loads occur on pipelines and manholes.

B. Defer removal of sheeting and bracing, where removal may cause soil to come into contact with concrete, until concrete has cured a minimum of 7 calendar days.

3.10 RESTORATION

A. Backfill and Foundation: Furnish, place, compact, and backfill all shaft excavations in accordance with Section 02301.

B. Site Restoration: Restore the work area disturbed by construction activities and repair any damage caused to existing utilities, to its original, or better, condition. Restore paved areas to original or better condition.

3.11 ENVIRONMENTAL CONTROLS

A. Groundwater Control: Provide groundwater control and drainage from shafts while work is in progress and until adjacent pipe joints have been properly sealed and the shaft is properly backfilled.

B. Remove water from excavation as fast as it collects.

C. Provide and maintain pumps, sumps, suction and discharge lines, power supply and other system components necessary to convey water away from excavations.

D. Surface Water Control: Divert surface water runoff from the shaft and protect the shafts from infiltration or flooding by surface water, including discharge from any dewatering operation. Shaft lining system at jacking shafts only may extend not more than 4 feet above existing, adjacent ground elevation. Receiving shafts shall be flush to the ground surface and plated over until their use is required.

E. No equipment or materials shall be stored on public streets or public property without written permission from the Owner (County of San Diego or Caltrans as appropriate). Store materials and equipment only in Contractor’s laydown areas as designated on the plans and within the limits of the shaft excavation.

F. Provide K-rail or fencing around the entire perimeter of jacking shaft excavations as appropriate if not plated over and flush to the existing ground surface.

3.12 WELL REMOVAL PROCEDURES

A. In accordance with California Department of Water Resources “California Well Standards – Bulletin 74-90,” destroy instrumentation wells, and groundwater monitoring wells required for construction of shafts. Submit documentation of well destruction to the Engineer for review prior to submission to the local permitting agency.

B. The top 5 feet shall be concrete. The pavement surface shall match existing adjacent surface material.

3.13 SAFETY

A. The Contractor shall be solely responsible for safety.

B. Place orange security fencing and flashing light barricades around the Contractor’s work area with appropriate signage and lighting. Construct a suitable K-rail barrier around the periphery of the shaft, meeting applicable safety standards. Properly maintain the barrier throughout the period the shaft remains open. Repair broken boards, supports, and structural members.

C. In addition, provide a full cover or other security barrier for each access shaft where no construction activity exists or that is unattended by the Contractor’s personnel.

3.14 RESTORING AND RESURFACING EXISTING ROADWAYS AND FACILITIES

A. The Contractor shall restore pavement or roadways damaged by construction operations to County of San Diego or Caltrans Standards, based on which agency has jurisdiction of the roadway.

3.15 DISPOSAL OF ALL MATERIALS

A. The Contractor shall haul away from the project site material removed from the excavations that does not conform to the requirements for fill and also shall dispose of that material in compliance with ordinances, codes, laws, and regulations at no additional cost to the Owner.

B. The Contractor shall utilize highway legal trucks for the export of material from the project site and to a site secured by the Contractor. No earth moving equipment or special construction equipment, as defined in Section 565, of the California Vehicle code shall be allowed for hauling material on public streets.

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SECTION 02443

MICROTUNNELING INSTRUMENTATION

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes: Requirements for installing geotechnical instrumentation, consisting of Inclinometer(s), and Multiple Point Borehole Extensometer(s), and Surface Monitoring Point(s), to monitor ground and structural movements during shaft and tunnel excavation. The Work shall include furnishing, maintaining, monitoring, and removing all instrumentation associated with the construction work shown in the Drawings and as necessary to safely complete the Work.

1.02 RELATED SECTIONS

A. Section 02441: Microtunneling

B. Section 02442: Microtunneling Shafts

1.03 SUBMITTALS

A. Contractor shall submit the following items:

1. Proposed surveyor and schedule for installation of microtunnel survey control points as required per this specification Section.

2. Description of the survey control point installation procedure as required for control of the MTBM per this specification Section. Coordination with the Owner provided surveyor to assure both surveyors use the same control points.

3. Detailed drawings indicating the layout and designation of all ground surface survey control points required per this specification section.

4. Description of the proposed methods for monitoring the survey control points required per this specification Section.

5. Instrumentation Specialist qualifications and supplier qualifications.

6. Manufacturer's product description, drawings, operation and maintenance procedures, and samples where applicable, as well as description of methods and materials for installing and protecting the instruments, including post-installation acceptance tests.

7. For each Multiple Position Borehole Extensometer (MPBX) to be installed, a certificate issued by the manufacturer stating that the instrument has been inspected and tested at the factory.

8. Reports of Surface Monitoring Point data to the Engineer within four hours after data collection, as well as Inclinometer and Multiple Position Borehole Extensometer (MPBX) data within two working days.

1.04 QUALIFICATIONS

A. Qualifications for Instrumentation Specialist: Employ a California Registered Professional Engineer specialized in geotechnical engineering with experience in the installation and maintenance of instrumentation similar to that specified herein, to supervise and direct instrument installation technicians.

B. Qualifications for Surveyor: Contractor shall employ a Land Surveyor licensed in the State of California for at least five years.

1.05 QUALITY ASSURANCE

A. Installation: Provide notice to the Engineer not less than two working days before instrument installation. Label all instruments with an identifying instrument number.

B. Installation Tolerances: Install all instruments within three feet of the horizontal location described within these specifications. Install to within 6 inches of the bottom elevation described within these specifications. Install Surface Monitoring Points, Inclinometers, and Multiple Position Borehole Extensometer casings within two degrees of vertical for the entire length of the casing.

C. Should actual field conditions prevent installation of instruments at the location and elevations specified herein, obtain prior acceptance from the Engineer for new instrument location and elevation.

D. Borehole Logging: Boreholes are to be logged under the supervision of a CA registered Geologist or PE with a minimum of five years experience.

E. Perform all surveying using NAVD 1988 monumentation for all elevations. Perform all horizontal positioning using California State Plane Coordinates based on the design survey points.

PART 2 - MATERIALS

2.01 MATERIALS

A. Sand: Shall conform to ASTM C 778 for 20-40 sand.

B. Cement Grout: Shall be Type II Portland cement and water in accordance with ASTM C 150.

2.02 SURFACE MONITORING POINTS

A. Where the ground surface consists of sidewalk, street, railroad, or vegetation, the Surface Monitoring Points shall be in accordance with the project drawings. A drill rig shall drill vertically a 6-inch hole to approximately 6 feet above the top of the proposed pipeline. The top 6 inches of the hole shall be cased to protect the instrument. A 4-inch diameter casing shall be installed vertically in the hole and the annular space grouted. The grout shall be weaker than the soil that was removed. A #8 re-bar shall be installed with 1 foot buried in the ground below the bottom of the hole. The top shall be capped to prevent damage to the instrument and protect the public. The Contractor shall ensure the functionality of the instrument to measure subsidence.

B. Where the ground surface consists of curbs, foundation, or footing, Surface Monitoring Points shall consist of a stable pin or nail.

C. Where a vertical object rises more than 6 feet above the ground surface, and is within 25 feet of the tunnel centerline, the survey shall include three-dimensional documentation of the vertical nature of the object.

D. Where an existing crack, gap, or joint in a structure needs to be monitored, the crack can be surveyed for location, photographed with a scale with a time and date stamp, and monitored with observations recorded or a Tell-Tale™ Crack Monitor as manufactured by RST Instruments Ltd. Canada, or equal, may be installed and monitored with observations recorded.

E. The Surface Monitoring Points shall be surveyed following installation, with a second survey completed before commencing tunneling. The second survey shall not be started until all Surface Monitoring Points for the construction zone have been installed and the first survey completed by at least one working day.

2.03 INCLINOMETERS

A. Inclinometers shall consist of inclinometer casing installed and grouted within vertical boreholes.

1. Inclinometer casing shall be approximately 2-3/4-inch standard flush coupled such as Model No. 51100100 manufactured by Slope Indicator Company, Mukilteo, WA or approved equal.

2. Inclinometer Probe and Assembly. One inclinometer probe assembly shall be furnished including a sensor (probe) on a minimum 100-foot cable, a pulley assembly, and a case. This equipment shall be Model No. 50302500 (sensor), and associated pulley assembly, and case manufactured by Slope Indicator Company, Mukilteo, WA or approved equal.

3. Inclinometer Readout Unit. Furnish one inclinometer readout unit. The readout unit shall be model No. 50310900 manufactured by Slope Indicator Company, Mukilteo, WA or equal. Readout unit provided shall be compatible with inclinometer probe and shall be calibrated by the manufacturer.

4. Inclinometer Software. Furnish computer software required to reduce, analyze, and plot the inclinometer data using an IBM-compatible personal computer. Furnish DMM software program (Order No. 50310970) supplied by Slope Indicator Company, Mukilteo, WA or approved equal, or software compatible with other approved readout units.

5. Provide a cement-bentonite grout for installing inclinometer. Grout mix shall be in accordance with manufacturer's requirements.

6. Provide a traffic cover of the size indicated.

2.04 MULTIPLE POSITION BOREHOLE EXTENSOMETERS (MPBX)

A. Borehole extensometers shall be of the fixed, rod type with anchor locations as described herein. Contractor shall provide the following materials and equipment:

1. Three-position multiple-anchor borehole extensometers to measure vertical deformation.

2. Rod type extensometer similar in design to Model 51815855 manufactured by Slope Indicator Company, Seattle, WA; flexible rod extensometer with "D" type rod assembly as manufactured by RST Instruments, Yakima, WA; or Model A-G as manufactured by Geokon, Inc., Lebanon, NH, or approved equivalent. An extensometer with electrical sensors equipped with a remote monitoring system shall be allowed.

3. Both a handheld depth micrometer type readout device Model 518096 manufactured by Slope Indicator Company, Seattle, WA, or approved equivalent and appropriate electronic readout device as required.

B. Extensometer equipment and installation shall satisfy the following criteria:

1. Range of each anchor shall be 2 inches for heave measurements and 4 inches for settlement measurements.

2. Grout subsurface anchor points and the entire subsurface assembly with an approved grout mix.

3. Provide a reference point for measurement of elevation of instrument at pavement or ground surface as required.

4. Provide a traffic cover of sufficient size to protect the instrument from damage, with a protective cap for the extensometer reference head as recommended by the instrument manufacturer.

5. Outer casings, if required, and other auxiliary materials shall be as recommended by the extensometer manufacturer.

PART 3 – EXECUTION

3.01 GENERAL

A. Provide the Engineer access to instrument locations and provide Engineer with Contractor-collected monitoring data.

B. Perform subsidence monitoring as described herein.

C. Interpret the data and make interpretations available to the Engineer.

D. The instrumentation specified is the minimum required. The Contractor shall install and monitor additional instrumentation as necessary to control the work and provide a safe working environment, and shall do so at no additional cost to Owner.

E. Contractor shall install Instrumentation at the locations specified, or as directed or approved by the Engineer and shall install all instruments a minimum of seven (7) calendar days prior to start of shaft excavation unless otherwise specifically stated in the specifications.

F. Locate conduits and underground utilities in all areas where subsurface geotechnical instrumentation is to be drilled and installed. Repair damage to existing utilities resulting from instrument installations at no additional cost to the Owner.

G. Protect the instruments and monitoring equipment from damage. Replace or repair damaged instruments or monitoring equipment prior to continuing tunneling activities.

H. Contractor shall restore all facilities to like condition at no additional cost to Owner.

3.02 INSTRUMENTATION AND MONITORING

A. Contractor shall carry out operations to minimize settlement and/or heave of the ground. Contractor shall repair, at Contractor's sole cost, all damage due to settlement, consolidation or heave from any construction-induced activities.

B. In the event of movement being detected of the ground surface or damage being recorded of the structure or utility, the Engineer may order that the Work be stopped and secured. Before proceeding, Contractor shall correct any problems causing or resulting from such movement, entirely at no additional cost to the Owner. If ground settlement or heave occurs which might affect the accuracy of temporary or permanent benchmarks, monitor and immediately report such movement to the Engineer.

3.03 SURVEY

A. Contractor shall adhere to the following requirements concerning survey oversight:

1. Initial Survey: Record the horizontal coordinates and elevations (within an accuracy of 0.01 feet) for each survey point location. Reference survey points so that they may be accurately re-established if lost or destroyed.

2. Interim Surveys: Take readings at least once per week unless otherwise required. Report on readings from the various instruments and survey points to the Engineer on the same day the readings are taken. Commence readings at the commencement of shaft sinking. Take initial readings one week before any other excavation or construction is started. Continue to monitor weekly and for at least 4 weeks after completion of any tunnel section.

3. Final Survey: At the end of all construction operations, make a final survey of all control points established for instrumentation and observation. Submit final readings to the Engineer upon completion of the survey.

3.04 SURFACE MONITORING POINTS

A. Establish a grid of Surface Monitoring Points on the ground surface for the purpose of monitoring ground subsidence resulting from tunnel excavations as required by the Engineer and as specified herein.

B. Establish Surface Monitoring Point arrays oriented perpendicular to the tunnel centerline at 10 foot distances from the jacking shaft and receiving shaft. Each array shall consist of three control points: one on the tunnel centerline; and two at 7-feet either side of tunnel centerline. Review Surface Monitoring Point locations in the field during construction with the Engineer and modify locations if required. Surface Monitoring Point arrays shall not be installed within environmentally sensitive areas.

C. Provide up to 2 additional Surface Monitoring Points at locations to be determined in the field by the Engineer, at no additional cost to Owner.

D. Determine the elevation of each Surface Monitoring Point to an accuracy of $\pm$ 0.01 foot.

E. Determine the elevation of each Surface Monitoring Point prior to commencing shaft excavation and survey each Surface Monitoring Point at daily intervals following commencement of shaft excavation.

F. Continue taking survey readings weekly for a period of two months following completion of shaft backfill, or as directed by the Engineer.

3.05 INCLINOMETERS

A. Establish a system of inclinometers for the purpose of monitoring ground movement adjacent to the shaft locations resulting from shaft construction as required by the Engineer.

B. Provide one (1) inclinometer at each shaft location.

1. Locate the inclinometer adjacent to and within 5-feet of the long side of the excavation.

2. Locate the inclinometer at a center span lagging location to detect the maximum deflection caused by the excavation.

C. Review inclinometer locations in the field during construction with the Engineer and modify locations, if required.

D. Install inclinometer casing in accordance with the manufacturer's recommendations and the approved Drawings.

1. Inclinometers are to be installed to at least 10 feet below shaft support system.

2. Grout annulus between inclinometer and casing from bottom of hole to ground surface using non-shrink cement grout as recommended by manufacturer. Use a grout tube inside the casing connected to grout port connection in bottom cap. Grout casing into hole immediately after installing both casings.

3. Install protective housing with locking cap and padlock, and give keys to the Engineer. Install protective housing within an approved flush-mounted roadway box or vault so as not to obstruct vehicle or foot traffic.

E. Provide baseline readings of each inclinometer to an accuracy of ± 0.001 foot.

1. Provide differential readings of each until the shaft is completely backfilled and accepted as properly compacted.

2. Continue taking inclinometer readings monthly for a period of two (2) months following completion of the shaft backfill.

3.06 MULTIPLE POSITION BOREHOLE EXTENSOMETERS

A. Establish a system of Multiple Borehole Extensometers (MPBX) along the alignment of the microtunnel excavation for the purpose of monitoring ground subsidence resulting from tunnel excavations as required by the Engineer.

B. Provide two MPBX at third point locations along the centerline of each microtunneling drive or as otherwise indicated on the Drawings. Review MPBX locations in the field during construction with the Engineer and modify locations if required. These replace two surface monitoring points on each drive.

C. Determine the elevation of each MPBX point to an accuracy of ± 0.001 foot prior to construction.

D. Determine the elevation of each MPBX prior to commencing tunnel excavation and survey each MPBX point at 2-working-day intervals following commencement of tunnel excavation.

E. Continue taking survey readings weekly for a period of 2 months following completion of tunnel excavation, or as directed by the Engineer.

F. Contractor shall install MPBX as specified herein and in accordance with the manufacturer's recommendation.

G. Contractor shall assist the Instrumentation Specialist with the installation of borehole extensometers, as required.

H. Make logs of soil and rock encountered during drilling. Present these field logs to the Engineer for final approval of individual anchor elevations prior to instrument installation. Drill logs shall be signed and sealed by a California Registered Geologist.

I. Prior to instrument installation, flush the borehole free of cuttings and debris.

J. Tremie approved grout from the bottom of the hole.

K. Install protective housing with locking cap and padlock, and give keys to the Engineer. Install Protective housing within an approved flush-mounted roadway box or vault to avoid obstructing vehicle or foot traffic.

3.07 MONITORING

A. Initial Readings: The Contractor shall take initial readings of all instruments to establish a baseline and provide the Engineer with these data.

B. Frequency: The Contractor shall monitor required instrumentation and provide the Engineer with these data. As a minimum, the Contractor shall use the following schedule:

Instrument Type	Active Zone–within 100 ft of Shaft Excavation or Tunnel Excavation	Outside Active Zone
Surface Monitoring Points	Every Working Day	Weekly/Monthly[(a)]
Inclinometers	Every 2 Working Days	Weekly/Monthly[(a)]
Multiple Position Borehole Extensometers	Every 2 Working Days	Weekly/Monthly[(a)]

Note:

(a) Weekly until movement substantially stops and monthly thereafter.

C. Reporting: The Contractor's submitted data shall include, but are not limited to, the following:

1. Data sheets containing a cumulative history of readings, including weather conditions and proximity of the excavation to the instrument location at the time of each reading.

2. A plot of measured values versus time, including a time history of construction activity likely to influence such readings.

D. Interpretation: The Contractor shall create interpretations of monitoring data for the Contractor's purposes. Data or interpretations shall not be published or disclosed to other parties without advance written permission of the Engineer. The Engineer may provide the Engineer's interpretations of the data to the Contractor at the Engineer's option.

E. Final Disposition: In accordance with California Department of Water Resources "California Well Standards – Bulletin 74-90," Contractor shall destroy all Instrumentation Boreholes as required for construction of the Work. Contractor also shall submit documentation to the Engineer for review prior to submission to the local permitting agency.

F. The Contractor also shall adhere to the following requirements:

1. Surface Monitoring Points: Remove all instruments during the cleanup and restoration work or as required by the Engineer.

2. Multiple Position Borehole Extensometers (MPBX) and Inclinometers: Abandon holes and remove protective housings and caps in accordance with applicable permits. Close all open permits at no additional cost to the Owner.

   a. Backfill remaining portions with approved non-shrink cement grout.

   b. Following backfilling, remove pre-cast boxes or vaults and reconstruct pavement in paved areas. Restore surface to the conditions existing prior to installation of the instruments.

3.08 RESPONSE VALUES

A. Response Values are a percentage of the Maximum Allowable Movement by Instrument Type and owner of the right-of-way. (RR = Railroads, Utility = Utility Pipeline Crossings and Storm Drain Crossings)

	Maximum Allowable Movement +/-		
Instrument Type	**Bonsall Creek Bridge**	**Ostrich Creek Bridge**	**Utility**
Surface Monitoring Point	0.50 inch	0.50 inch	0.50 inch
Inclinometers	0.50 inch	0.50 inch	0.50 inch
Multiple Position Borehole Extensometer	0.50 inch	0.50 inch	0.50 inch

B. The Contractor shall abide by the following Response Values:

Instrument	**Threshold Value**	**Contractor Response Value**	**Shutdown Value**
Surface Monitoring Point	50%	90%	100%
Inclinometer	50 %	80 %	100 %
Multiple Position Borehole Extensometer	50%	90%	100%

C. When a given response value is reached, the Contractor shall respond in accordance with the following:

1. Threshold Value. The Contractor shall meet with the Engineer to discuss his means and method to determine what changes, if any, shall be made to better control ground movement. Instrument readings shall be required on a daily basis until five consecutive working days of readings below the Threshold Value.

2. Contractor Response Value. The Contractor shall actively control ground movement in accordance with the approved plan to prevent reaching the Shutdown Value. Instrument readings shall be required on a daily basis until five consecutive working days of readings below the Threshold Value.

3. Shutdown Value. Contractor shall stop all Work immediately. The Contractor shall meet with the Engineer to develop a plan of action before the Work can be resumed.

END OF SECTION

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SECTION 02445

CONDUCTOR CASING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Install steel conductor casings under roadways where indicated on the Drawings. Conductor casings shall be smooth steel casing pipe designed by the Contractor for the loads to be imposed. The casings shall be installed by jacking using methods that will not disturb roadways, railroads or utilities. Any damages shall be immediately repaired at the Contractor's expense to the satisfaction of the agency or utility having jurisdiction. Jacking shall not interfere with highway or railroad traffic.
   2. Conductor casing sites have been classified by the Department of Industrial Relations. Conspicuously post the classifications at the place of employment. Install said crossings and perform work in accordance with the requirements of the Tunnel Safety Orders of the Department of Industrial Relations, Division of Industrial Safety, State of California.

B. Related Sections:
   1. Section 02301: Earthwork
   2. Section 02530: Sewers
   3. Section 09960 High Performance Coatings

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM):
   1. A252 Specification for Welded and Seamless Steel Pipe Piles

B. American Association of State Highway and Transportation Officials (AASHTO)

1.03 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Submit a complete description of proposed installation methods and materials of casing pipes and other items to the Engineer prior to construction under the Product Review category. Submittal shall include structural and deflection calculations for conductor casings.

1.04 QUALITY ASSURANCE

A. Allowable Tolerances. Conductor casings shall not vary from the line established on the plans by more than 1 foot, nor from the grade established on the plans by more than 0.5 foot vertically.

1.05 PERMITS

A. The *Owner has applied for permits from Caltrans.* Refer to the General Conditions. The work shall comply with the requirements of the applicable permitter. The work will be inspected by the permitter. Right of Entry shall be obtained in writing from all agencies prior to beginning the work, and copies shall be provided to the Engineer.

B. It shall be the Contractor's responsibility, at his own expense, to obtain any additional permits and agreement as required for the installation of conductor casings.

PART 2 - PRODUCTS

2.01 CASING MATERIAL

A. Pipe: Steel casing pipes shall be smooth-welded steel pipe, conforming to ASTM A252 Grade 1, with watertight butt welded seams and field joints. Field joints shall be watertight. Minimum casing inside diameter shall be at least 4 inches larger than maximum outside diameter of the carrier pipe, or 28-inch outside diameter, whichever is larger. The minimum pipe wall thickness shall be designed by the Contractor to withstand installation loads, and service load of earth cover and a superimposed AASHTO H20 wheel load in roadways, with a deflection of less than 3%. The minimum thickness shall not be less than 0.375 inches.

B. Grout Plugs: Install *four* rows of 2 inch threaded and plugged grouting holes on 10-foot centers in the casing pipe where shown on the Drawings. Coordinate the grout plug locations with insulators to allow free passage of the carrier pipe.

C. Lining is not required.

D. Coating: Coat exposed conductor casing pipe per System No. 2 of Section 09960. Installation shall occur in accordance with Section 09960. Buried conductor casings do not require coating.

2.02 CARRIER PIPE SUPPORT

A. Provide casing insulators to support the carrier pipe within the casing, to prevent the carrier pipe from floating, and to electrically insulate the carrier pipe from the casing. Insulators shall be designed and spaced to support the carrier pipe when full, with no water in the annular space.

B. Insulators: Flanged steel bands with PVC insulating liner, and phenolic insulating runners. Steel bands shall be coated with heat-fused polyvinyl chloride, and nuts and bolts shall be painted with enamel after installation. PSI Industries Model A; equivalent product by T.D. Williamson, Inc.; or equal.

2.03 GROUT

A. Grout shall consist of a suitable mixture of portland cement, sand, and any chloride-free admixture designed to provide a pumpable mix. The grout shall contain no less than 470 pounds of portland cement per cubic yard and no more water than necessary to provide a pumpable grout.

2.04 CASING SEALS

A. Seals shall be standard wrap around ends seals, made of synthetic rubber, with watertight seams and seals, and provided with stainless steel bands and clamps. PSI Industries Model W; equivalent product by T.D. Williamson; or equal.

PART 3 - EXECUTION

3.01 JACKED CASING PIPE INSTALLATION

A. Installation shall be appropriate for the specific subsurface conditions and shall result in a safe, expeditious, and non-disruptive crossing. Earth shall be removed by auguring, boring, or other favorably reviewed methods, and shall be in full accordance with the permit requirements of all affected utilities, companies and agencies.

B. Install casing pipes in such a manner that they are not damaged or deflected to reduce their effective true circular diameter. Jacking pits of adequate size shall be excavated, and suitable backstops constructed therein to provide stable backings for hydraulic jacks.

C. The diameter of the excavated hole shall not be more than 0.1 foot greater than the outside diameter of the pipe. Sluicing or jetting with water will not be permitted. When material tends to cave in from outside these limits, a shield shall be used ahead of the first section of pipe or the face of excavation shall not extend beyond the end of the pipe more than 1 1/2 feet, unless otherwise permitted by the Engineer.

D. Voids outside the casing shall be grouted as required by the permitter.

3.02 INSTALLATION OF CARRIER PIPE

A. Install the carrier pipe in the conductor casing on insulators of sufficient thickness to prevent the pipe from touching the casing as shown on the Drawings and to align the pipe to meet the grade shown on the Drawings. The final grade of the carrier pipe through the conductor pipe shall be favorably reviewed by the Engineer. On all bell and spigot pipe, insulators shall be installed behind each bell and one within 18 inches of each spigot end and have a maximum spacing of 10 feet center to center. On welded cement mortar lined and coated steel pipe or reinforced concrete cylinder pipe, the insulators shall have a maximum spacing of 10 feet center to center. Place an insulator within 6 inches of each end of the conductor casing. There shall be a minimum of two insulators installed or skids on each section of pipe.

B. Where sections of conductor casings are joined by welding, touch up the coating, inside and outside with the same material, prior to recommencement of jacking operations.

C. Install conductor casing end seals. Secure seals in place with stainless steel band. Make watertight by bonding together the exposed overlapping surfaces with a permanent sealing adhesive.

3.03 EXCAVATION AND BACKFILL OF JACKING PITS

A. All earthwork for working pits for conductor casings shall be done in the dry in accordance with Section 02301, as modified below.
   1. Dimension of pits shall be as required for sheeting and bracing and for proper performance of the work.
   2. Boring pits shall be dug with minimum length and width dimensions and to the depth necessary for installation of the boring and encasement to the proper grade. The boring pit shall be kept dry at all times. Where the bottom is not firm, a layer of crushed rock shall be placed on the bottom to provide

working surface. Where a utility goes through a boring pit, it shall be adequately supported and protected.

3. Boring pits shall be adequately shored to support the adjoining ground. All boring pits shall at all times be adequately barricaded from public access and for the protection of workers.
4. Backfill for the pit shall be as shown on the Drawings and as specified for trenches.

3.04 ALTERNATIVE METHOD OF INSTALLATION

A. The Contractor may propose alternate methods of installing conductor casings, subject to the favorable review of the Engineer and permitting agencies.

END OF SECTION

SECTION 02530

SEWERS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Furnish and install all piping as shown on the Drawings, described in the Specifications and as required for a complete and operable system.

B. Related Sections:
   1. Section 02080: Precast Concrete Sectional Manholes
   2. Section 02301: Earthwork

1.02 REFERENCES

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

1.	A74	Specification for Cast Iron Soil Pipe and Fittings
2.	C76	Specification for Reinforced Concrete Culvert, Storm Drain and Sewer Pipe
3.	C425	Specification for Compression Joints for Vitrified Clay Pipe and Fittings
4.	C443	Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets
5.	C564	Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
6.	C700	Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
7.	C923	Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals
8.	D3034	Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings
9.	D3212	Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
10.	F477	Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
11.	FC79	Specification for Poly (Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings

B. Cast Iron Soil Pipe Institute.

1.03 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Submit the following in for review:
   1. Potholing Report: Verify by excavation, inspection and measurement all installation conditions, including existing utilities and structures, for buried pipe before preparation of Shop Drawings. Submit field measurements, elevations, station locations, and photos. See also paragraph 3.02, Existing Utilities, of Section 02301.
   2. Shop Drawings: Submit data to show that the products specified in this Section conform to the Specification requirements.

3. Leakage Testing Plan.
4. Samples: Submit two sample gaskets of each type to be used with an explanation of the markings.
5. Test Results: As required herein.

1.04 QUALITY ASSURANCE

A. All materials and equipment furnished under this Section shall be of manufacturers who have been regularly engaged in the design and manufacture of the materials and equipment for a period of at least 5 years.

B. Factory Quality Control: The Contractor shall test all products as required herein and by the reference specifications.

C. Field Quality Control:
1. The Contractor shall:
a. Perform leakage tests
b. Perform mandrel tests
c. Be responsible for the costs of additional inspection and retesting by the Owner resulting from non-compliance.

1.05 POTHOLING (CHECK ON LOCATIONS)

A. Do not prepare any shop drawings for, or make final order for, or design any pipe materials for any particular section of pipeline until all utilities in that section of pipeline have been exposed, as specified in paragraph 3.02 of Section 02301, entitled Existing Utilities, and until such time as no interferences are found between said existing utilities and the proposed pipeline alignment. If interferences are found in any particular section of pipeline, do not prepare any shop drawings for, or make final order for, or design any pipe materials for that particular section of pipeline until the pipeline alignment has been modified by the Engineer to eliminate all such interferences.

PART 2 - PRODUCTS

2.01 GENERAL

A. Pipe sizes are nominal inside diameter unless otherwise noted.

B. All materials delivered to the job site shall be new, free from defects, and marked to identify the material, class, and other appropriate data such as thickness for piping.

C. Acceptance of materials shall be subject to strength and quality testing in addition to inspection of the completed product. Acceptance of installed piping systems shall be based on inspection and leakage tests as specified hereinafter.

2.02 POLYVINYL CHLORIDE PIPE (PVC)

A. Refer to Section 15050.

2.03 VITRIFIED CLAY PIPE (VCP)

A. Pipe and Fittings: Extra strength, unglazed, vitrified clay pipe with integral bells, ASTM C700.

B. Joints: Plastic compression joints, ASTM C425.

2.04 CONNECTION DEVICES

A. Transition Couplings: Transition couplings shall be elastomeric plastic or synthetic rubber resistant to sewage and grease, chemicals and normal sewer gases. Couplings shall be designed to slip over the outside of the pipes being connected with a snug fit. Coupling shall be held in place and sealed with a stainless steel band clamp around each end. Couplings shall be specifically manufactured for making the transition between various types of pipe with different outside diameters. Couplings shall meet the requirements of the Uniform Plumbing Code. Fernco; Indiana Seal; or equal.

B. Transition Donuts: Transition donuts shall be elastomeric plastic resistant to sewage and grease, chemicals and normal sewer gases. They shall be designed to be inserted in the bells of sewer pipe to adapt the bell to accept the spigot of a smaller size spigot. They shall have reversed fins on the inside and outside to grip the bell and spigot. Transition donuts cast or grouted into concrete pipe or manhole sections shall have an outside diameter at least 2 inches greater than the inside diameter. Fernco; Indiana Seal; or equal.

C. Manhole Adaptors: Manhole adaptors shall be SBR rubber manhole waterstops for use with PVC sewer pipe, Fernco, or equal.

D. Flexible Manhole Connectors: ASTM C923

E. Other Devices: Other equivalent connection devices will be considered provided that they are made of elastomers resistant to sewage and grease, chemicals and normal sewer gases. Metallic parts shall be stainless steel.

2.05 APPURTENANCES

A. Furnish and install all necessary guides, inserts, anchors and assembly bolts; washers and nuts, hangers, supports, gaskets, and flanges; all other appurtenant items shown on the Drawings, specified or required for the proper installation and operation of the piping; devices included in or on the piping equipment; and piping accessories.

PART 3 - EXECUTION

3.01 FLOW CONTROL

A. Divert sewage flows and storm water around all sewer and drain replacement work areas, including building connection sewer replacement. Furnish, install, and operate pumps, plugs, conduits, and other equipment to divert the flow of sewage around the pipeline reach in which work is to be performed. Plugs shall be designed so that all or any portion of the sewage can be released. The plug shall be provided with a tag line. The pumping system shall be of sufficient capacity to handle existing flow plus additional flow that may occur during a rainstorm. If pumping is required on a 24 hour basis and engine drives are required, engines shall be equipped in a manner to keep noise to a minimum. Refer to Section 01140 for noise control requirements. Standby pumps shall be provided as required. Pumping shall be done in such manner as will not damage public or private property or create a nuisance or health menace. After the work has been completed, flow shall be restored to normal. Existing sewers to be abandoned shall be disconnected after the new service is operating.

B. Notify residents of the impending work and request their cooperation to minimize flows shortly before working in each area.

3.02 BUILDING CONNECTION REPLACEMENT

A. Locate and replace all existing building connection sewers from the main to the property line.

B. Locations:
   1. The exact locations of building connection sewers are not known.
   2. The Contractor shall maintain a log to record the method used to determine the status of all existing connections to the sewer mains. The log shall record the location of building connection sewers, reconnected or abandoned, and shall record the address(es) served by "live" connections.

C. Replacement Connections: Install replacement building sewers on the most direct alignment between the property line and the main sewer, unless otherwise directed by the Engineer. The Contractor shall connect the building connection sewers to manholes when so directed by the Engineer. Provide outside drops when the invert of building connection sewer is 18 inches or more higher than the top of the main sewer. Payment for drops when a building sewer is connected to a manhole will be in accordance with Article 9 of the General Conditions.

D. Sizes: 4 inch minimum diameter or match the size of the existing building sewer, whichever is larger.

E. Cleanouts: Provide new cleanouts on each building sewer behind the curbs near the property line as shown on the Drawings.

F. Pipe Laying:
   1. Line and Grade: Lay the pipe on a uniform grade between the tee, wye, or the top of the riser section and the end of the existing house connection sewer at the point of reconnection. Minimum slope shall be 1/4 inch per foot unless otherwise permitted by the Engineer. Control the grade by means of a good-quality builder's level, not less than 24 inches in length.
   2. Fittings: Maximum deflection permissible with one fitting shall not exceed 45 degrees except at vertical laterals, and shall be accomplished with long-radius elbows. Short-radius elbows will not be permitted, except by permission of the Engineer.
   3. Field cuts of existing building connections shall be performed in a neat and workmanlike manner providing a clean, flush, saw-cut end.
   4. Any building connection sewer pipe upstream of the reconnection, which is damaged or loosened by the Contractor’s operation, shall be replaced or repaired at the Contractor's expense.

3.03 PIPING INSTALLATION

A. Storage and Handling:
   1. Great care shall be exercised to prevent damage to the pipe during handling, transportation or storage. Pipe shall not be stored on rough ground and rolling of the pipe on the coating will not be permitted. Any damaged pipe sections shall be repaired or replaced at the expense of the Contractor as satisfactory to the Engineer.
   2. Store polyvinyl pipe under opaque covers, which do not transmit ultraviolet light.

3. Each pipe section shall be carefully inspected before installation, and all damaged areas patched in the field or replaced as satisfactory to the Engineer.

B. General Piping Installation:
1. Trenching, bedding, and backfill for buried piping shall be as shown on the Drawings and as specified in Section 02301, Earthwork.
2. The profile drawings show invert elevations at certain structures and may show pipe slopes. In case of any conflicts the invert elevations shall govern over slopes. Install pipe with straight grades between indicated invert elevations.
3. Manhole locations are identified on the plan drawings by coordinates and by station. In case of any conflicts the coordinates shall govern over the stations.
4. Lay each length of pipe on a firm bed with a true bearing for its entire length between bell holes. Excavate holes of only sufficient size to accommodate the bell at each joint location. Adjust line and grade by scraping away, filling in and tamping the earth to provide true grade to fit the barrel of the pipe. No wedging or blocking up of the pipe will be permitted. The trench and bell holes shall be kept free from water during the laying of the pipe.
5. Except when noted specifically otherwise on the Drawings, whenever piping leaves a structure, concrete encasement, or concrete bedding, a joint capable of angular deflection shall be provided within 12 inches of the structure, encasement or bedding.
6. All dirt and foreign matter shall be removed from the pipe interior prior to installation and all joints shall be thoroughly cleaned before joining.
7. Plug open ends of pipe when construction is not underway.
8. Lay pipe upgrade with bell end forward, unless specifically shown otherwise.
9. After making each joint, rigidly secure the pipe in place by backfilling to the top of the pipe at the center, but not as to fill the bell hole nor interfere with the next jointing operation.

C. Installation Specifics:
1. Polyvinyl chloride pipe:
a. Install pipe in accordance with the manufacturer's instructions.
b. Place pipe within the installation areas at least 24 hours prior to installation to permit temperature equalization.
c. Cut pipe ends squarely, ream and deburr inside and out.
d. Clean pipe ends and bells of dirt, grease and other foreign materials prior to making the joint.

3.04 CLEANING

A. Prior to testing, the inside of each main sewer shall be thoroughly cleaned of all dirt, loose scale, sand and other foreign material. Cleaning shall be by flushing with water or balling as appropriate for the size and type of the pipe.

3.05 PERMANENT PLUGS

A. Clean interior contact surfaces of all pipes to be cut off or abandoned. Construct a concrete plug in the end of all pipe 18 inches or less in diameter. Minimum length of concrete plugs shall be 8 inches. For pipe 21 inches and larger, the plugs may be constructed of common brick or concrete block. The exposed face of block or

brick shall be plastered with mortar. All plugs shall be watertight and capable of withstanding all internal and external pressures without leakage.

3.06 LEAKAGE TESTS

A. General:
   1. Perform leakage tests on all sanitary sewer mains, building connection sewers, and storm drains installed in this project.
   2. Furnish all equipment, materials, personnel, and supplies to perform the tests.
   3. Pressure gauges and metering devices shall be of a type, accuracy and calibration acceptable to the Engineer. The Engineer may require certification of the gauges and meters by an independent testing firm at the Contractor's expense.
   4. Leakage tests shall be performed on all piping at a time agreed upon and in the presence of the Engineer.

B. The leakage test shall be made after all pipe is installed and backfilled, but prior to placing permanent resurfacing. The Contractor may conduct preliminary tests prior to backfill. If the Contractor elects to conduct preliminary tests, he shall provide any necessary temporary thrust restraint, and shall retest as set forth herein prior to surfacing placement.

C. Test Procedure: Leakage tests shall be air pressure tests conducted as follows:
   1. Furnish all materials, equipment and labor for making an air test. Air test equipment shall be favorably reviewed by the Engineer.
   2. The Contractor may conduct an initial air test of the sewer mainline after densification of the backfill but prior to installation of the house connection sewers. Such tests will be considered to be for the Contractor's information and need not be performed in the presence of the Engineer.
   3. Each section of sewer shall be tested between successive manholes, or in sections if favorably reviewed by the Engineer, by plugging and bracing all openings in the sewer mainline and the upper ends of all building connection sewers. Prior to any air pressure testing, all pipe plugs shall be checked with a soap solution to detect any air leakage. If any leaks are found, the air pressure shall be released, the leaks eliminated, and the test procedure started over again. The Contractor has the option of wetting the interior of the pipe prior to the test.
   4. The final leakage test of the sewer mainline and building connection sewers, shall be conducted in the presence of the Engineer in the following manner:
   5. Air shall be introduced into the pipeline until 4.0 psi (27kPa) gage pressure has been reached; or if groundwater is present, 4.0 psi (27kPa) above the computed pressure exerted by the average adjacent groundwater. Reduce the flow of air and maintain the air pressure within plus or minus 0.5 psi (3kPa) for at least 2 minutes to allow the internal air temperature to reach equilibrium. Pressure in the pipeline shall be constantly monitored by a gage and hose arrangement separate from hose used to introduce air into the line. A blowoff valve shall be provided on the test apparatus to prevent over pressurizing the pipeline.
   6. After the temperature has stabilized and no air leaks at the plugs have been found, the air pressure shall be permitted to drop until the internal pressure has reached 3.5 psi (24kPa) gage pressure; or when groundwater is present, 3.5 psi (24kPa) above the computed pressure exerted by the average adjacent groundwater. A stopwatch or sweep-second-¬hand watch shall be

used to determine the time lapse required for the air pressure to decrease an additional 1.0 psi (7kPa).

7. If the time lapse (in seconds) required for the air pressure to decrease the additional 1.0 psi (7kPa) exceeds that shown in Table, Low Pressure Air Test for Sewers, in the Standard Specifications for Public Works Construction the pipe shall be presumed to be within acceptance limits for leakage.
8. If the time lapse is less than that shown in this table, the Contractor shall make the necessary corrections to reduce the leakage to acceptance limits without additional compensation.

   T =Time in seconds for pressure to drop to 2.5 psi (17kPa) gage pressure.
   D =Inside diameter of pipe in inches (mm).

D. Correction of Defects: If leakage or infiltration exceeds the allowable, the installation shall be repaired or replaced and leakage tests shall be repeated as necessary until conformance test requirements specified herein have been fulfilled. All detectable leaks shall be repaired, regardless of the test results.

E. Reports: Keep records of each piping test, including:
   1. Description and identification of piping tested.
   2. Description of test procedure.
   3. Date of test.
   4. Witnessing by Contractor and Engineer.
   5. Test evaluation.
   6. Remarks, to include such items as:
      a. Leaks (type, location).
      b. Repairs made on leaks.
   7. Test reports shall be submitted to the Engineer.

3.07 MANDREL TEST OF POLYVINYL CHLORIDE PIPE

A. Following the placement and densification of backfill by at least 30 days, and prior to the placing of permanent pavement, all reaches of new mainline sewer constructed of polyvinyl chloride shall be cleaned and then mandrelled to measure for obstructions and pipe deflections.

B. A standard, commercially-manufactured, rigid, odd-numbered-leg (9 legs minimum) mandrel, with a circular cross section having a diameter of at least 95% of the specified average inside diameter, shall be pulled through the pipe by hand. The minimum length of the circular portion of the mandrel shall be equal to the nominal diameter of the pipe. Proof rings for verification of mandrel diameters shall be available at all times during mandrel tests. Rings shall be a standard product of the mandrel manufacturer.

C. Obstructions or deflection of the pipe barrel resulting in a reduction of the inside diameter by more than 5% encountered by the mandrel shall be corrected by the Contractor. The method employed to correct obstructions or excessive deflections shall be favorably reviewed by the Engineer prior to its implementation. The use of vibrating rerounding devices will not be permitted.

END OF SECTION

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SECTION 02550

CURED-IN-PLACE PIPE (CIPP) LINING

PART 1 - GENERAL

1.01 SCOPE

A. This section covers the rehabilitation of fully deteriorated gravity sanitary sewers, inclusive of the following:
   1. Cleaning and flushing existing sanitary sewer pipelines.
   2. Closed circuit televising (CCTV) of existing sewer pipelines.
   3. Public relation requirements.
   4. Cured-In-Place-Pipe (CIPP) liner design and installation.
   5. Sampling and testing requirements.

1.02 REFERENCE STANDARDS

A. Supply all products and perform all work in accordance with the latest applicable ASTM International (ASTM) standards.

B. The following ASTM Standards are being made part of the Specifications for the various approved processes and will be used as a minimum. Latest revisions of all standards are applicable.

1.	ASTM C581	Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass Fiber Reinforced Structures Intended for Liquid Service.
2.	ASTM D543	Standard Test method for Resistance of Plastics to Chemical Reagents.
3.	ASTM D578	Specification for Glass Fiber Strands.
4.	ASTM D638	Standard Test Method for Tensile Properties of Plastics.
5.	ASTM D790	Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
6.	ASTM D2990	Standard Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics.
7.	ASTM D5035	Test Method for Breaking and Elongation of Textile Fabrics (Strip Method).
8.	ASTM D5199	Standard Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.
9.	ASTM D5813	Specification for Cured-in-Place Thermosetting Resin Sewer Pipe.
10.	ASTM E1251	Standard Practice for General Techniques for Qualitative Infrared Analysis.
11.	ASTM F1216	Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube.
12.	ASTM F1743	Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP).

13. ASTM F2019 Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic (GRP) Cured-in-Place Thermosetting Resin Pipe (CIPP).
14. ASTM F2561 Rehabilitation of a Sewer Service Lateral and its Connection to the Main Using a One Piece Main and Lateral Cured-in-Place Liner.

1.03 SUBMITTALS

A. Product Data:
   1. CIPP Liners: Submit manufacturer's information on resin, resin enhancer, tube material, curing chemicals, sealant/caulking material, end seals, and lubricants.
   2. Submit manufacturers' certificates certifying products meet or exceed specified requirements. Certification shall state that all CIPP materials have been manufactured in accordance with all applicable ASTM standards, and the CIPP method is suitable for the installed environment.

B. Shop Drawings:
   1. For all liners, indicate liner dimensional information for each pipe size to be relined. Include field measurements of each host pipe section with liner design.

C. Manufacturer's Storage and Installation Instructions:
   1. Submit manufacturer's requirements for receiving, handling, and storage of materials.
   2. CIPP Liner: Submit detailed description of liner placement and curing procedures for piping. Submit manufacturer's recommended installation pressures and cure times, minimum and maximum, for each reach. Include description of procedures for sealing liner material at manholes and re-establishing service connections.

D. Contractor Qualifications:
   1. Submit documentation of lining installer's experience.
   2. Submit certification of Contractor's and Superintendent's licensure to install the provided lining method.
   3. Submit documentation from the manufacturer that there is an established and ongoing quality control and quality assurance program for the product at the manufacturer's production facility. This should include proof that the manufacturer has the necessary equipment and trained personnel to properly implement the program.

E. Design Data: Liner thickness design calculations, in conformance with the specified design requirement, shall be submitted. Design shall be signed and sealed by a Professional Engineer registered in the State of California.

F. Field Measurements: Contractor to verify pipe materials and measure the actual diameter of each pipe section to be lined. Measurements shall be provided to Engineer. For CIPP lining, each liner section shall be manufactured per actual diameter of pipe section. Provide actual measurements and liner dimensions for each pipe section with liner deign.

G. CIPP Resin Curing Schedule: Submit resin curing schedule indicating the time and temperature for each pipe reach per the manufacturer's requirements.

H. CCTV Inspection Records and Reports: CCTV inspections, in accordance with Section 02951, shall be provided for each installation, manhole to manhole.
   1. Submit CCTV after cleaning and prior to lining, showing the condition of existing pipe and pipe joints, and location of existing service connections.

I. Public Notification Letter: Submit public notification letter/flyer to Engineer for review and acceptance prior to distribution to public.

J. CIPP Sample Test Results: When requested by the Owner, the Contractor shall submit test results from prior CIPP field installations to verify that the physical properties specified have been achieved in previous field applications. Testing submittal shall include an affidavit from a third-party testing laboratory of installation samples.

K. Traffic Control Plan per Section 01550.

L. Closeout Submittals
   1. Submit post lining CCTV within 3 days after liner installation is complete, showing entire finished liner and re-established service connections. Line shall be dry and clean during the video inspection and CCTV shall include both ends of liner.
   2. CIPP Resin Curing logs shall be submitted after the liner installation.
   3. Record Drawings per Section 01700.

1.04 DESIGN REQUIREMENTS

A. GENERAL
   1. Design lining material for a fully deteriorated host pipe in accordance with ASTM F1216 or ASTM F1743. Rehabilitated pipe shall have sufficient structural strength to support dead loads, live loads, and groundwater loads imposed.
   2. Design liner to least possible thickness to minimize decreasing the inside pipe diameter.
   3. Design liner material to provide joint less and continuous structurally sound construction.
   4. CIPP liner will only be installed from MH to MH. There will be no installation of connection joints between liners in manholes.

B. Cured-in-Place Pipe, Resin Impregnated Felt Design Requirements: The liner shall be designed in accordance with ASTM F1216, Appendix X1. The design shall assume no bonding to the original pipe wall. All material properties used in design calculations shall be long-term (time-corrected) values. The cured-in-place liner minimum design thickness shall be calculated based on the following physical conditions of the existing pipe.
   1. The liner shall be structurally designed for a minimum service life of 50 years.
   2. The safety factor shall be 2.0.
   3. Long-term modulus and strength shall be set to 50% of the initial values given in paragraph 2.01B, above.
   4. Design lining material for a fully deteriorated host pipe.
   5. Live loading shall be considered to be HS-20 except for railroad crossings in which case use Cooper E-80.
   6. Water table shall be assumed to be at 0 feet below ground surface unless otherwise specified.
   7. All pipes shall be considered to have a minimum of two percent (2%) ovality in the circumference.

8. Allowable liner deflection of 5%.
9. The pipeline depth, diameter, and length shown on the Drawings are based on field investigation and existing records. The Contractor shall use field measurements of the pipeline length and diameter for the liner design. Any discrepancies between the Drawings and the field measurements shall be reported to the Engineer.

C. Cured-in-Place Pipe, Glass Reinforced Plastic Design Requirements: The cured-in-place liner thickness shall be calculated based on the following physical conditions of the existing pipe.
1. The liner shall be structurally designed for a minimum service life of 50 years.
2. A safety factor shall be set to 2.0.
3. Long-term modulus and strength shall be set to 50% of the initial values given above.
4. Design lining material for a fully deteriorated host pipe.
5. Live loading shall be considered to be HS-20 except for railroad crossings in which case use Cooper E-80.
6. Water table shall be assumed to be at 0 feet below ground surface unless specified otherwise.
7. All pipes shall be considered to have a minimum of two percent (2%) ovality in the circumference.
8. Allowable liner deflection of 5%.
9. The pipeline diameter and length shown on the Drawings are based on field investigation and existing records. The Contractor shall use field measurements of the pipeline length and diameter for liner design. Any discrepancies between the Drawings and the field measurements shall be reported to the Engineer.

1.05 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum 3 years of documented experience.

B. Installer: Company specializing in performing work of this section and who is licensed and approved by the manufacturer. Company shall have a minimum of 3 years of documented experience with projects of similar size and complexity as this project; and with the installation of liner materials specified herein. Project Superintendent shall have a minimum of 3 years of experience as Superintendent on similar Projects.

C. Design liner under the direct supervision of Professional Engineer experienced in design of this work and licensed in the State of California.

1.06 MATERIAL DELIVERY, STORAGE AND HANDLING

A. Materials shall be transported to, and stored at, the site in such a manner that they will not be damaged, exposed to direct sunlight, or result in any public safety hazard, and per manufacturers' recommendations.

1.07 COORDINATION

A. Notify property owners and businesses in advance of expected disruption of sanitary service. Notification shall be provided to each affected property owner in a written format. Submit the public notification letter/flyer to Engineer for review and acceptance prior to distribution to the public.

B. Limit disruption of service to individual properties to one-time occurrence for maximum **8 hours.**

C. Do not disrupt customer service between the hours of **5:00 p.m. and 8:00 a.m** unless stated otherwise on the Drawings.

D. Contractor must coordinate service disruptions **with Rainbow Municipal Water District.**

PART 2 - PRODUCTS

2.01 CURED-IN-PLACE PIPE, RESIN IMPREGNATED FELT

A. Materials

1. Tube: Fabricated from one or more layers of absorbent non-woven felt fabric meeting the requirements of ASTM F1216 or ASTM F1743.
   a. The tube shall be fabricated to a size that when installed will tightly fit the internal circumference and length of the original pipe. The Contractor shall make allowances in determining the felt tube length and circumference for stretch during installation and shrinkage during curing and aging. The minimum design length shall be that which continuously spans the distance from the center of the inlet manhole to the center of the outlet manhole.
   b. The tube shall have a uniform thickness equal to the designed nominal tube thickness when compressed at installation pressures.
   c. The layers of the cured CIPP shall be uniformly bonded. It shall not be possible to separate any two layers with a probe or point of a knife.
   d. The tube shall be homogeneous across the entire wall thickness containing no intermediate or encapsulated layers.
   e. The outside layer of the tube (before installation) shall be plastic coated with a translucent flexible material that clearly allows inspection of the resin impregnation (wetout) procedure. The plastic coating shall not be subject to delamination after curing of the CIPP.
2. Resin: Shall be a corrosion resistant polyester, vinyl ester, or epoxy and catalyst system that when properly cured within the tube composite meets the requirements of ASTM F1216 and ASTM F1743. Maximum amount of resin enhancer shall be 30 pounds per 100 pounds of resin.

B. Structural Requirements: The physical properties of the cured CIPP shall have minimum initial test values as defined in Table 1 of ASTM F1216 and supplemented below for polyester resin. Properties for the polyester or any other enhanced resins shall be substantiated with third party test data.

Property	Test Method	Cured Composite (per ASTM F1216)
Modulus of Elasticity	ASTM D790	400,000 psi minimum
Flexural Stress	ASTM D790	4,500 psi

C. The tube thickness shall meet approved design calculations based on structural requirements listed herein. The nominal CIPP thickness shall be at least the calculated design thickness, per ASTM F1216, except where fabric layers overlap, in which case it may be in excess of this value. The wall thickness of the felt tube

shall be ordered to the next standard 1.5 mm incremental thickness above the minimum calculated design thickness.

D. Chemical Resistance: The CIPP shall meet the chemical resistance requirements of ASTM F1743, Section 7.

E. Manufacturers:
   1. Tube manufacturers:
      a. Insituform Technologies, Inc.
      b. Liner Products, LLC
      c. Applied Felt
      d. National Liner
      e. Or Approved Equal
   2. Resin manufacturers:
      a. AOC
      b. Richold
      c. Interplastic
      d. Substitutions: Not Permitted

2.02 CURED-IN-PLACE PIPE, GLASS REINFORCED PLASTIC

A. Materials:
   1. Tube: Corrosion resistant fiberglass fabric tube meeting the requirements of ASTM F2019-03, Section 5.
      a. The Contractor shall make allowances in determining the tube length and circumference for stretch during installation and shrinkage during curing and aging. The minimum design length shall be that which continuously spans the distance from the center of the inlet manhole to the center of the outlet manhole. The Contractor shall verify the lengths in the field before the liner tube is cut and impregnated. Individual installation runs may include one or more manhole-to-manhole sections as authorized by the Engineer.
      b. The flexible tube shall be fabricated to a size that when installed will neatly fit (minimum 99.75%) the internal circumference of the existing sanitary sewer lines (including services). Allowance shall be made for circumferential stretching during insertion so that the final cured product is snug against the wall of the host pipe.
      c. The tubes shall have a uniform thickness equal to the designed nominal tube thickness.
      d. The layers of the cured CIPP shall be uniformly bonded. It shall not be possible to separate any two layers with a probe of point of a knife.
      e. Liner material shall be manufactured with the resins pre-impregnated within the liner to eliminate the possibility of air bubbles and voids.
   2. Resin: Chemically resistant isophthalic polyester or vinyl ester UV curing resin and catalyst system compatible with the UV light curing process.

B. Structural Requirements: The physical properties of the cured CIPP shall have minimum initial test values as defined in ASTM F2019 or as shown in the table below, whichever is greater.

Property	Test Method	Cured Composite (per ASTM F2019)
Modulus of Elasticity	ASTM D790	1,015,000 psi minimum
Flexural Stress	ASTM D790	20,000 psi

C. The tube thickness shall meet approved design calculations based on the structural and design requirements listed in paragraph 2.02B. The nominal CIPP thickness shall be at least the calculated design thickness, per ASTM F1216, except where fabric layers overlap, in which case it may be in excess of this value.

D. Chemical Resistance: The cured CIPP shall meet the chemical resistance requirements of ASTM D5813, Sections 6.4.1 and 6.4.2. The finished in place UV Light Cured Fiberglass pipe liner shall be fabricated from materials which when complete are chemically resistant to and will withstand internal exposure to domestic sewage having a pH range of 5 to 11 and temperatures up to 150° F.

E. Manufacturers
1. Prokasro & Saertex GmbH
2. Insituform Technologies, Inc.
3. InLiner Technologies
4. Applied Felt
5. Or Approved Equal

2.03 CURED-IN-PLACE PIPE (CIPP), FIBERGLASS POINT REPAIR

A. Materials:
1. The fiberglass mat should consist of two or more layers of 0/90º bias woven fiberglass with a Trevara felt coating on one side prescribed to the circumference and length of the repair being made. It shall be capable of carrying resin, withstanding installation pressures and curing temperatures. The fiberglass mat should be compatible with the resin system used. The fiberglass mat, when installed, will form to the internal circumference of the original pipe. Allowance should be made for circumferential stretching during installation.

2. Resin - A two-component, silicate based, ambient cure, low viscosity and corrosion resistant resin that is compatible with the installation process should be used. The Cured in Place Point Repair can be expected to have as a minimum structural properties given in paragraph B.

B. Structural Requirements:

Property	Test Method	Cured Composite (per ASTM F2019-03)
Modulus of Elasticity	ASTM D790	750,000 psi
Flexural Stress	ASTM D790	10,000 psi

2.04 END SEALS

A. End seals shall create a water tight seal between the liner and the host pipe and meet the requirements of ASTM F1216 and ASTM F1743.

B. Acceptable manufacturers:
1. LMK
2. Or Approved Equal

2.05 SERVICE CONECTION INFILTRATION SEALS

A. Epoxy / Ground Infiltration Seals
1. For infiltration at the tap connection, Contractor shall install an epoxy or grout seal at the tap to eliminate the infiltration at the connection.

2. The epoxy shall be an approved two-part system consisting of a resin and hardener. The epoxy shall be specifically formulated to bond strength and non-sag properties regardless of the type of pipe materials. Epoxy shall be suitable for bonding either on a wet or dry surface. The expected service life of the epoxy shall be at least 20 years. Shop drawings must be submitted for approval.
3. Acceptable Products:
    a. Pressure Injected Epoxy Lateral Repair
    b. AvantiGrout Lateral Repair
    c. Or Approved Equal

B. Cured-in-Place Lateral Infiltration Seal
1. For infiltration inside the service, Contractor shall install a service connection infiltration seal at the tap.
2. Manufacturers
    a. BLD Services LLC: Top Hat
    b. LMK T-Liner OR T-Liner Shorty OR Stubby
    c. Perma-Liner Industries: InnerSeal System
    d. Or Approved Equal

PART 3 - EXECUTION

3.01 EXAMINATION

A. Contractor shall verify existing conditions before starting work in accordance with Division 1 and other applicable specifications.

B. Site verification of conditions:
1. Verify field measurements of pipe inside diameters and lengths between manholes prior to design, fabrication, and delivering of liner material.
2. Verify existing pipe material changes from previous repairs.
3. CIPP Liners: Contractor to measure actual diameter of each pipe section to be lined. Measurements shall be provided to Engineer and each liner section shall be manufactured per actual diameter of pipe section. Provide actual measurements and liner dimensions for each host pipe section with liner design.

3.02 CLEANING, FLUSHING, AND LINE OBSTRUCTIONS

A. It is the responsibility of the Contractor to clear the line of obstructions such as roots, debris, sedimentation, grease, and mineral deposits that will prevent or hinder the insertion of the liner prior to liner installation. Presence of obstructions in the pipeline are considered incidental to the work and are not reason for a change order. Costs for the cleaning and disposal shall be borne by the Contractor.

B. Clear obstructions, service piping protrusions more than ¼ inch and other materials from entire circumference of existing pipe to ensure inserted pipe liner contacts only existing pipe wall.

C. If the cleaning work is not satisfactory to the Owner, the Contractor shall perform additional cleaning, at the Contractor's sole cost, so that the installation of the liner pipe is not hindered.

D. All sludge, dirt, sand, rocks, grease, and other solid or semi-solid material resulting for the cleaning operation shall be removed from the sewer system and properly disposed of by the Contractor, at the Contractor's sole cost.

E. Precautions shall be taken to ensure that the cleaning operation will not cause any damage or flooding to public and/or private property being serviced by the sewer line. The Contractor shall bear full costs associated with any flooding or damage to basements of structure.

F. If the pre-lining video inspection reveals an obstruction such as a protruding service connection, offset joint, or a collapse that will prevent the CIPP insertion process, and it cannot be removed by conventional sewer cleaning equipment, the Contactor shall uncover and remove the obstruction through a point repair. Such excavation must be approved in writing by the Owner prior to the commencement of work. If the obstruction was not shown on the Drawings or revealed by the Contractor at the time of the bid, the work will be considered as a separate pay item by Change Order.

3.03 INITIAL VIDEO INSPECTION

A. Conduct closed-circuit video inspection in accordance with Section 02951 - Video Inspection of Pipelines after cleaning and removal of line obstructions.

B. Pipeline shall be dry during the pre-lining inspection.

C. Notify the Engineer if any of the following defects are observed:
   1. Major offset of joints
   2. Crushed walls
   3. Other obstructions.

D. Identify sizes and locations of service entrances and service connections. Identify the addresses of all live and capped service connections.

E. If flow is resumed in the pipe prior to lining, and after the pre-lining video inspection, the Contractor is required to re-inspect the pipeline immediately before lining to ensure no debris has been introduced into the pipe.

F. Submit the initial video inspections on DVD or thumb drive to the Field Administrator or other Owner Representative for review. DO NOT start trenchless rehabilitation until the Owner has reviewed and accepted the initial video inspections. The Owner may require additional videotaping to ensure that all obstructions have been removed prior to lining.

G. Submit the video "logs" to the Field Administrator or other District Representative for review. Each service connection or tap must be documented and the following information provided:
   1. Whether the service is active or "capped". Contractor shall determine by dye test, running water, or visual inspection whether connections of active or abandoned.
   2. Linear distance from starting manhole.
   3. Circumferential position on pipe (2 o'clock, 10 o'clock, etc.).

H. Engineer and Contractor shall agree prior to liner installation which services are to be re-established. Engineer or Owner's representative will review video logs and respond to contractor with **7 calendar days** with approval or required action.

3.04 PUBLIC RELATIONS

A. The Contractor is responsible for contacting property owners and businesses that are affected by the construction activities to inform them of the Work to be done and the estimated schedule and timing for the Work. Written notice shall be delivered to each home or business 2 weeks prior to installation of the liner. Notice shall include a local telephone number of the Contractor, and contract information for the Owner or Engineer. Written notices must be reviewed by the Engineer prior to distribution to the public.

B. Two (2) days prior to the liner installation, a follow-up notice shall be delivered to each home or business that has a service connection on the sewer pipeline that is scheduled to be lined. The notice shall instruct occupants to minimize water usage on the day of the liner installation and to fill floor drain traps with water to prevent potential odors.

3.05 INFILTRATION

A. Minor infiltration (drips or wet, blotchy areas) is a normal condition and is not to be considered a change in conditions by the Contractor. For CIPP liners, if, in the opinion of the Contractor and Engineer, infiltration is significant enough to adversely affect the curing process, the Contractor shall install chemical grout or perform other remedies to address the infiltration, as approved by the Engineer. Chemical grouting or other infiltration remedies will be considered additional work and will be paid for through a Change Order.

3.06 BYPASS SEWAGE

A. The Contractor is responsible for setting up the bypassing pump system per Section 02070 - Wastewater Flow Management Plan, and Section 02072 - Wastewater Emergency Response Plan to isolate each section of piping for lining.

B. Maintain bypass pumping until lining is totally formed and fully cured and service connections are re-instated.

C. Coordinate with manhole rehabilitation work prior to removal of bypass pumping.

D. All traffic control issues resulting from the bypass pumping, including interruption of traffic flow due to laying bypass pipe across intersections, are the responsibility of the Contractor and shall be coordinated with the appropriate jurisdictions and governing agencies. Contractor is also responsible for coordination with local businesses and residences that may be affected by the bypass pumping operations. Driveway access shall be maintained to homeowners and business at all times.

E. Bypass design flows are listed in Section 02070. Flows listed are approximated and should be verified by the Contractor prior to start of work.

F. If required by Owner, laterals will be bypassed to provide continuous service to customers. Where cleanout installation is required for bypassing service flows the cost for installation **and removal** will be considered incidental to the project and should be included in the total cost for lining.

3.07 INSTALLATION, CURED-IN-PLACE PIPE - RESIN IMPREGNATED FELT

A. Cured-In-Place Pipe installation shall be in accordance with ASTM F1216, or ASTM F1743, with the exception that resin impregnation shall only take place at a permanent facility. Field wet-outs are not allowed.

B. Pre-qualified Installers:
   1. Layne Inliner, LLC (National)
   2. Insituform Technologies (National)
   3. Reline America (National)

C. The Contractor shall verify the lengths between manholes in the field before the liner tube is cut and impregnated. Individual installation runs may include one or more manhole-to-manhole sections as authorized by the Engineer.

D. Resin Impregnation: The quantity of resin used for tube impregnation shall be sufficient to fill the volume of air voids in the tube with additional allowances for polymerization shrinkage and the loss of resin through cracks and irregularities in the original pipe wall. A vacuum impregnation process shall be used. To ensure thorough resin saturation throughout the length of the felt tube, the point of vacuum shall be located to create adequate withdrawal of air so that the tube is fully wet out and no dry spots are visible at the exterior coating.

E. Unless otherwise specified to provide for excess resin migration, the gap thickness of the wetting out equipment shall be sized to allow an excess of 5 to 10 percent resin to pass during impregnation.

F. The leading edge of the resin slug shall be as near to perpendicular as possible. A roller system shall be used to uniformly distribute the resin throughout the tube. If the Installer uses an alternate method of resin impregnation, the method must produce the same results.

G. Tube Insertion: The wet-out tube shall be positioned in the pipeline using either inversion or a pull-in method. If pulled into place, a power winch should be utilized and care should be exercised not to damage the tube as a result of pull-in friction. The tube should be pulled-in or inverted through an existing manhole or approved access point and fully extend to the next designated manhole or termination point.

H. Temperature gauges shall be placed inside the tube at the invert level of each end to monitor the temperatures during the cure cycle. Curing logs are to be kept and submitted to Engineer.

I. Curing shall be accomplished by utilizing hot water under hydrostatic pressure or low temperature stream pressure in conjunction with low pressure air for inversion in accordance with the manufacturer's recommended cure schedule. Once the liner installation has started, installation pressures shall be maintained between the minimum and maximum pressures as required by the manufacturer until the operation has been completed. Should the pressures deviate from within the acceptable operating range, the installed liner will be rejected and the Contractor must remove and dispose of the tube at no cost to the Owner. Cure schedules must be strictly adhered to with no exceptions.

J. "Dimples" shall be visible where service openings are present so it is absolutely clear where the service openings are located. If dimples are not present, Contractor to use infrared device to locate sanitary sewer service connections.

K. The Contractor shall apply an annular space, hydrophilic sealant at the manhole or CIPP termination point. The seal shall be of a material compatible with the CIPP material and shall be approved by the Owner or Engineer.

L. If the Contractor lines through a manhole or structure, the top half of the CIPP liner shall be neatly cut off, not broken or sheared off. The opening shall be smoothed so that no tears or burrs are present. The channel section through the manhole shall be smooth. Void space between the liner and the channel wall shall be filled with non-shrink grout and sealed with the annual space sealant. All manholes shall be individually inspected. Liners installed through structures that have deflection angles greater than 45 degrees, shall be cut off at the pipes and the liners shall be removed from inside the structure.

M. Liner shall be trimmed at the inside edge of the manhole. The trimmed liner shall be smoothed so that no tears or burrs are present.

3.08 INSTALLATION, CURED-IN-PLACE PIPE - GLASS REINFORCED PLASTIC

A. Cured-In-Place Pipe installation shall be in accordance with ASTM F2019-03.

B. Pre-qualified Installers:
   1. Acceptable Installers:
   2. Layne Inliner, LLC (National)
   3. Reline America (National)
   4. FinaLiner (Western Region)

C. Resin Impregnation: The reconstruction tube shall be vacuum impregnated with UV Curing Resins in the manufacturing facility prior to installation. The manufacturer will allow the Engineer or Owner to inspect the manufacturing facility and observe manufacturing process if required by the Owner. The Contractor shall allow the Owner to inspect the materials prior to installation.

D. Tube Insertion: The wetout tube shall be positioned in the pipeline using a pull-in method. A power winch should be utilized and care should be exercised not to damage the tube as a result of pull-in friction. The tube should be pulled-in through an existing manhole or approved access point and fully extended to the next designated manhole or termination point.

E. The Fiberglass Liner shall be inflated in place using low-pressure air to the Manufacturer's specification for installing the UV Chain. The Ultra Violet Light Chain, with built-in safety air loss shut off sensors, as provided by the ProKasro UV light chain (or approved equal), shall then be installed into the liner and the gates are then closed. The fiberglass liner will then be inspected with a camera mounted on the UV Chain as it is pulled to the end of the liner. After inspection and complete inflation to Manufacturer's specifications, the UV light bulbs will be turned on. The curing process will commence at a rate specified by the Manufacturer according to the total length and diameter of the liner.

F. As the liner is curing, the UV Curing System shall record all curing data in DVD format for review by the Owner. Initial cure shall be deemed complete when the UV Chain arrives at the initial entry point of insertion.

G. "Dimples" shall be visible where service openings are present so it is absolutely clear where the service openings are located. If dimples are not present, Contractor to use infrared device to locate sanitary sewer service connections.

H. The Contractor shall apply an annular space, hydrophilic sealant at the manhole or CIPP termination point. The seal shall be of a material compatible with the CIPP material and shall be approved by the Owner or Engineer.

I. If the Contractor lines through a manhole or structure, the top half of the CIPP liner shall be neatly cut off, not broken or sheared off. The opening shall be smoothed so that no tears or burrs are present. The channel section through the manhole shall be smooth. Void space between the liner and the channel wall shall be filled with non-shrink grout and sealed with the annual space sealant. All manholes shall be individually inspected. Liners installed through structures that have deflection angles greater than 45 degrees, shall be cut off at the pipes and the liners shall be removed from inside the structure.

3.09 INSTALLATION - CURED-IN-PLACE PIPE, POINT REPIAR

A. The fiberglass mat shall be thoroughly wet out with the catalyzed resin.

B. The impregnated fiberglass mat shall be wrapped around the carrier packer and secured in place using ties supplied by the manufacturer.

C. The carrier packer shall be winched to the damaged area and positioned by Closed Circuit TV camera (if necessary) guiding the installation. The carrier packer shall be inflated not to exceed the pressures recommended by the manufacturer and held in place until the point repair cures.

D. If point repair is to be installed on top of an existing cured-in-place pipe liner, existing line shall be "roughened" to allow a mechanical bond to form between the existing liner and point repair products.

3.10 SERVICE CONECTION INFILTRATION SEALS

A. Epoxy / Grout Infiltration Seal:
   1. The infiltration seal shall be installed after the trenchless pipeline rehabilitation is complete, and the post-lining video has been approved by the Owner or the Owner's Engineer. Infiltration seal shall not extend into service line further than 3 inches.
   2. After infiltration seal has been installed, surface must be smoothed so that it is free of burrs and sharp edges. The cured product shall be free from any structural defects that would impact the repair and allow water or roots to intrude into the host pipe.

B. Cured-in-Place Lateral Infiltration Seal:
   1. The infiltration seal shall be installed after the trenchless pipeline rehabilitation is complete, and the post-lining video has been approved by the Owner or the Owner's Engineer.
   2. The infiltration seal shall extend into the service past the first bend. After infiltration seal has been installed, surface must be smoothed so that it is free of burrs and sharp edges.
   3. All ends of Cured-in-Place Lateral seals will be installed with hydrophilic end seals to create water tight seal between the lateral pipe and the liner and main pipe and the liner. For larger diameter pipes or products without full segment tees in the main line a hydrophilic connection gasket at the tap location may be used instead of installing O-rings in the main line.

3.11 INSTALLATION - END SEALS AT MANHOLES

A. End seals will create a water tight seal between the host pipe and the liner. Seals will be installed per manufacturer recommendations and meet all applicable ASTM standards.

B. Where voids are present, a sealant may be used in addition to end seals. Sealant shall be a quick-set epoxy or high viscosity epoxy with good adhesion to the liner and concrete. Contractor will apply sealant to create a watertight and flexible seal between the liner and the host pipe.

C. The channel in the manhole shall be a smooth continuation of the pipe(s) and shall be merged with other lines or channels. Void space between the liner and channel wall shall be filled with non-shrink grout and sealed with sealant.

D. All sealants and grouts coming into contact with the CIPP material will be approved for use with the CIPP product by the CIPP manufacturer.

E. All manholes shall be individually inspected for liner cut-offs and end sealing works. Liner shall be cut off at pipes and all liner removed within intermediate manholes..

3.12 FIELD QUALITY CONTROL

A. Construction Observation will be performed in accordance with Division 1 and applicable specifications. Additional observation may be required by Engineer.

B. Manhole structures shall be protected from damage.

C. When liner fails to form, remove failed liner and install new liner.

D. No infiltration of groundwater is permitted after installation of liner.

E. Confirm service connections are complete and are unobstructed.

F. Wrinkles or lifts shall not exceed 2% of the host pipe diameter, or ¼ inch, whichever is greater. Contractor shall repair or replace that section of the pipe at no additional cost to the Owner. Methods of repair shall be proposed by the Contractor and submitted to the Engineer for approval.

G. Defects such as foreign inclusions, dry spots, pinholes, delamination, and wrinkling beyond the specification allowances, as determined by the Engineer as affecting the integrity or strength of the liner, or as adversely affecting the hydraulic capacity of the pipe, shall be repaired or replaced. Contractor shall repair or replace that section of the pipe at no additional cost to the Owner. Methods of repair shall be proposed by the Contractor and submitted to the Engineer for approval.

H. Excavate for point repairs or service connections only on an emergency basis and as permitted by the Owner or Engineer.

3.13 FIELD SAMPLES

A. This section applies to Cured-In-Place Pipe for Resin Impregnated Felt and Glass Reinforced Plastic.

B. Field Samples for CIPP:

1. Contractor shall submit samples as required herein. Contractor shall provide all labor and materials necessary to produce samples for laboratory and/or field testing. Contractor to contract directly with third party certified laboratory for testing as required.

2. The wall thickness will be measured in accordance with the applicable ASTM Standards. Test method to be determined by testing laboratory. Any liner having a measured wall thickness of less than 80% of the required thickness shall be removed and replaced with a liner meeting the minimum thickness requirements.
3. The flexural strength and flexural modulus of elasticity shall be determined in accordance with ASTM D-790. Any liner having test results with flexural strength or flexural modulus of elasticity of less than 80% of the specified flextural strength and flexural modulus shall be removed and replaced with a liner meeting the strength requirements.
4. Method for obtaining sample 15 inch-diameter or smaller pipe:
    a. Prior to lining work, install an inverted, half-section short piece of pipe, 12 inches minimum length, with an equal or comparable diameter. Hold sample pipe in place by a suitable heat sink, such as sandbags.
    b. Line the testing pipe with the same tube as the sewer line being rehabilitated, and complete the cure process.
    c. Cut and remove the sample pipe where the pipe enters the manhole.
    d. Label the manhole number and date of installation, and submit the sample pipe to laboratory for testing.
5. Method for obtaining sample for 18 inch-diameter pipe or larger:
    a. Provide a flat plate sample using the method described in ASTM F1216. An affidavit shall be provided by the wet out facility for each flat plate sample. The affidavit shall state that the flat plate sample is the same as the liner it represents.
    b. Label the manhole number and date of installation, and submit the sample pipe to the laboratory for testing.
6. Sample frequency:
    a. **One (1) sample per every 1,000 feet of liner installed.** (Note to Specifier: Recommended for long runs of the same size being installed in the same location)

3.14 POST-LINING VIDEO INSPECTION

A. Conduct closed-circuit video inspection in accordance with the specifications of this project regarding Video Inspection of Pipelines after cleaning and removal of line obstructions.

B. Pipeline shall be dry during the post-lining inspection.

C. Submit the post video inspections on DVD or thumb drive to the Field Administrator or other Owner Representative for review.

D. Submit the video "logs" to the Field Administrator or other District Representative for review.

3.15 CLEANING AND SITE RESTORATION

A. Remove debris resulting from work and unused materials from site and legally dispose.

B. Areas damaged or modified by the Work shall be repaired or restored to a condition equal to or better than the original condition. Site restoration is incidental to the Work and shall not be regarded as a reason for change orders.

C. Care shall be taken to avoid damage to private property (i.e. sprinkler systems, lawn areas, etc.). If damage occurs, repairs shall be completed as soon as possible. Costs associated with the repairs shall be the responsibility of the Contractor.

END OF SECTION

SECTION 02700

PAVING AND SURFACING

PART 1 - GENERAL

1.01 SUMMARY

A. Furnishing all labor, material, equipment, tools, and services required for the placing and compacting of asphalt concrete pavement for airfields, roadways, parking lots, and walkways to the lines, grades, and dimensions shown on the Drawings and as specified herein.
   1. Also included shall be the repair and resurfacing of existing roadway and area paving damaged or removed during construction.
   2. Also included shall be applying penetration treatment to aggregate base surfaces shown on the Drawings.

B. Related Sections: Repair or replace concrete curbs, gutters and sidewalks damaged by the work in accordance with Section 02775.

1.02 REFERENCE SPECIFICATIONS

A. Whenever the words "Standard Specifications" are referred to, the reference is to the *latest edition of the State of California, Department of Transportation, Standard Specifications*.

B. ASTM International (ASTM):
   1. D422 Test Method for Particle-Size Analysis for Soils
   2. D1556 Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
   3. D2027 Specification for Cutback Asphalt (Medium Curing Type)
   4. D2922 Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

C. California Department of Transportation (CALTRANS):
   1. California Test 216 Method of Test for Relative Compaction of Untreated and Treated Soils and Aggregates
   2. California Test 231 Method of Test for Relative Compaction of Untreated and Treated Soils and Aggregates by the Area Concept Utilizing Nuclear Gauges

1.03 SUBMITTALS

A. Submit the following under the Product Information category.
   1. Samples: Furnish, without additional cost to the Owner, such quantities of construction materials as may be required by the Engineer for test purposes. The Contractor shall cooperate with the Engineer and furnish necessary facilities for sampling and testing of all materials and workmanship. All materials furnished and all work performed shall be subject to rigid inspection, and no materials shall be used in the construction work until it has been inspected by the Engineer.
   2. Submit a signed verification from each source of supply for each construction material employed on this project indicating that the materials meet the Specification requirements.

3. Mix design for asphalt concrete.
4. Submit manufacturer's certification of the actual volatile organic compound (VOC) content for all pavement paints and bituminous pavement sealers proposed for use on this project. Submit certification of the actual VOC content for all coatings. VOC content shall be measured in grams per liter by weight of coating as applied excluding water and color added to the tint base.
5. Submit verification that bituminous pavement sealers and paint products furnished meet applicable San Diego County Air Pollution Control District (APCD) regulations as to allowable VOC content for the time and place of application and use intended.

1.04 QUALITY ASSURANCE

A. Comply with *"Standard Specifications" of State of California, Department of Transportation (CALTRANS)*.

B. All pavement stripe painting shall be performed by competent and experienced Equipment operators and painters using proper equipment, tools, stencils, templates, and shields in a workmanlike manner.

1.05 REGULATORY REQUIREMENTS

A. All work, material, procedures and practices under this Section shall conform to requirements of the San Diego County Air Pollution Control District (APCD).

PART 2 - PRODUCTS

2.01 ASPHALT CONCRETE

A. Asphalt Concrete *Type B* shall conform to the applicable requirements of *Section 39 of the Standard Specifications*. Asphalt binder shall be paving asphalt or liquid asphalt (cutback). Mineral filler shall consist of portland cement or mechanically reduced rock. Proportioning shall be as set forth in Paragraph "D" below.

B. Paving asphalt *PG 64-10* conforming to the requirements of *Section 92 of the Standard Specifications* shall be used as the asphalt binder. *Bitumen ratio shall be selected by the supplier in accordance with the tests specified in Paragraph 39-3.04 of the Standard Specifications.*

C. Liquid asphalt (cutback) MC-800 or SC-800 conforming to the requirements of *Section 93 of the Standard Specifications* shall be used as the asphalt binder.

D. Mineral filler shall be mechanically reduced rock, conforming to the following gradations when tested in accordance with ASTM D422:

Particle Size	Percentage
Passing No. 200 sieve	75-100
Finer than 0.05 mm	65-100
Finer than 0.02 mm	35-65
Finer than 0.01 mm	26-35
Finer than 0.0005 mm	10-22

E. Mix Design:

Mix	Type	Grade	Binder Content (%)
Normal	A	3/4" max.	4.5 to 6.5
Patching	A or B	No. 4 max.	4.8 to 7.5
Open graded	--	3/8" max.	5.0 to 8.0

2.02 TACK COAT

A. Material for tack coat shall be *SS-1,* grade emulsified asphalt conforming to *Section 94 of the Standard Specifications*.

2.03 FOG SEAL

A. Fog seal shall be *SS-1,* asphaltic emulsion fog seal conforming to the requirements of *Sections 37 and 94 of the Standard Specifications.*

2.04 PRIME COAT (PENETRATION TREATMENT)

A. Material for prime coat shall be liquid asphalt *SC-70* conforming to the requirements of *Sections 92 and 93 of the Standard Specifications* and ASTM D2027.

2.05 SLURRY SEAL

A. Slurry seal shall be *SS1h* asphaltic emulsion, cationic quick-setting type, conforming to the requirements of *Section 37-2 and Section 94 of the Standard Specifications*. Aggregate shall conform to *Type II.* Asphalt emulsion shall be 14% to 18% of aggregate weight.

2.06 HEADERS

A. At straight sections, wood headers shall be constructed of 2-inch by 6-inch construction heart redwood, held in place by 2-inch by 4-inch stakes, of the same materials, 2 feet long and set at 8-foot centers.

B. At curved sections, wood headers shall be constructed of three ½-inch by 4-inch construction heart redwood bender boards. Boards shall be lapped at one-third of the length of individual boards, with no two boards lapped at the same place. Hold boards in place with stakes same as above.

2.07 AGGREGATE BASE

A. Aggregate base shall conform to the applicable requirements of the *Standard Specifications Section 26, for Class 2 aggregate base*. The aggregate base shall conform to that specified for the *1-1/2-inch OR ¾-inch maximum,* unless otherwise indicated. *Paragraphs 26-1.06 and 26-1.07 are not applicable*.

2.08 PARKING STRIPES

A. Parking stripes paint shall be non-reflective *Sherwin Williams Series 338-116(W), 338-117(Y) and 338-333(B), or Pervo Paint Company No. 4773-A(W), 4473-4A(Y) and 473-5A(B)*. Paint shall be stored at the project site in the manufacturer's sealed and labeled containers. Labels shall clearly identify the manufacturer, specification number, batch number, intended use, quantity and contract number.

2.09 TRAFFIC STRIPES AND PAVEMENT MARKINGS

A. Thermoplastic material and glass beads shall comply with *paragraphs 84-2.02 and 84-2.03 of the Standard Specifications*.

2.10 TEMPORARY PAVEMENT (COLD MIX)

A. Temporary pavement shall consist of No. 4 sieve maximum aggregate size, graded in accordance with *Section 39 of the Standard Specifications*. The aggregate shall be blended with *5-8% SC-800* liquid asphalt.

2.11 LIQUID ASPHALT DISTRIBUTOR

A. The distributor used in applying all liquid asphalt shall be of the self-propelling type, of sufficient power and capacity to apply the asphalt under pressure uniformly and at the proper rate with not more than 10% variation therefrom. The distributor shall be equipped with tachometer and charts, pressure gauge, thermometer well, and thermometer; and shall have adjustable length spray bars of sufficient length to cover one-half of the roadbed at one time. The spray bars shall be adjustable vertically to permit application of the asphalt at the height above the surface approved by the Engineer and shall be of the full-circulating type with satisfactory cutoff device at each nozzle. The use of trailer-type distributors shall not be permitted.

B. A trough shall be located under the sprays, properly arranged to be swung out of the way after the sprays are operating in a uniform manner at the desired pressure or, in lieu thereof, building paper shall be spread over the treated surface for a sufficient length back so that the sprays are operating properly when the uncovered surface is reached. The building paper shall then be removed and disposed of. If the cutoff is not sufficiently positive, the similar use of paper may be required at the end of the area being covered. The distributor shall be operated in such a manner that liquid asphalt will not be splashed on adjacent guardrails or structures. Any asphalt so splashed may be removed at the expense of and by the Contractor.

PART 3 - EXECUTION

3.01 GENERAL

A. This Specification shall cover newly paved areas as well as existing pavement restoration.

B. Where trenching or other construction activity has resulted in damage to a localized area of pavement, the damaged pavement shall be cut back 6 inches and shall be removed and replaced.

C. Where the damaged area extends over more than 50% of the road width or paved area, as determined by the Engineer, the full pavement width or area shall be cut away, removed and repaired.

D. Structures such as valve boxes, manhole frames and covers, and electrical vaults shall be adjusted to grade as necessary within paved areas.

E. Existing asphalt pavement islands of 50 square-feet or less and strips 18 inches or less in width shall be removed and replaced.

F. Adjust existing manholes, meter boxes, cleanouts, etc. to match the new grade.

3.02 PAVEMENT CUTTING

A. After backfilling and prior to paving, proper tools and equipment shall be used in marking and breaking so that the pavement shall be cut accurately and on neat lines parallel to the trench. The asphalt pavement shall be saw cut (using a concrete saw) to a minimum depth equal to or greater than one-half the thickness thereof. The pavement shall be cut back 6 inches on each side of the trench or excavation wall. Any pavement damaged outside these lines shall be re-cut and restored at the expense of the Contractor. Should voids develop under existing pavements during construction, those affected pavements shall be neatly saw cut in straight lines and replaced after the voids have been filled.

B. Construct joints between successive runs vertical and at right angles to the line of the improvement. Exercise care in construction of all joints to ensure that the surface of the pavement is true to grade and cross-section. Lapped joints will not be permitted.

3.03 PLACEMENT OF AGGREGATE BASE

A. Subgrade Preparation: The subgrade shall be watered or dried as required to bring the soil, as close as practicable, to the optimum moisture content for proper compacting and then compacted, as specified, to a relative compaction of not less than 95% in the upper 6 inches. When compaction of the subgrade areas on fill and embankments has been properly obtained, only such additional rolling will be required as necessary to obtain a thoroughly compacted subgrade immediately prior to placing the aggregate base thereon.

B. Aggregate Base Tolerance: The aggregate base shall not be placed before the subgrade is approved by the Engineer. The finished aggregate base shall not vary more than 0.05-foot above, nor 0.10-foot below, the planned grade.

C. Aggregate Base Placing: The aggregate base material shall be spread on the prepared subgrade by means of approved spreading devices subject to approval by the Engineer; the aggregate base material may be dumped in piles upon the subgrade and spread by bulldozing ahead from the dumped material. Each layer shall not exceed 0.50 feet. Segregation of large or fine particles of aggregate shall be avoided, and the material as spread shall be free from pockets of large and fine material.

D. Compaction: The relative compaction of each layer of compacted aggregate base material shall not be less than 95% as determined by *California Test 216 or ASTM D1556 (Sand Cone), or California Test 231 or ASTM D2922 (Nuclear method when approved by the Engineer)*. Compaction shall be in accordance with *Section 26-1.05 of the Standard Specifications*. Aggregate base, after compaction, shall be watered as provided in *Section 17 of the Standard Specifications. Paragraph 17-1.04 is not applicable.*

3.04 PRIME COAT APPLICATION

A. Prime Coat: In advance of spreading paving materials, a prime coat of liquid asphalt shall be applied to all base course surface areas to be covered with asphaltic concrete.

1. Preparation of Base Course: Immediately before applying the prime coat, the area to be surfaced shall be cleaned of all loose material by means of hand brooms.

2. Application: Liquid asphalt shall be applied by pressure distributors at a temperature between 125 and 200°F. The Engineer reserves the right to require an adjustment of the temperature of the liquid asphalt at the time of placement. The rate of application shall be between 2/10 and 3/10 gallon per square yard. Excess liquid asphalt, which has failed to penetrate the base, shall be covered with fine sand. All loose sand shall be removed from the treated areas before placing any surfacing material thereon. Liquid asphalt shall not be applied when the atmospheric temperature is below 50°F. The prime coat shall be applied at least 24 hours in advance of paving. Immediately in advance of paving asphalt concrete surfacing, additional prime coats shall be applied, as directed by the Engineer, to areas where the prime coat has been damaged.

3.05 TACK COAT APPLICATION

A. Tack Coat: In advance of spreading bituminous material upon an existing bituminous or portland cement concrete surface, a tack coat shall be applied to all areas to be surfaced and to all vertical surfaces of existing pavement, curb, gutters and construction joints in the surfacing against which additional material is to be placed. When two or more lifts of asphaltic concrete are required, a tack coat shall be applied between each lift.
   1. Preparation: Immediately before applying a tack coat, the area to be surfaced shall be cleaned of all loose material.
   2. Application: The tack coat shall be applied by means of pressure distributors by pressure hand-spray equipment. The rate of application shall be 1/20 gallon per square yard. Emulsified asphalt shall not be applied when the atmospheric temperature is below 40°F. *If emulsified asphalt Type SS-1 is used, it may be diluted with an equal part of water*. The rate of application of the dilution shall be such that the rate of application of undiluted emulsion shall be within the tolerances specified.

3.06 PLACEMENT OF ASPHALT CONCRETE

A. Delivery and Spreading: Bituminous mixtures shall be delivered to the roadbed at temperatures specified in the *Standard Specifications*. Spreading of the mixture shall be in accordance with *Section 39 of the Standard Specifications*. *Paragraph 39-8 does not apply*. All loads shall be covered with tarpaulin or other material during transportation. The top layer of asphalt concrete shall not exceed 0.20 feet in compacted thickness. The next lower layer shall not exceed 0.25 feet in compacted thickness, and any lower layers shall not exceed 0.50 feet in compacted thickness.

B. Compaction: Initial or breakdown rolling and the final rolling of the uppermost layer of the asphalt concrete shall be compacted in accordance with *Section 39 of the Standard Specifications. Paragraph 39-8 does not apply*. Compaction by vehicular traffic shall not be permitted. The Engineer reserves the right to require an adjustment of the temperature of the asphalt concrete at the time of placement.

C. Pavement Thickness: Pavement shall match the existing adjoining pavement in thickness, or as indicated on the Drawings, or as specified, whichever is greater.

D. Joining Pavement: The joints between old and new pavements or between successive days' work shall be carefully made in such manner as to ensure a continuous bond between old and new sections of the course. Edges of existing pavement shall be exposed and cleaned and edges cut to straight, vertical

surfaces. All joints shall be painted with a uniform coat of tack coat before the fresh mixture is applied.

E. Protection of Pavement: After final rolling, no vehicular traffic of any kind shall be permitted on the pavement until it has cooled and hardened and in no case less than 6 hours.

3.07 APPLICATION OF FOG SEAL

A. A fog seal shall be applied to the upper surfaces of all installed asphalt concrete. It shall be applied in accordance with the applicable requirements of *Section 37, BITUMINOUS SEALS, of the Standard Specifications, Seal Coats. Subparagraphs 37-1.08 and 37-1.09 are not applicable*.

3.08 PAVEMENT RESTORATION

A. Final pavement restoration shall be made as soon as practicable after backfilling. In that period of time between backfilling and final pavement restoration, the trench shall be maintained level with the adjacent pavement and shall be covered with a 1-inch minimum layer of cutback. Prior to placing the final pavement, the temporary pavement shall be removed, the aggregate base excavated to the lines indicated on the Drawings, and the existing pavement edges saw cut as herein specified. The final asphalt pavement shall not be placed before the primed aggregate base surface is approved by the Engineer.

3.09 PENETRATION TREATMENT APPLICATION

A. Preparation of Base Aggregate Surface: Immediately before applying the first coat of the penetration treatment, the area to be treated shall be cleaned of all loose material.

B. Application:
   1. The penetration treatment shall be applied in three applications. The first application shall be applied at the rate of 0.5 gallon per square yard, and the second and third applications shall be applied at the rate of 0.25 gallons per square yard. The second and third application shall be placed two to three weeks apart as approved by the Engineer and after the previous applications have thoroughly penetrated the base.
   2. Liquid asphalt shall be applied by pressure distributors at a temperature between 140 and 255°F. The Engineer reserves the right to require an adjustment of the temperature of the liquid asphalt at the time of placement. Excess liquid asphalt, which has failed to penetrate the base in the third application, shall be covered with fine sand. Liquid asphalt shall not be applied when the atmospheric temperature is below 50°F.

3.10 SLURRY SEAL APPLICATION

A. A slurry seal shall be applied to the upper surface of all existing asphalt pavement prior to placing of the overlay. If the slurry seal is placed shortly before the overlay, and is cured, a tack coat may not be required. The slurry seal shall be applied in accordance with the applicable requirements of *Section 37-2 of the Standard Specifications. Subparagraphs 37-2.07 and 37-2.08 are not applicable*.

3.11 HEADERS

A. Install wood headers along pavement edges bordered by soil. Install new headers where existing wood headers are damaged during construction, or removed for construction. Install headers with uniform slope between spot elevation indicated on the Drawings or to conform to existing grades.

3.12 PAVEMENT MARKINGS

A. Preparation: Immediately before applying the paint, the pavement surface shall be thoroughly cleaned of all dust, dirt, scale, curing compound, oil, grease, or other objectionable matter as directed by the Engineer. Solvent material that will damage the pavement shall not be used as a cleaning agent.

B. Tolerances: Marking and striping shall be within 2 inches of the correct alignment. Dimensions of marking and stripings shall be within ½-inch.

C. Mixing: Mechanical mixers shall be used to mix paint. Prior to applying, the paint shall be mixed a sufficient length of time to thoroughly mix the pigment and vehicle together, and shall be kept thoroughly agitated during its application.

D. Application: Pavement marking shall be applied only on dry surfaces and only during periods of favorable weather. Painting shall not be performed when the atmospheric temperature is below 40°F when using solvent-borne paint or below 50°F when using water borne paint; when freshly painted surfaces may become damaged by rain, fog, or condensation; nor when it can be anticipated that the atmospheric temperature will drop below said 40°F or 50°F temperatures during the drying period.

1. Immediately following the preparation of the pavement, the paint shall be applied. The paint shall be applied at the rate of 100 to 110 square feet per gallon of paint. The stripe painting machine shall have a compressor capacity of at least 105 cubic feet per minute and be capable of operating at an air pressure of 125 psi. The paint shall be mechanically agitated while the machine is in operation. The striping machine shall be equipped with a guide post so designed that the machine will hold exactly to the alignment. The propelling vehicle shall be equipped with a guide post so designed that the machine will hold exactly to the alignment. The propelling vehicle shall be equipped with a speedometer or tachometer, and with a suitable device for determining the quantity of paint in the container. The paint container and spray nozzles on the machine shall be thoroughly cleaned before starting each day's work. The stripe shall be of the required width, with clean, true edges and without sharp breaks.
2. Application of a bituminous seal coat and the permanent pavement marking shall meet local and state requirements. The Contractor shall allow sufficient time before applying permanent pavement marking so that the paint does not bleed, curl or discolor when applied to bituminous surfaces. If bleeding or discoloring occurs, apply an additional coat(s) of paint as needed to provide a clean and neat final product.
3. Remove existing permanent or temporary markings and striping which are to be abandoned or obliterated, by wet sandblasting or other favorably reviewed methods. Dry sandblasting may be used in selected areas only with prior approval of the Engineer and with approval of the air pollution control authority having jurisdiction over the area in which the work will be performed. Obliteration of traffic striping with black paint or light emulsion oil shall be

done only with the prior favorable review shall not be used as a removal agent.

E. Provide all warning devices required to protect the painting operation and the finished work. Repaint, to the applicable specifications, any portion of the stripe damaged by any type of traffic within 24 hours after the stripe has been applied. For striping less than 50 feet in length, favorably reviewed portable painting equipment may be used.

END OF SECTION

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SECTION 02775

CONCRETE CURB, GUTTERS, AND SIDEWALKS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Provide concrete curbs, curbs and gutters, gutters, and sidewalks as shown on the Drawings and as specified herein.

1.02 REFERENCE SPECIFICATIONS

A. Wherever the words "Standard Specifications" are referred to, the reference is to the State of California, Department of Transportation, Standard Specifications.

1.03 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Submit certificate of compliance indicating that the concrete complies with the specifications as Product *Information* submittals.

PART 2 - PRODUCTS

2.01 CONCRETE

A. Comply with the Standards Specifications, Paragraph 73-1.01.
   1. Cement: Type II Modified.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Comply with the Standard Specifications, Section 73, Paragraphs 1.02 through 1.06, inclusive.

B. Unless shown otherwise on the Drawings, replace existing curbs, curbs and gutters, gutters and sidewalks in kind.

C. Adjust structures such as valve boxes, manhole frames and covers, and electrical vaults to grade after the curb and gutter or sidewalk has been constructed for a reasonable distance on all sides of the structure. Complete the concrete work after the structure is adjusted.

END OF SECTION

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SECTION 02825

ORNAMENTAL STEEL FENCES AND GATES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Ornamental steel swinging gates.
   2. Electric gate operators and controls and related hardware.
   3. Factory painting and field touchup painting.
   4. Concrete foundations.

1.02 REFERENCES

A. American Society for Testing Materials (ASTM):
   1. A 36 Standard Specification for Carbon Structural Steel
   2. A 123 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
   3. A 500 Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
   4. A 513 Standard Specification for Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing
   5. A 653 Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip
   6. B 26 Standard Specification for Aluminum-Alloy Sand Castings

B. American Welding Society (AWS):
   1. AWS B2.1 Specification for Welding Procedure and Performance Qualification

C. California Building Standards Commission
   1. 2019 California Building Code (CBC) (California Code of Regulations, Title 24).

1.03 SUBMITTALS.

A. Submit the following for Product Review in accordance with Section 01300.

B. Product Data: Fully describe all products proposed for use.

C. Shop Drawings: Show the specific items and assemblies proposed for this project.

D. Operation and Maintenance Manual for electric gate operators.

E. Manufacturer's standard and custom color selections.

1.04 QUALITY ASSURANCE

A. Contractor's Qualifications: Welding procedures, welders, and welding operations shall be qualified for the type of work required in accordance with AWS Standard Qualification Procedures.

B. Comply with requirements of local Fire Marshal Fire and Prevention Department having jurisdiction for emergency operation of gated entry points.

C. Comply with applicable provisions in the CBC, adopted edition and the National Electrical Code.

D. All work shall be in strict conformance with manufacturer's printed instructions and recommendations.

1.05 DELIVERY, STORAGE AND HANDLING

A. Deliver materials in good condition and properly protected against damage to factory-finished surfaces.

B. Store materials in a clean, dry location. Cover with protective materials to avoid damage, especially from dust, chemicals and moisture in the air.

C. Handle materials carefully on the job site to protect factory finishes.

PART 2 - PRODUCTS

2.01 ORNAMENTAL STEEL FENCES

A. Provide a minimum three rail, fully welded, heavy industrial grade, galvanized steel, factory painted, ornamental wrought iron picket fence with swinging gates system: Builders Fence Company, Inc.; Amazing Gates; Iron Fence Shop; or equal.

B. Material:
1. Pickets, rails, and posts shall be manufactured from tubing meeting the requirements of ASTM A 513 or A 500 Grade B.
2. Solid steel bars, flat plates and shapes shall be manufactured from steel conforming to the requirements of ASTM A 36.
3. Pickets for personnel gate shall be of the same size and style as those in the vehicular gate panels. Frames for gates shall be of sufficient size and thickness to provide adequate support without sag. Adjustable trussing may be required at vehicular gates. Gate hardware shall be supplied by the manufacturer and shall be of sufficient size and capacity to support the gate specified.

2.02 FABRICATION

A. Steel used in the manufacturing of panels, gates and posts shall conform to the ASTM standards specified and shall be new prime material.

B. Panels, gates and flanged posts shall be of welded construction. No wire rods, screws or rivets shall be accepted to attach pickets to rails. Layout and welding shall be done by experienced craftsmen. Welds shall be made by the gas metal arc method and welds shall be neat, clean and of the sizes indicated on the shop drawings. All flush welds shall be ground smooth.

C. After fabrication, steel panels, gates and posts shall be power washed in a phosphoric acid solution, rinsed and dried.

D. Personnel Gate Components:
1. Steel post sizes, maximum spacing and minimum foundation size. Provide barrier coating at dissimilar materials:

Height	Rails	Max. Spacing	Min. Square Tube Posts	Min. Concrete Foundations
6 feet	3	8 feet	3" x 12 gauge	12" dia. x 36" deep
7 feet	4	8 feet	3" x 11 gauge	15" dia. x 42" deep
8 feet	4	6 feet	4" x 10 gauge	18" dia. x 48" deep

2. Gate posts and foundations: Minimum 4-inch x 10-gauge post and an 18-inch-diameter x 48-inch-deep concrete foundation.
3. Tube or "U" channel rails:
   a. 2-inch x 1-1/2-inch x 0.120-inch-thick (11-gauge) "U" channels
   b. 2-inch x 2-inch x 0.120-inch-thick (11- gauge) tube.
4. Steel tube pickets:
   a. 1-inch x 1-inch x 16-gauge steel spaced 6 inches o.c.
   b. Each picket to be capped with fleur de lis-style pointed top. Color to match pickets. Provide barrier coating at dissimilar materials.
   c. Provide matching “puppy panels”. Place between full-size pickets. Provide matching picket tops.
5. Fence post tops:
   a. Zinc alloy die cast ball. Color to match pickets. Provide barrier coating at dissimilar materials.

E. Fabrication:
1. Factory cut all material. Punch rails for pickets. Assemble fence panels in longest sections that can be transported. Weld all joints. Provide "U" shaped slip joints for field assembly by welding or by using stainless steel 1/4-inch-diameter bolts or 1/4-inch-diameter stainless steel industrial rivets.

F. Hardware:

1. Provide ADA-compliant mortise lockset (storeroom function) at personnel gate. Verify keying requirements with Owner prior to ordering. Provide finish to match new hardware at Lift Station; coordinate with Contractor and building supplier.

G. Finish:
1. All steel material shall be hot-dip galvanized G-90.
2. Rinse and clean.
3. Steel material to be phosphate etch, rinse clean and oven dry.
4. Steel First Coat: Powder coat with zinc-rich epoxy primer.
5. Steel Second Coat: Polyester powder coat, 3.5 mils average dry film thickness and bake at 450ºF.

2.03 STEEL GATES, SWINGING

A. Provide electric motor-operated, steel swinging gates. Builders Fence Company, Inc.; Amazing Gates; Iron Fence Shop; or equal.
1. Swinging gates shall be as shown on the Drawings and shall be constructed as follows:
   a. All components shall be steel tube, all joints shall be welded. All steel members to be hot-dip galvanized after fabrication. Finish to match fence panels.
2. Gate frame shall be 3-inch x 3-inch x 0.125-inch tube. Weld corners to create a rigid frame. Provide a 2- x 3-inch horizontal rail near the top of the gate that lines up with a similar fence rail.

3. Pickets shall be 1-inch x 1-inch x 0.65-inch steel tube spaced 6-inches o.c.
   a. Each picket to be capped with fleur de lis-style pointed top. Color to match pickets. Provide barrier coating at dissimilar materials.
4. Provide matching “puppy panels”. Place between full-size pickets. Provide matching picket tops.
5. Fence post tops:
   a. Zinc alloy die cast ball. Color to match pickets. Provide barrier coating at dissimilar materials.
6. Gates shall have electric motor operators.

B. Gate Hardware: Hinges, operator arms, and idle roller on end of swinging section, shall be Richard-Wilcox; Stanley; or equal.

C. Finish:
1. All steel material shall be hot-dip galvanized G-90.
2. Rinse and clean.
3. Steel material to be phosphate etch, rinse clean and oven dry.
4. Steel First Coat: Powder coat with zinc-rich epoxy primer.
5. Steel Second Coat: Polyester powder coat, 3.5 mils average dry film thickness and bake at 450ºF.

D. Electric Gate Operator:
1. Extra heavy-duty 1 HP swing type crank arm electric gate operator. Elite Gates; Customline Inc.; or equal.
2. Two stage gear reduction. Automatic limit switches, motor starter for open/close operation and built-in safety switch to reverse gate direction if gate contacts any unintended object. All prewired in a self-contained weatherproof housing. Operation shall be rated for 120 volts, 1 phase electrical service. See also electrical drawings.
3. Locking or latching devices and gates must operate in a "fail safe" mode so that the gates are automatically unlocked and manually operable by one person whenever remote control or electric operation fails.

E. Reversing Safety Edge:
1. Provide a reversing safety edge that will immediately stop the electric gate operator and reverse its direction whenever the leading edge of the gate encounters an obstruction with a force of 4 pounds or more.
2. Miller Edge #ME-123; Anchor Group; or equal.
   The contractor shall lubricate the hinges, rollers and other gate hardware after installation. Provide barrier coating at dissimilar materials.

F. Control of Gate Operator:
1. Provide programmable wireless gate controller and two portable operators (remote clicker) to control vehicular gate for the site. Both gate remotes shall include a dedicated button for the site’s vehicular gate.
2. Provide for local emergency operation of gate by Fire Department or Owner under both power on and power failed conditions. Provide support and mounting for Knox electric switch (Model #KS-2) for emergency use on both sides of gate.

PART 3 - EXECUTION

3.01 PREPARATION

A. The contractor shall layout the new fence in accordance with the drawings, shop drawings, and all applicable requirements and codes.

B. The contractor shall verify any grade changes or surface irregularities.

C. Discrepancies between the approved shop drawings and field conditions must be approved by the Engineer prior to proceeding with the installation.

3.02 INSTALLATION

A. Gate posts shall be set plumb and level at locations shown on the drawings.

B. Excavate for concrete foundations. All concrete foundations shall be as shown but not less than listed in paragraph 2.02.D.1 of this Section. Place rebar and pour concrete for foundations in accordance with Section 03300.

C. Gate panels shall be welded or bolted to the posts. Field welding of rail to the post shall be a complete 360 degree (all four sides) and shall be the size indicated on the shop drawings. Welds shall be cleaned and coated with a primer the same day the welding is performed. Bolted connections shall use bolts and tabs of the size indicated on the drawings. After tightening bolt, threads shall be peened. Provide barrier coating at dissimilar materials.

D. Gates shall be installed plumb and level and shall be the sizes and style indicated on the drawings. Install swinging gate sections and hardware in accordance with manufacturer's instructions. The contractor shall install any gate stops that may be required. Any padlock provisions or strikes shall be field attached to assure alignment. The contractor shall lubricate the hinges, rollers and other gate hardware after installation. Provide barrier coating at dissimilar materials.

E. All field welds and any abrasions to factory coatings shall be thoroughly cleaned, re-primed and touched up by the contractor with paint of the same quality, color and gloss of that used by the manufacturer.

F. Adjust gates for smooth easy operation.

END OF SECTION

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SECTION 02905

LANDSCAPE PLANTING AND IRRIGATION

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Provide all:
   1. Landscape irrigation
   2. Soil preparation
   3. Landscape planting

B. Related Work Specified Elsewhere:
   1. Section 03100: Concrete Formwork and Accessories
   2. Section 15400: Plumbing

1.02 QUALITY ASSURANCE

A. Comply with all applicable requirements in the adopted editions of *the International Building Code (IBC), Uniform Building Code (UBC), California Building Code (CBC), and the California Plumbing Code (CPC).*

B. Comply with applicable local amendments to the above referenced codes.

PART 2 - PRODUCTS

2.01 TOPSOIL MIX

A. Fertile, friable topsoil free of refuse, roots, heavy or stiff clay, stones larger than 1 inch, weeds, weed seeds, sticks, brush, litter and other deleterious substances. Topsoil shall be free of toxic amounts of acid alkaline elements and shall be capable of sustaining healthy plant life.

2.02 SOIL AMENDMENTS

A. Commercial fertilizer, clean, uniform composition, in labeled bag containers showing the following analysis: 11% nitrogen; 9% phosphoric acid; 6% potash.

2.03 PLANT MATERIALS

A. Plants shall be first class representatives of their normal species or variety. They shall have normal or average branch systems and vigorous root systems. Plants shall be free from pests and diseases, disfiguring knots, scalds, abrasions of the bark, or other disfiguring injury. Plants not conforming to these requirements shall be rejected and must be removed immediately from the site. All plants shall be of the size, age and condition *required to match existing plants to be replaced*. Plants

delivered to the site shall be adequately protected from sun and wind shock until planted.

B. Names of Plants and Standards: All plant materials shall conform to the standards as outlined by the Association of Nurserymen.

C. Inspections: The Contractor shall be responsible for all inspection of plant materials required by the state, federal and county authorities and shall provide the necessary certificates.

D. Container Stock: Container stock shall have been well established in the container in which delivered. The roots shall not have grown beyond the limits of the container.

E. Quantities: Quantities necessary to restore or replace existing landscaping and provide full coverage *to complete the work shown on the drawings* shall be furnished.

2.04 LANDSCAPE IRRIGATION MATERIALS

A. Pipe, fittings and related material matching existing.

2.05 GRASS SOD

A. G*rass mixture matching the existing lawn* nursery grown, harvested as a sod and delivered in rolls.

PART 3 - EXECUTION

3.01 SOIL PREPARATION

A. Scarify existing soil to a depth of 6 inches and incorporate soil amendments and fertilizer. Bring soil to grade or slightly above grade by adding topsoil.

B. Compact soil surface with a lawn roller or tamper.

3.02 INSTALLING SOD

A. Cut existing soil surface down so that when sod is placed the finished surface will be flush with existing grass lawn and flush with or slightly above adjacent pavement.

3.03 INSTALL PLANT MATERIALS

A. Dig holes for plants at least 6 inches larger all around than the plant's rootball.

B. Scarify sides of hole.

C. Place plant on a 2-inch layer of new topsoil, place plant in hole, and backfill with topsoil.

D. Place plants high enough so that when they settle in place the crown of the rootball will be slightly above surrounding grade.

E. Place a mulch of 3/4-inch fir bark all around new plant materials.

F. Stake all 5-gallon and larger plants.

3.04 WATERING AND MAINTENANCE

A. Water and sod and plant material immediately after planting.

B. Maintain and guarantee all plant material and sod for 30 days after planting. Keep material watered and in good growing condition. Replace sickly or dying plant material.

3.05 ADJUSTMENT OF FINISHED SURFACE LEVELS

A. In planted or sodded areas make a final adjustment of finished levels after 30 days. It is essential that finished grades are flush with adjoining paving within 1/4-inch as required by Accessibility Standards in Federal ADA and the *California Building Code*.

3.06 ADJUSTING THE HEIGHT OF EXISTING SPRINKLER HEADS

A. Raise existing sprinkler heads to be flush with the new soil levels. Cut the existing pipe and install new pipe fittings where required.

B. Replace existing damaged sprinkler heads with new sprinkler heads matching the replaced heads in quality and function.

END OF SECTION

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SECTION 02951

VIDEO INSPECTION OF PIPELINES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Pipeline flushing and cleaning.
   2. Audio-Video inspection of sewer pipelines (pre and post-repairs).

1.02 SUBMITTALS

A. Submit completed compact discs or DVDs, identified by number, project name, street name, right-of-way property name, and manhole numbers. Compact discs or DVDs become property of Owner.

B. Submit cleaning and television inspection logs for each section of sewer line to be inspected.

C. If required, submit a specific detailed description of proposed bypass pumping system to include written description of plan and addressing quantity, capacity, and location of pumping equipment. Submit spill plan to address any spills that might occur.

1.03 QUALIFICATIONS

A. Video inspection of pipelines to be completed by a Company specializing in performing work of this section with minimum 5 years documented experience.

B. Contractor shall use equipment specially designed and constructed for sewer inspection and video recording. Camera must have light sources of suitable illumination output to provide a clear picture of the entire periphery of the pipe. Camera must be capable of panning and rotating to a position that will ensure the total periphery of the pipe is always in focus, regardless of the diameter of the pipe being inspected.

C. Camera, transport system, and other components of the video system shall be capable of producing a picture adequate for the purposes of the inspection as stated herein. The adequacy of the proposed equipment, resulting video, and the inspection logs shall be demonstrated to the District, including interfacing with the District's software system, if so requested, prior to the award of the contract. The cost of such demonstration shall be borne by the Contractor.

1.04 SEQUENCING

A. Provide video inspection prior to repairs and after repairs are made.

PART 2 - PRODUCTS

2.01 MEDIA

A. Windows Real Player, Windows Media Player or Flexireader formatted Compact Discs or DVDs.

B. Audio track containing simultaneously recorded narrative commentary describing in detail condition of pipeline interior.

2.02 CONTENTS OF VIDEO INSPECTION.

The following information, to the extent it can be reasonably determined, is to be recorded visually on the compact discs or DVDs, and video logs.

A. Date: The date on which the videotaping was performed at the beginning of each segment.

B. Manhole to Manhole: The manhole identification number for both the upstream and downstream manholes at either end of the taped segment.

C. Direction of Video: Relative to flow direction, indication whether the camera is facing upstream or downstream.

D. Continuous Digital Counter: A digital counter to designate the distance from the “upstream” manhole.

E. Street Name: The street name which contains the video segment and/or the nearest cross street.

F. Service Identification: Identification of all taps by size, type, and pipe entrance location. A clock reference is also preferred.

G. Root Intrusion: Identification of all types of root structures (hair, string, chunk) encountered by severity (minor, moderate, or severe) and location.

H. Addresses: If services are encountered which have roots in or around the sewer service, the street address from which the service is believed to originate.

I. Cracks: Identification of all cracks (spiral, lateral, beam) by type, severity, location and footage.

J. Broken Pipe: Identification of all broken pipe other than cracks by location, cause if known (i.e., improper installation of service, encroachment of other utility, etc.), severity, and footage.

K. Sags: Identification of all sags greater than one inch (1”) by beginning/start, best estimate of depth of sag (greatest point), and ending footage. If the segment has a number of sags or one long continuous sag, view the apparent length and depth of the sag. Once convinced as to the extent of the sag, suck the sag down

by the use of the jet cleaning unit so the condition of the pipe wall can be viewed. Also identify any apparent high spots.

L. Grease: Audible identification of all forms of grease accumulation apparent within the pipe by severity, location and footage.

M. Infiltration: Identification of all forms of infiltration (or exfiltration) by estimation of flow volume (GPM), possible source, visible calcium deposits, and footage.

N. Vertical/Horizontal Offset Joints: Identification of all joints which appear to be offset from original alignment, severity, location, and footage.

O. Wide Joints: Identification of all joints which appear to have a wider separation of bell and spigot than normal, by width and footage.

P. Oval/Deformed Pipe: If PVC or other flexible pipe material exists which may deflect and not sustain noticeable failure, identification of shape of pipe (i.e., egg shaped, non-circular, etc.), footage, and location.

Q. Percent Deterioration: Identify severity of deterioration.

R. Lens Height: Indication whether the camera has been lowered, and the reason. Otherwise, the camera should be set as close to the center of the pipe as possible.

S. Size and Type (Material): A best estimate of the inside pipe diameter and type of material for each pipe segment. If possible, note specifically unusual, as well as standard, types of pipe (e.g., sliplined, PVC, concrete, clay, etc.).

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify existing conditions before starting work. Notify Engineer of changed conditions.

B. Verify location of sewer pipelines to be inspected.

3.02 PREPARATION

A. Flush and clean pipeline interiors to remove sludge, dirt, sand, stone, grease, and other materials from pipe to ensure clear view of interior conditions.

B. Intercept flushed debris at next downstream manhole by use of weir or screening device, remove, and dispose of debris from system off site.

3.03 APPLICATION

A. Closed-circuit TV Camera System:
   1. Camera shall be operative in 100% humidity and be specifically designed and constructed for closed-circuit sewer line inspection for pipes ranging 6-inches to 24-inches in diameter.

2. Camera shall produce a continuously monitored picture with the resolution to discern small hairline cracks and other minor defects in the sewer line. Minimum resolution 720 x 576 pixels. Minimum zoom capability: 120x (10x optical, 12x digital).
3. Camera shall be equipped with a ring of low intensity lights to obtain maximum peripheral vision and prevent fogging within the line being inspected.
4. Camera shall be equipped with a panning and rotational camera head with remote adjustable optical focus and automatic light compensating iris.
5. Camera shall be capable of moving both upstream and downstream; minimum 1,000 feet horizontal distance with one setup; direct reading cable position meter.

3.04 PROCEDURES

A. Color Video: Since color provides better contrast and detail, no black and white video will be accepted.

B. Video (Travel) Speed: To the extent practicable, the speed range at which all segments will be videotaped will be a maximum of 1 Ft/Sec, and a minimum of ½ Ft/Sec. Should variance from these parameters occur, it must be noted on the audio, and the reason for the variance. It is recognized that variance from the minimum speed according to the condition of the pipe is not a serious problem, but that exceeding the maximum velocity can reduce the viewability of the video, and may be grounds for request of re-videotaping the specified segment.

C. Counter Variance:
1. Variance of counter/as-built distance shall not exceed the following:

As-Built Distance	Variance
0 - 100 feet	1%
101 - 200 feet	1%
201 - 300 feet	2%
301 - 400+ feet	2%

2. If the as-built distance and counter distance have a greater difference than specified by the variance, the contractor shall either verify recorded as-built distance or re-video the entire segment.

D. Lens Obstruction: If the lens is obstructed by a foreign object or by fog (e.g., water spray, mist, etc.), attempt to clear the lens of the obstruction. If attempts fail and additional videotaping would produce the same results, continue to videotape the extent of the segment; otherwise, re-video all or the portion which had not been viewed.

E. Lighting: Ensure that the illumination level inside the pipe is high enough to identify clearly the condition of the interior circumference. If segments are not already visible, a request will be made to re-video the segment. If there are

outside contributing factors which make the pipe impossible to illuminate, identify such on video log.

F. Skips in Video: If a portion of the video segment is not recorded on the CD or DVD (such as through malfunction of equipment), the segment must either be entirely re-videotaped from the beginning of the skip to the end, or the entire segment must be re-videotaped. Such corrective action will be at the contractor's expense.

G. Video Footage: Properly identify footage from "upstream" manhole (i.e., as-built footage is from center of manhole to center of manhole). State location of beginning of video segment and correlate counter to this footage (i.e., beginning of pipe segment would be 2 feet, center of manhole would be 0 feet).

END OF SECTION

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SECTION 03100

CONCRETE FORMWORK AND FORMWORK ACCESSORIES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Design, construction, and treatment of formwork to confine and shape concrete to the required dimensions.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. ACI 117 Standard Tolerances for Concrete Construction and Materials
   2. ACI 301 Specifications for Structural Concrete for Buildings
   3. ACI 306 Guide to Cold Weather Concreting
   4. ACI 318 Building Code Requirements for Structural Concrete
   5. ACI 347 Guide to Formwork for Concrete
   6. ACI 350 Code Requirements for Environmental Engineering Concrete Structures

B. American Plywood Association (APA):
   1. Material grades and designations as specified in this Section.

1.03 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Product Data:
   1. Formwork products: Submit technical data including installation instructions, independent laboratory test reports (ICC), and handling and storage instructions.
      a. Forms, if fabricated off construction site.
      b. Form facing materials.
      c. Form ties or through-bolts or coated ties, if utilized.
      d. Form release agents.
      e. Form coatings.
      f. Form liners.
      g. Reshoring or backshoring for suspended slabs and beams.

C. Shop Drawings:
   1. Shop drawings and calculations for formwork beams sealed and signed by a licensed Civil or Structural Engineer in the State of California.
   2. Procedures, drawings, calculations, layout and sequence for shoring, reshoring and backshoring suspended concrete slabs and beams sealed and signed by a licensed Civil or Structural Engineer in the State of California. Include formwork removal procedure and magnitude of construction loads permitted during reshoring or backshoring on shop drawings.

1.04 QUALITY ASSURANCE

A. Contractor Qualifications: See Section 03300.

B. Construction Standard: Applicable requirements of the CBC, ACI 301, ACI 318 and ACI 350.

C. Concrete Products and Materials Tests: Certified by independent commercial testing laboratories.

D. Preconstruction Meeting: See Section 03300.

1.05 DEFINITIONS

A. Water Containment Structure(s): A reservoir, basin, tank, channel, sump, or conduit.

B. Exposed Concrete: A concrete wall, slab, beam or column which will have surfaces exposed to view in the finished work. It includes similar exposed surfaces in water containment structures from the top of walls to 2-feet below the normal water surface (for concrete finishes for “exposed surfaces” see Specification Section 03350).

1.06 SYSTEM DESCRIPTION

A. Formwork and Formwork Accessories Design Requirements:
   1. Design and engineer formwork. Sign and seal design calculations for formwork and formwork drawings by Licensed Civil or Structural Engineer in the state of Californiah.
   2. Design formwork, shores, reshores, and backshores to carry all loads transmitted to them and to comply with the requirements of the applicable building code. Formwork shall be designed in accordance with the requirements of ACI 301, ACI 318, and ACI 347.
   3. Design formwork to withstand the pressure resulting from placement and vibration of concrete and to maintain specified tolerances. The design shall consider any special requirements due to the use of plasticized and/or retarded set concrete. Should satisfactory concrete placement require any changes in concrete mix design, the formwork shall be re-designed and modified as required for the changed mix designs.

B. Formwork and Formwork Accessories Performance Requirements:
   1. Maximum deflection of facing materials reflected on concrete surfaces exposed to view shall be 1/240 of the span between structural members of the formwork, unless noted otherwise on Drawings.
   2. Design forms to construct a flat, uniform concrete surface requiring minimal finishing or repairs. Form design shall accommodate all of concrete mix designs being used by the Contractor.
   3. Set form facing materials in an orderly and symmetrical arrangement, and keep the number of seams to a practical minimum. Facing materials shall be supported with studs or other backing capable of maintaining deflections within the tolerances. Fit adjacent panels with tight joints.
   4. Conform forms for circular structures to the circular shape of the structure. When permitted, straight panels may be substituted for circular panels if the straight panels do not exceed 2 feet in width and do not have a deflection angle greater than 3-1/2 degrees per joint.
   5. Secure to forms as required or set for embedment as required, all sleeves, inserts, anchors, miscellaneous metal items, reglets, and other embedded items furnished under other Sections and required to be cast into concrete.

1.07 DELIVERY, STORAGE AND HANDLING

A. Lumber: Store all lumber, including plywood for forms, to prevent direct contact with the ground. Protect the stored lumber from the elements by a suitable covering, such as polyethylene film or waterproof building paper, suitably held in place.

PART 2 - PRODUCTS

2.01 GENERAL

A. Provide new materials meeting the requirements referenced in this Section.

2.02 FORMWORK PRODUCTS

A. Formwork Materials:
   1. Provide form-facing materials that will meet the concrete finish requirements for formed surfaces of Section 03350.
   2. Use plywood, tempered concrete-form-grade hardboard, steel, plastic, paper, or other acceptable materials capable of producing the desired finish for form-facing materials.
   3. Use form-facing materials that will produce a smooth, uniform texture on the concrete.
   4. Do not use form-facing materials with raised grain, torn surfaces, worn edges, patches, dents, or other defects that will impair the texture of concrete surfaces.
   5. Provide facing-materials of clean, smooth surfaces of wood, plywood, metal, or other approved material.
   6. Construct wood forms of sound lumber or plywood of suitable dimensions and free from knotholes and loose knots.
   7. Where used for exposed surfaces, dress and match boards.
   8. Furnish plywood with a waterproof, synthetic resin bonded face manufactured for formwork.
   9. Furnish steel forms that incorporate reinforcement, inserts, pipe fittings, box-outs, and other details shown on the Drawings without modification to these details.

B. Formwork Accessories: Use commercially manufactured accessories for formwork accessories that are partially or wholly embedded in concrete, including ties and hangers. Do not use nonfabricated wire form ties. Moldings for chamfers and rustications and the recesses for joint sealants shall be smooth and of nonabsorbent material.

C. Fabrication and Manufacture:
   1. Formwork shall be essentially watertight and shall prevent loss of mortar from concrete. Seal all joints or gaps with an acceptable material.
   2. Use 3/4 inch minimum chamfer strips in the corners of formwork. Use mill run chamfer strips surfaced all sides.
   3. Design temporary openings, where needed, at the base of vertical formwork to facilitate cleaning, inspection, placement, and vibration at construction joints and along form.

D. Column forms:
   1. Rectangular columns shall be formed as specified for wall forms. All corners shall have a 3/4 inch chamfer unless otherwise noted on the Drawings.

2. Circular columns shall be formed with steel, fiberglass reinforced plastic. The forms shall be continuous for the height of the column between construction joints indicated on the Drawings..

2.03 FORM TIES

A. Form ties for Building or Other Structures:
   1. Provide commercially manufactured steel rods or through-bolts, Cone-Snap Ties or taper ties capable of withstanding applied pressures.
   2. Other ties shall not be used.
   3. Provide form ties designed that when forms are removed, no metal shall remain within 1-1/2 inch to the finished concrete surface.

B. Form ties for Water Containment Structures:
   1. Provide form ties that have no metal or other material within 1-1/2 inches of the concrete surface.
   2. Provide form tie assembly with cone-shaped depressions at the concrete surface at least 1 inch in diameter and 1-1/2 inches deep to allow for filling and patching.
   3. Provide portions of form ties that are to remain in place with an integral water barrier at or near the midpoint of the tie.
   4. Taper form ties that are to be entirely removed from the structure for easy removal and suitable size for filling of the void after removal.
   5. Furnish ties adjustable in length or of proper fixed length,
   6. Use a plastic cone spacer at each end of the form tie.
   7. Provide ties for walls resisting water or earth pressure with integral water barrier of diameter 3/4-inch greater than the rod, bonded to rods at the wall centerline, or with other favorably reviewed water seal devices.
   8. Provide tapered form ties or removable through-bolts at least 1-inch in diameter at smallest end.
   9. Manufactured neoprene or polyurethane tapered plug to be installed at the wall centerline. X-Plug by Greenstreak, or equal.

2.04 FORMWORK RELEASE AGENTS

A. Use commercially manufactured formwork release agents that prevent formwork absorption of moisture, prevent bond with concrete, and do not stain the concrete surfaces. Coat forming surfaces using an effective, non-residual, bond breaking form coating unless otherwise noted.

B. When concrete surfaces are in contact with potable water, formwork release agents shall be acceptable for potable water contact in accordance with NSF/ANSI 61 – Drinking Water System Components.

C. Do not use and formwork release agents that will impart any material or residue to the concrete surface detrimental or incompatible with any specified paint, concrete or architectural finish, adhesives, waterproofing system, plaster or coating system to be applied later. Do not use oil-based products on formed surfaces that are to be painted, coated, or bonded to other concrete.

PART 3 - EXECUTION

3.01 CONSTRUCTION AND ERECTION OF FORMWORK

A. At construction joints, lap contact surface of the form sheathing for flush surfaces over the hardened concrete in the previous placement. Ensure formwork is placed against hardened concrete so that offsets at construction joints attain specified tolerances and minimize loss of mortar.

B. Construct formwork so that concrete surfaces conform to the tolerance limits of ACI 117. The class of surface for offset between adjacent pieces of formwork facing material, as defined in ACI 117, shall be Class B for surfaces permanently exposed to view and Class D for surfaces that will be permanently concealed.

C. Provide positive means of adjustment (such as wedges or jacks) of shores and struts. Do not make adjustments in the formwork after concrete has reached its time of initial setting. Brace formwork securely against lateral deflection and lateral instability.

D. To maintain specified tolerances, camber formwork to compensate for anticipated deflections in formwork during concrete placement. Set formwork and intermediate screed strips for slabs accurately to produce designated elevations and contours of the finished surface before removal of formwork. Ensure that edge forms and screed strips are sufficiently strong to support vibrating screeds or roller pipe screeds.

E. When formwork is cambered, set screeds to a like camber to maintain required concrete thickness. Fasten form wedges in place after final adjustment of forms and before concrete placement.

F. Anchor formwork to shores, supporting surfaces, or members to prevent upward or lateral movement of the formwork system before and during concrete placement.

G. Construct formwork for wall openings to facilitate removal and to counteract swelling of wood formwork.

H. Provide runways for moving equipment and support runways directly on the formwork or structural member without resting on the reinforcement.

I. Place sleeves, inserts, anchors, and embedded items required for adjoining work or for support of adjoining work before concrete placement. Secure all embedments against displacement, fill voids in inserts to prevent entry of concrete, and isolate or coat surfaces of aluminum embedments to prevent reaction with the concrete.

J. Place 3/4 inches minimum chamfer strips in the corners of formwork to produce beveled edges on permanently exposed surfaces including the top edges of walls, machinery bases and curbs. Do not bevel reentrant corners or edges of formed joints of concrete. Provide rounded top edges of sidewalks, walkways and where directed.

K. Seal tie holes in formwork to prevent leakage where ties penetrate the formwork. Place taper form ties with the larger end on the side of the structure that will be in contact with liquid.

L. Clean surfaces of formwork and embedded materials of mortar, grout, and foreign materials before concrete is placed.

M. Cover surfaces of formwork with an acceptable material that will prevent bond with the concrete. A field applied formwork release agent or a factory-applied liner may be used. If a formwork release agent is used, apply to the surfaces of the formwork in accordance with the manufacturer's recommendations before placing reinforcement. Do not allow formwork release agent to puddle in the forms. Do not allow formwork release agent to contact reinforcement or hardened concrete against which fresh concrete is to be placed.

N. Inspect formwork and remove deleterious material immediately before concrete is placed.

O. Do not use earth cuts as forms for vertical or sloping surfaces.

P. If inadequate support is provided by the forms, as evidenced by excessive deflection, formwork failure or leakage, remove placed concrete and replace.

Q. Formed Surfaces:
   1. Ensure that the reinforcement has been favorably reviewed by the special inspector before closing up the wall forms.
   2. Provide exposed, unpainted concrete surfaces that are uniform in appearance and color. Apply non-staining form coating compound before placing the forms. Remove any excess coating with cloths. Scrape and clean any reused forms before coating again.
   3. Provide flush fitting caps over any unused form tie holes.

R. Form Ties and Through-Bolts:
   1. Provide sufficient number and strength to prevent spreading of forms while placing concrete.
   2. Remove the removable portion immediately after stripping the forms. Avoid spalling the exposed concrete surfaces.
   3. Provide a separate support system for the curtains of reinforcing, with a minimum 1-inch clearance between rebar and form ties or bolts.

S. Construction Joints:
   1. At ends of the first concrete placement, provide forms that positively locate waterstop. Ensure the end forms of walls are removable without releasing the side forms. Provide seals around reinforcement and waterstop to prevent mortar leaks.

3.02 ALLOWABLE VARIATIONS FOR FORMED SURFACES

A. General:
   1. Tolerances: ACI 301 and as noted below:
   2. Set and maintain concrete forms to ensure that, after removal of the forms and prior to patching and finishing, no portion of the concrete work will exceed the tolerances. Measure variations in floor levels before removal of supporting shores.
   3. The specified variation for one element of the structure will not be applicable when it will permit another element of the structure to exceed its allowable variation.

B. Variations in Size or Thickness:
   1. Footings:
      a. Length and width: ±1/2-inch
      b. Reduction in thickness: 5%

2. Slabs and walls:
   a. Thickness of 6 inches or less: +1/4-inch, -0-inch
   b. Thickness of more than 6 inches: ±1/4-inch

C. Allowable Tolerances (Location, Lines and Grades):

1. Horizontal misplacement or eccentricity of footings	2% of footing width, but no more than 1-inch
2. Variation of vertical dimensions at all floor levels from specified position:	±1/2-inch per 100-foot
3. Variation of vertical dimensions from specified position:	±1/4-inch
4. Variation from level or from slopes specified for floors, ceilings, water channels and conspicuous lines	±1/4-inch per 20 feet
5. Variation in location from specified position for sleeves, pits, floor, and wall openings:	±1/4-inch

3.03 REMOVAL OF FORMWORK

A. When formed surfaces require finishing, remove forms as soon as removal operations will not damage concrete.

B. Remove top forms on sloping surfaces of concrete as soon as removal will not allow concrete to sag. Perform needed repairs or treatment required at once and follow immediately with specified curing.

C. Loosen wood formwork for wall openings as soon as loosening operations will not damage concrete.

D. Do not damage concrete during removal of formwork for columns, walls, sides of beams, and other parts not supporting the weight of the concrete. Perform needed repair and treatment required on vertical surfaces at once and follow immediately with specified curing.

E. Leave formwork and shoring in place to support construction loads and weight of concrete in beams, slabs, and other structural members until in-place strength of concrete is at least *fc'*.

F. When removal of formwork or reshoring is based on concrete reaching the specified compressive strength, concrete shall be presumed to have reached this strength when test cylinders, field cured the same as the concrete they represent, have reached the compressive strength specified. Mold and cure cylinders in accordance with ASTM C31. Test cylinders in accordance with ASTM C39.

G. When shores and other supports are arranged to allow form-facing material to be removed without allowing structural slabs or members to deflect, form-facing material and horizontal supporting members may be removed at an earlier age.

H. Minimum duration after completion of concrete placement prior to removal of the formwork, unless the provisions of 03305 or 03306 apply:

1. Walls and wall or slab construction joints	12 hours
2. Sides of beams and girders	12 hours
3. Columns	12 hours
4. Underside of suspended slabs, walkways, beams and girders	28 days, or 21 days and full design compressive strength verified by data from

additional field cured cylinders.

I. Cold Weather: See Section 03306.

J. Construct formwork to permit easy removal.

3.04 RESHORING AND BACKSHORING

A. Submit for review, requirement for accelerated partial stripping and reshoring and backshoring of forms that may be necessary to maintain the construction program.

B. During reshoring and backshoring, do not allow concrete in beams, slabs, columns, or any structural member to be loaded with combined dead and construction loads in excess of the loads permitted for the concrete compressive strength.

C. Place reshores and backshores in sequence with stripping operations.

D. Tighten reshores and backshores to carry the required loads without overstressing the concrete members. Leave them in place until tests indicate that the concrete compressive strength has attained the minimum value.

E. For floors supporting shores under newly placed concrete, either leave the original supporting shores in place, or install reshores or backshores. The shoring system and the supporting slabs shall resist the anticipated loads.

3.05 FIELD QUALITY CONTROL

A. Establish and maintain controls and benchmarks in an undisturbed condition until final completion and acceptance of the project.

B. Variations from plumb and designated building lines shall not exceed the tolerances specified in ACI 117.

C. Notify Owner when the forms are complete and ready for inspection at least 16 working hours prior to the proposed concrete placement.

D. Concrete Placement:
   1. Verify that forms and reinforcement are accurately placed and secured in position. Confirm that both forms and reinforcement have been favorably reviewed.
   2. Verify that tie wire ends have been bent back away from the forms.
   3. Verify that sleeves, castings, pipes, conduits, bolts, anchors, and other items required, are accurately and securely placed within or on the forms.
   4. Verify waterstop is correctly in place and that splices are watertight.
   5. Verify adequate vibrators are available.
   6. Verify construction and expansion joint faces have been prepared for the next concrete placement.
   7. Check that the mix design is compatible with the method of placement of the concrete, by pump or by batch.
   8. For wall placements, verify that the modified concrete mix required at construction joints is to be delivered.
   9. Verify the concrete delivered to site is satisfactory, including checks on the batch tickets, quality assurance tests and direct observation of the batches.

E. Failure of the forms to comply with the requirements specified or to produce concrete complying with requirements of this Section shall be grounds for rejection of that portion of the concrete work. Rejected work shall be repaired or replaced at

no additional cost to the Owner. Such repair or replacement shall be subject to the requirements of this Section and Section 03935.

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SECTION 03150

CONCRETE JOINTS AND ACCESSORIES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Construction of joints in concrete, including materials and accessories.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. ACI 318 Building Code Requirements for Structural Concrete
   2. ACI 350 Environmental Engineering Concrete Structures

B. ASTM International (ASTM) Standard Specification or Test Method:
   1. ASTM A167 Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
   2. ASTM A675 Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties
   3. ASTM C881 Epoxy-Resin-Base Bonding Systems for Concrete
   4. ASTM C920 Elastomeric Joint Sealants
   5. ASTM D1056 Flexible Cellular Materials - Sponge or Expanded Rubber
   6. ASTM D1751 Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction. (Nonextruding and Resilient Bituminous Types)
   7. ASTM D1752 Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
   8. ASTM E96 Water Vapor Transmission of Materials

C. U.S. Army Corps of Engineers (COE) Specifications:
   1. COE CRD-C-572 Polyvinylchloride Waterstops

D. California Building Code (CBC) 2019 Edition**.**

E. International Code Council (ICC)

1.03 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Product Data: Submit technical data including installation instructions, independent laboratory test reports (ICC), handling and storage instructions.
   1. Waterstops, including waterstop joints
   2. Expansion joint materials
   3. Premolded joint filler
   4. Bond breakers and bond breaker tape
   5. Joint sealants
   6. Epoxy bonding compounds
   7. Other joint accessories

C. Shop Drawings:
   1. Location and details of construction, expansion, and contraction joints.

2. Construction joint layout, including waterstop placement; coordinate with Section 03100.
3. Sequence of concrete wall and slab pours.
4. Program and method of concrete placement.

D. Quality Control Certifications
1. Certification that all materials used within the joint system are compatible with each other.

1.04 QUALITY ASSURANCE

A. Contractor Qualifications: See Section 03300.

B. Preconstruction Meeting: See Section 03300.

1.05 DELIVERY, STORAGE AND HANDLING

A. Waterstop: Reject any cracked material, any joints with offsets between ribs or incomplete bond. Protect material from oil, grease and dirt and cover against direct sunlight.

B. Joint Fillers, Bond Breakers, Inserts: store in accordance with manufacturer's recommendations, maintain all warranty provisions.

PART 2 - PRODUCTS

2.01 GENERAL

A. Provide new materials. All materials used together in a given joint shall be compatible with one another. Coordinate selection of suppliers and products to provide compatibility. Do not use asphaltic bond breakers or asphaltic joint fillers in joints receiving sealant.

2.02 PREFORMED JOINT FILLER

A. Structures Retaining Water or Earth: ASTM D1753 Type III or equal. Neoprene ponge rubber, closed cell, resistant to oil, medium swell, firm. Supply premolded product, Self-Expanding Cork Expansion Koint by WR Meadows; equivalent product by Armacell; or equal.

B. Miscellaneous Structures Above Grade: ASTM D1752 Type 1, 1-inch thick unless indicated otherwise on drawings.

C. Seperation joints between structures: Compressible Joint Filler: The joint filler shall be a non extruded watertight strip material used to fill joints between structures. The material shall be capable of being compressed at least 40 percent for 70 hours at 68 degrees F and subsequently recovering at least 20 percent of its original thickness in the first 1/2 hour after unloading. Compressible Joint filler shall be Evazote 380 E.S.P, by E-Poxy Industries, Inc., Ravena, NY; Evazote by Capital Services, Albany, NY; or equal.

2.03 BOND BREAKER

A. Bond breaker tape shall be an adhesive backed glazed butyl or polyethylene tape which will satisfactorily adhere to the preformed joint filler or concrete surface as required. The tape shall be the same width as the joint.

B. Bond breaker for concrete other than where tape is specifically called for on the drawings shall be either bond breaker tape or a nonstaining type bond prevention coating such as Super Bond Breaker WB by Burke Co.; Silcoseal 87, by Nox-crete Inc., or equal.

2.04 JOINT SEALANTS

A. General: ASTM C920, polyrethane, grade and class appropriate for use. Use joint sealants in liquid-containment structures suitable for submerged service as recommended by the manufacturer. Provide a compatible primer when recommended by the manufacturer.

B. Provide sealants used in structures for treated water resistant to chlorine exposure at the expected concentrations.

C. Provide an acceptable bond-breaking tape as recommended by the sealant manufacturer.

D. Exterior Exposure: Sikaflex-2c, by Sika Corp., Select Seal U-200 by Select Products Corp., or equal.

E. Prepare surfaces and provide primer and sealants in strict accordance with manufacturer's recommendations.

F. Backing Rod: Extruded, closed cell, polyethylene foam rod, compatible with sealant. Provide 5/8-inch-diameter rod for ½-inch joint, 1-1/4-inch rod for 1-inch joint.

2.05 WATERSTOPS

A. Polyvinyl Chloride (PVC) Waterstops: Provide for construction or expansion joints in new concrete.
   1. Material: Extruded PVC, manufactured from virgin materials.
   2. Physical properties: COE CRD-C-572. Nominal thickness of flexible waterstops not less than 1/4 inch for construction joints or contraction joints and not less than 3/8 inch for expansion joints. Flexible waterstops used in expansion joints and contraction joints shall have a bulb-shaped center section designed to accommodate movement. Minimum width of flexible waterstops shall be 6 inches When used in expansion joints, the minimum width shall be 9 inches.

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   3. Waterstop Types:
      a. Serrated (Ribbed) Flat: Vinylex R6-38; Greenstreak Style 679.
      b. Serrated (Ribbed) with Centerbulb: Vinylex RB9-38H; Greenstreak Style 735.
   4. Splices:
      a. Make splices in waterstops and use molded pieces at splices and corners. Provide factory fabricated waterstop intersections, leaving only straight butt-joint splices for the field. Waterstop intersections and directional changes to be miter cut and heat welded with centerbulb and ribs aligned to maintain continuity. Splices to be free from defects.
      b. Tensile Strength: 80% of parent material.
   5. Provide factory installed hog rings or grommets, 12” on center, ½” or less from both edges of the waterstop and tie wire to rigidly locate waterstops in forms.

6. Manufacturers:
    a. Vinylex Corporation
    b. Greenstreak Plastic Products Company, Inc.

2.06 SOURCE QUALITY CONTROL

A. Forms: Verify that components pre-assembled offsite are satisfactory for the purpose. Verify that designs, products and samples have been submitted for Product Review.

PART 3 - EXECUTION

3.01 CONCRETE JOINTS

A. General:
    1. Provide joints:
        a. As shown on the Drawings and as noted below in these Specifications.
        b. As required for constructability.
        c. After favorable review of layout, sequence and concrete placement program.
        d. Position and support waterstops, joint materials, and other embedded items to prevent displacement. Fill voids in sleeves, inserts, and anchor slots temporarily with readily removable material to prevent entry of concrete into voids. Embedded items shall be free of all mud, oil, loose rust, or other material that might inhibit bond.
    2. Provide minimum curing times before the second placement:
        a. 10 days after each adjacent concrete placement for infill pours (i.e. in-between two existing sections) or checkerboard (existing concrete on two or more sides) placement patterns.
        b. 2 days after the first concrete placement at the joint.
    3. During placement of the new concrete, ensure there are no interruptions to the 14-day curing time and 14-day load restriction plan for the adjacent pours.

B. Control Joints:
    1. Space typical control joints in slabs on grade or suspended slabs not exceeding 10 feet, or as shown on the Drawings. Control joints shall not be provided in water containment structures.
    2. If cast-in with the concrete, positively locate the preformed joint filler and hold rigidly in place during concreting.
    3. If saw-cut, use a wheeled power saw as soon as the concrete surface is firm enough. Saw-cut control joints must be constructed within 12 hours after concrete placement. Fill the groove with sealant over a backer rod.

C. Construction Joints:
    1. Produce quality concrete, with full continuity of reinforcing and water tightness across the joints.
    2. Locate horizontal joints in walls and columns at the underside of floors, slabs, beams, or girders and at the tops of footings or floor slabs.
    3. Place beams, girders, haunches, drop panels, and capitals monolithically as part of a slab system, unless otherwise noted.
    4. Locate joints such that beams, girders, or slabs supported by columns or walls will not be cast until concrete in the vertical support members is no longer plastic.

5. Make joints perpendicular to the main reinforcement.
6. Space typical slab joints not exceeding 20 feet in the direction of the transverse or secondary reinforcing, typically the smaller reinforcing nearer to the center of the slab thickness. Space typical vertical wall joints no more than 30 feet apart.
7. Provide all joints in walls and slabs, retaining liquids, or earth with 6-inch ribbed waterstops. Continue all reinforcing through the joint unless otherwise noted.
8. After the first concrete placement at the joint, do not walk on or disturb any reinforcing extending into the second placement area for at least 48 hours.
9. Before depositing new concrete on or against concrete that has hardened, remove laitance and thoroughly clean and roughen the entire surface of the joint exposing clean coarse aggregate solidly embedded in mortar matrix. Provide typically ¼-inch roughness or amplitude of the concrete surface measured from the top of the exposed aggregate to the bottom of pockets between stones.
10. Drench the prepared joint with clean water and remove prior to the concrete pour.
11. Cover horizontal wall joints and wall-to-slab joints with a minimum thickness of 2 inches and a maximum of 6 inches of the modified concrete mix, consisting of the designated concrete mix with one-half of the coarse aggregate removed.
12. Use special care in vibrating adjacent to construction joints to ensure thorough consolidation of the concrete around the waterstops and against the hardened portion of the joint. Additional hand tamping may be required.
13. For joints that are shown on architectural drawings as having a continuous reveal or recess, leave the wood form or pour strip used to create the reveal or recess in place or re-insert before roughening. Prevent the next concrete placement from filling the reveal or recess.

D. Expansion Joints:
1. Stop all steel reinforcing clear of the joint at each side.
2. Provide 9-inch ribbed centerbulb waterstop continuously around the joint in walls and slabs retaining liquids. Prepare a smooth first concrete surface with all voids filled.
3. Provide preformed joint filler, securely fastened to the existing concrete as directed by the Manufacturer.
4. Install bond breaker tape and a joint sealant applied in a suitable groove or recess at each accessible face after curing is completed and when directed.
5. Tape all joints in the premolded joint filler to prevent intrusion of mortar.

E. Bonding to Pre-existing Concrete: Mechanically roughen the old surface to a ¼-inch amplitude, as defined in construction joint paragraph above. Apply epoxy bonding system material prior to concreting and in accordance with the manufacturer's instructions.

F. Embedded PVC Waterstop:
1. Use pieces of premolded waterstop with a maximum practical length to hold the number of splices to a minimum.
2. Provide continuous waterstops at all corners and intersections.
3. Center waterstops in joints unless otherwise indicated.
4. Waterstops shall be secured in position by acceptable methods.

5. Vertical waterstops shall be anchored back to the reinforcement with wire ties.
6. At flexible waterstops placed horizontally, fold the waterstop upward along its entire length while concrete is placed and consolidated up to the level of the waterstop, and then the waterstop shall be pressed into the top of the fresh concrete. Then complete concrete placement and consolidation so as to provide full encasement of the waterstop in concrete.
7. Terminate waterstops at vertical joints 3 inches below the tops of exposed walls.
8. Where waterstops with a center bulb are used, plug the ends of the center bulb with a flexible material, such as foam rubber, to prevent concrete intrusion at ends where the bulb will be exposed to concrete extrusions.
9. Uncoil waterstop 24 hours prior to installation for ease of handling and fabrication.
10. Restrict field splices to butt joints in straight runs. For PVC type, make by heat welding, using a waterstop splicing iron with non-stick surface set to the correct temperature (per manufacturer's recommendations). Follow the manufacturer's specifications.
11. Positively locate and support waterstop in the forms so that concrete may be placed, consolidated, and vibrated on both sides of the embedded portion without displacement of the waterstop and without causing voids in the concrete (use copper-clad hog rings or grommets at 12-inch maximum on-center to secure waterstop to adjacent reinforcing steel. Crimped hog ring should be located between the last two ribs on waterstop leg). Protect the outstanding portion from damage during the first concrete pour and clean and positively support prior to the second pour. Place, consolidate and vibrate the second pour without displacement of the waterstop and without causing voids in the concrete. After first pour, clean unembedded waterstop leg to ensure full contact of second concrete pour. Remove laitance, spillage, form oil and dirt.
12. Waterstop Quality Assurance: Edge welding will not be permitted. Centerbulbs shall be compressed or closed when welding to non-centerbulb type. Waterstop splicing defects which are unacceptable include, but are not limited to the following:
    a. Tensile strength not less than 80% of parent sections.
    b. Free lap joints.
    c. Misalignment of centerbulb, ribs, and end bulbs greater than 1/16-inch.
    d. Misalignment which reduces waterstop cross section more than 15%.
    e. Bond failure at joint deeper than 1/16-inch or 15% of material thickness.
    f. Misalignment of waterstop splices resulting in misalignment of waterstop in excess of ½-inch in 10 feet.
    g. Visible porosity in the weld.
    h. Charred or burnt material.
    i. Bubbles or inadequate bonding.
    j. Visible signs of splice separation when cooled splice (24 hours or greater) is bent by hand at sharp angle.

3.02 FIELD QUALITY CONTROL

A. See Sections 03100 and 03300.

END OF SECTION

SECTION 03200

CONCRETE REINFORCEMENT AND REINFORCEMENT SUPPORTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Materials, fabrication, placement, and tolerances of reinforcement and reinforcement accessories.

1.02 REFERENCES

A. ASTM International (ASTM) Standard Specifications:
   1. ASTM A185: Steel welded wire fabric, plain, for concrete reinforcement.
   2. ASTM A615: Deformed and plain billet - steel bars for concrete reinforcement.
   3. ASTM A970: Headed Steel bars for concrete reinforcement

B. American Concrete Institute:
   1. Details and Detailing of Concrete Reinforcement (ACI 315).
   2. Building Code Requirements for Reinforced Concrete (ACI 318).

C. Concrete Reinforcing Steel Institute: Manual of Standard Practice (CRSI Manual).

D. International Code Council: Evaluation Reports (ICC Reports).

E. American Welding Society: D1.4 Structural Welding Code - Reinforcing Steel (AWS D1-4).

1.03 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Product Data:
   1. Bar supports and chairs.
   2. Mechanical bar connectors, including ICC Reports.
   3. Certified mill test results for reinforcement.
   4. Tests on unidentified bars.

C. Shop Drawings:
   1. Bar and wire fabric layouts.
   2. Bar bending diagrams.
   3. Placing drawings showing fabrication dimensions and locations for placement of reinforcement and reinforcement supportsincluding the length and location of lap splices and mechanical connector locations.
   4. Accessories and inserts layout.

D. Quality Assurance/Control Submittals:
   1. Welding: Description of reinforcement weld locations, chemical analysis of reinforcement, welding procedures, and welder qualifications.
   2. Submit a request to relocate any reinforcement that exceeds placement tolerances.

1.04 QUALITY ASSURANCE

A. Testing agencies that perform testing services on reinforcing steel shall meet the requirements of ASTM E329.

B. Material Tests: Not required for bars, wire fabric rolls or sheets delivered in bundles from the mill and tagged with valid Identification Certificate.
   1. Unidentified Bars: Test samples from each five tons or fraction thereof for each size. If already delivered to site, test additional samples from each day of planned concrete placement. Perform one tension and one bend test from each sample for each size.
   2. Test standard: ASTM A615.
   3. Testing Laboratory: Selected by Engineer, to take samples and perform tests. Costs paid by Contractor.
   4. Unidentified Wire Fabric: Not acceptable.

C. Standard: CRSI Manual, except as otherwise indicated or specified.

1.05 DELIVERY, STORAGE AND HANDLING

A. Prevent permanent bending and protect bar surfaces from contact with soil, oil, or other materials that may decrease bond to concrete.

B. Bundle reinforcement and tag with suitable identification to simplify sorting and placing. Transport and store at site so material is not damaged. Store reinforcement off ground, place under cover and keep clean. Store welded fabric in flat sheets, not rolls. Keep an adequate supply of reinforcement at site to avoid delays.

PART 2 - PRODUCTS

2.01 REINFORCING BARS

A. General: Deformed bars, ASTM A615, Grade 60.

B. Dowels: All dowels are deformed bars unless shown otherwise on the Drawings.
   1. Deformed bars: ASTM A615, Grade 60.
   2. Smooth bars: ASTM A615, Grade 60, or ASTM A675, Grade 60.
   3. Threaded bars: ASTM A572, Grade 50.

C. Spiral Reinforcement:
   1. Deformed bars, ASTM A615, Grade 60, unless otherwise noted.
   2. Cold-drawn steel wire, if noted, plain, ASTM A82, deformed, ASTM A496.
   3. Tack welded cages

2.02 TIE WIRE

A. Annealed steel, 16-gauge minimum.

2.03 MECHANICAL CONNECTORS

A. Type: Tension-compression.

B. Strength: Develop 125% of the reinforcing yield strength in tension and compression.

C. Manufacturer:

1. Tension-compression: Lenton by Erico Products, Inc., Dowel Bar Splice Systems by Richmond Screw Anchor Co., or equal.
2. Future Extension Mechanical Butt Splice: Lenton Form Saver by Erico Products, Inc., DBR series by Dayton Superior or equal. Provide plastic taper threaded plugs for “long-term” thread protection.

D. Not all Mechanical Connectors are shown on the drawings, Mechanical Connectors may be required by notes on the drawings for certain splices.

2.04 SUPPORTS AND ACCESSORIES

A. Secure and support the reinforcement within specified tolerances. Conform to CRSI Manual Chapter 3, for Types SB, BB, BC, JC, HC, CHC, and others of standard types as required. Use Class "1" plastic-coated chairs and spacers at waterbearing surfaces, roofs of waterbearing structures, and at all interior or exterior surfaces exposed to view or weather in the completed structure. Plastic thickness of 3/32 inch or greater at points of contact with formwork and extend the plastic along the wire at least 1/2 inch from the point of contact with the formwork. Precast concrete block supports with embedded wire ties are not acceptable.

B. Use precast concrete supports that have a surface area of not less than 4 inches^2 and have a compressive strength equal to or greater than specified compressive strength of concrete being placed. Water absorption and porosity of precast concrete supports equal to or less than water absorption and porosity of concrete being placed. Use precast concrete block supports with embedded wire ties or dowels for placement on grade or on membranes. Cast the blocks with concrete equal in strength, cement type and aggregate to the parent concrete. Do not use aluminum or stainless steel supports or accessories.

2.05 FABRICATION

A. General: CRSI Manual Chapters 6 and 7, including tolerances.

B. Splice, development and embedment lengths: Furnish bars with lap lengths equivalent to ACI 318, Section 12, Class B splices for the specified concrete strength, bar size and location, unless noted otherwise.

C. Bending and Forming: Fabricate bars of indicated size and accurately form to shapes and lengths indicated and required. Fabricate by methods not injurious to materials. Bend reinforcement cold. Fabricate reinforcement in accordance with fabricating tolerances of ACI 117. Reject bars with kinks or bends not scheduled.

D. Welding: When welding of reinforcement is approved, comply with the requirements of AWS D1.4. Do not weld crossing bars (tack welding) for assembly of reinforcement, supports, or embedded items.

E. Concrete Cover: Detail and fabricate the reinforcement to provide specified cover to outer edge of rebars and other installed items.

F. Dowels:
1. Provide deformed reinforcing bar dowels at all construction joints, unless noted otherwise.
2. Provide smooth or threaded dowels where shown on Drawings.
3. Provide same dowel size and spacing as the reinforcing to which they are spliced, unless noted otherwise.

2.06 SOURCE QUALITY CONTROL

A. Testing agencies that perform testing services on reinforcing steel shall meet the requirements of ASTM E329.

B. Verify bend tolerances are not exceeded.

C. Verify bar end cuts are within tolerance when mechanical connectors are to be used.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General: CRSI Manual Chapter 8 including placement tolerances. No reduction of concrete cover is allowable for bars at concrete surfaces exposed in liquid or water-containing structures.

1. Cleaning: Before placing reinforcing, and again before concrete is placed, clean reinforcement of loose mill scale, dried concrete, oil, or other materials deleterious to bond. Do not allow form coatings, release agents, bond breaker, or curing compound to contact reinforcement.
2. Placement: Place, support, and fasten reinforcement as indicated. Do not exceed the placing tolerances specified in ACI 117. Do not reduce cover requirements for placing tolerances. When necessary to move reinforcement beyond the specified placing tolerances to avoid interference with other reinforcement, conduits, or embedded items, submit the resulting arrangement of reinforcement for review. Accurately place reinforcement and securely wire tie in position, at an adequate number of points, where bars cross so as to prevent displacement. Tie stirrups to bars at both top and bottom. Bend ends of tie wire inward allowing no encroachment into the concrete cover.
3. Concrete cover: Provide cover for reinforcement as shown on Drawings. Minimum concrete cover for reinforcement for cast-in-place concrete is shown in the table below for the exposure condition noted. Provide minimum cover to the outer edge of bar spacers, hangers, and like items. For bundled bars, minimum concrete cover shall be equal to the equivalent diameter of the bundle but need not be greater than 2 inches, except the minimum cover shall not be less than specified in the table below. Base the equivalent diameter of the bundle on a single bar of a diameter derived from the equivalent total area.

Exposure Condition for Reinforcement	Cover
A. Concrete cast against and permanently exposed to earth	3 in.
B. Concrete exposed to earth, liquid, weather, or bearing on work mat or slabs supporting earth cover	
Slabs and joists	2 in.
Beams and columns	
Stirrups, spirals, and ties	2 in.
Primary reinforcement	2 ½ in.
Walls 12 inches or over in thickness	2 ½ in.
Footings and base slabs	

Formed surfaces	2 in.
Top of footings and base slabs	2 in.
C. Exposure conditions not covered in A and B above	
Slabs and joists	
No. 11 bars and smaller	1 in.
No. 14 and No. 18 bars	1 ½ in.
Beams and columns	
Stirrups, spirals, and ties	1 ½ in.
Primary reinforcement	2 in.
Walls	
No. 11 bars and smaller	1 ½ in.
No. 14 and No. 18 bars	1 ½ in.

4. Reinforcement supports: CRSI Manual, Chapter 3. Unless noted otherwise on Drawings, use the following reinforcement supports:
   a. Place reinforcement supported from the ground or mud mat on precast concrete reinforcement supports.
   b. Place uncoated reinforcement supported from formwork on reinforcement supports made of concrete, metal, or plastic.
   c. Place zinc-coated (galvanized) reinforcement supported from formwork on wire reinforcement supports that are galvanized, coated with dielectric material, or made of dielectric material.
   d. Reinforcement and embedded steel items used with zinc-coated (galvanized) reinforcement shall be zinc-coated (galvanized) or coated with nonmetallic materials.
5. Field bending: Not permitted, except where specifically shown, or approved.
6. Bar spacing: Between parallel bars, no less than 1-1/2 times the maximum aggregate size and in no case less than 1-1/2 inches. At splices, bundle and wire together bars to accomplish this.
7. Column dowels: Furnish and use templates for placement of column dowels.
8. Welding of reinforcing: Proceed after continuous inspection has been authorized. Welding procedure: Satisfy AWS D1.4.
9. Smooth dowels: Straight dowels at movement joints free of loose rust or scale. Include on dowels used at expansion joints an expansion cap at one end designed to allow at least 1-1/2 inches of expansion. Use an acceptable bond breaker on the dowel on one side of the movement joint.
10. Reinforcement termination: Where reinforcement does not extend through a joint, termine the reinforcement 2 inches from the face of the joint.

3.02 FIELD QUALITY CONTROL

A. Inspect all reinforcement installations. Provide 48 hours notice for inspection before concrete placement.

B. Verify placement tolerances are not exceeded.

C. Mechanical Connectors: Install favorably reviewed products, following the Manufacturer's recommendations, under continuous inspection.

D. Welding Reinforcement: Perform only when approved and only under continuous inspection. Notify the Engineer at least 48 hours in advance of any procedure involving welding.

END OF SECTION

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SECTION 03300

CONCRETE MIXTURES, HANDLING, PLACING AND CONSTRUCTING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
1. Requirements for materials, proportioning, production, and delivery of concrete.
2. Production of cast-in-place structural concrete.
3. Methods and procedures for obtaining quality concrete through proper handling, placing, finishing, curing, and repair of surface defects.

1.02 REFERENCES

A. American Concrete Institute (ACI):
1. ACI 117 Standard Tolerances for Concrete Construction and Materials
2. ACI 301 Specifications for Structural Concrete for Buildings
3. ACI 306 Guide to Cold Weather Concreting
4. ACI 318 Building Code Requirements for Structural Concrete
5. ACI 347 Guide to Formwork for Concrete
6. ACI 350 Environmental Engineering Concrete Structures

B. ASTM International (ASTM) Standard Specification or Test Method:
1. ASTM C31 Making and Curing Concrete Test Specimens in the Field
2. ASTM C33 Concrete Aggregates
3. ASTM C39 Compressive Strength of Cylindrical Concrete Specimens
4. ASTM C40 Organic Impurities in Fine Aggregates for Concrete
5. ASTM C42 Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
6. ASTM C87 Effect of Organic Impurities in Fine Aggregate on Strength of Mortar
7. ASTM C88 Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
8. ASTM C94 Ready-Mixed Concrete
9. ASTM C131 Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
10. ASTM C136 Sieve Analysis of Fine and Coarse Aggregates
11. ASTM C138 Density (Unity Weight), Yield, and Air Content (Gravimetric) of Concrete
12. ASTM C142 Clay Lumps and Friable Particles in Aggregates
13. ASTM C143 Slump of Hydraulic-Cement Concrete
14. ASTM C150 Portland Cement
15. ASTM C156 Water Retention by Concrete Curing Materials
16. ASTM C157 Length Change of Hardened Hydraulic-Cement Mortar and Concrete
17. ASTM C171 Sheet Materials for Curing Concrete
18. ASTM C172 Sampling Freshly Mixed Concrete
19. ASTM C173 Air Content of Freshly Mixed Concrete by the Volumetric Method

20.	ASTM C192	Making and Curing Concrete Test Specimens in the Laboratory
21.	ASTM C227	Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)
22.	ASTM C231	Air Content of Freshly Mixed Concrete by the Pressure Method
23.	ASTM C260	Air-Entraining Admixtures for Concrete
24.	ASTM C289	Potential Alkali-Silica Reactivity of Aggregates (Chemical Method)
25.	ASTM C309	Liquid Membrane-Forming Compounds for Curing Concrete
26.	ASTM C494	Chemical Admixtures for Concrete
27.	ASTM C595	Blended Hydraulic Cements
28.	ASTM C618	Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
29.	ASTM C827	Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixtures
30.	ASTM C869	Foaming Agents Used in Making Preformed Foam for Cellular Concrete
31.	ASTM C881	Epoxy-Resin-Base Bonding Systems for Concrete
32.	ASTM C920	Elastomeric Joint Sealants
33.	ASTM C989	Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
34.	ASTM C1064	Temperature of Freshly Mixed Hydraulic-Cement Concrete
35.	ASTM C1077	Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
36.	ASTM C1107	Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
37.	ASTM C1240	Use of Silica Fume as a Mineral Admixture in Hydraulic-Cement Concrete, Mortar, and Grout
38.	ASTM C1293	Determination of Length Change of Concrete Due to Alkali-Silica Reaction
39.	ASTM C1602	Mixing Water Used in the Production of Hydraulic Cement Concrete
40.	ASTM D882	Tensile Properties of Thin Plastic Sheeting
41.	ASTM D1056	Flexible Cellular Materials - Sponge or Expanded Rubber
42.	ASTM D1752	Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
43.	ASTM D2419	Sand Equivalent Value of Soils and Fine Aggregate
44.	ASTM E96	Water Vapor Transmission of Materials

C. California Building Code (CBC) 2019 Edition**.**

D. International Code Council (ICC)

1.03 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Product Data:

1. Concrete mix product certification: Submit certified laboratory test results that the mix proportions and materials comply with these Specifications.

a. Cementitious materials: types, manufacturing location, shipping locations, and certificates showing compliance with ASTM C150, C595, C618, C845, or C989.
b. Coarse and fine aggregates: types, pit or quarry locations, producers' names, gradations, specific gravities, and evidence not more than 90 days old demonstrating compliance with material requirements.
c. Admixtures: types, brand names, producers, manufacturer's technical data sheets, and certification data.
d. Water: source of supply.
e. Ready-mix plant certification or ASTM C94 certification documentation.
f. Mixture proportions and characteristics.
g. Mix test results (see Paragraph 2.05.F for required testing).
h. Description of conveying equipment.

C. Shop Drawings:
1. After defects are identified and investigation, Contractor to submit design of repair plan specific for each noted defect in accordance with Section 03935.

D. Samples: Submit any item of Product Data not fully assembled by a single manufacturer.

E. Quality Assurance/Control Submittals
1. Test Agency Reports: Submit records of test and inspection. Submit report results.
2. Submit advance notification of concrete placement at least 24 hours in advance.

1.04 QUALITY ASSURANCE

A. Contractor Qualifications: 10 years of experience on similar water containment facilities.

B. Construction Standard: Applicable quality requirements of the CBC, ACI 301, ACI 318 and ACI 350.

C. Concrete Products and Materials Tests: Certified by independent commercial testing laboratories. Submit certification on cementitious products and aggregates performed within the past 6 months. Furnish any necessary labor to assist in obtaining and handling samples at the project site or at the source of materials

D. Concrete Mix Designs: By an independent commercial testing laboratory or batching plant laboratory, complying with ASTM C1077 and favorably reviewed by the Engineer. Concrete mix design proportions shall be established on the basis of field experience and trial mixtures with the materials to be employed in accordance with ACI 318 Chapter 5.

E. Concrete Mix Test Results:
1. Submit in accordance with requirements of Paragraph 2.05.F.
2. Allow time for review of submittals, in accordance with the general conditions, and allow time for additional reviews to provide adjustments to comply with the Specifications.

F. Preconstruction Meeting:

1. Attend meeting with Owner and Engineer, bringing representatives of concrete supply, pumping, placement and finishing subcontractors plus testing laboratories.
2. Review preliminary concrete placing plans for walls and slabs, prior to plan submittals.
3. Meeting agenda includes:
    a. Mix design.
    b. Schedule of mix review.
    c. Formwork products.(Section 03100)
    d. Miscellaneous products.
    e. Construction joint layout (Section 03150).
    f. Concrete placement.
    g. Finishes required (03350).
    h. Curing and protection methods.
    i. Field Testing (03300-1.04-G).
    j. Test result distribution and review schedule.
    k. Testing of hydraulic structures (Section 03340).
    l. Other special inspection requirements.
    m. Hot weather concrete requirements.
    n. Cold weather concrete requirements.
    o. Resolve any difficulties foreseen by any interested party
    p. Other Issues

G. Concrete Tests, as Placed: Performed by the Owner's Representative:
1. Testing agencies that perform testing services on concrete materials shall meet the requirements of ASTM C1077.
2. Provide Owner's Representative with at least 48 hours notice in advance of operations to allow for completion of quality tests and for assignment of personnel.
3. Provide and maintain adequate facilities for safe storage and proper curing of concrete test specimens on the project site for initial curing as required by ASTM C31.
4. Test frequency:
    a. Obtain at least one composite sample for each 100 yd3, or a fraction thereof, of each concrete mixture placed in any one day.
5. Concrete samples: In accordance with ASTM C172. Provide all material required.
6. Compressive strength: A set of six standard 6-inch x 12-inch concrete cylinders shall be cast for each test set for concrete greater than 2,500 psi.
    a. Making, storing, initial cure, and final cure of cylinders: ASTM C31. Provide site storage and initial cure, 16 hours minimum and 24 hours maximum.
    b. Test of cylinders: ASTM C39. Testing laboratory will transport cylinders from site, cure, test, and provide report. Test two cylinders at age of 7 days, two at 28 days, and hold two for additional testing at 56 days, if required.
    c. Evaluation: Test results from standard molded and cured test cylinders shall be evaluated separately for each specified concrete mixture. For evaluation, each specified mixture shall be represented by at least five tests.
7. Slump: Test will be performed on each 50 cubic yards or fraction thereof. Test each sample used for strength tests.

a. Testing: ASTM C143.
b. Results outside the limits indicate possible cause for rejection of concrete at the sole discretion of the Engineer..

8. Air content: Test will be performed on concrete samples used for strength tests. Use calibrated equipment to perform the test.
   a. Testing: ASTM C231 or ASTM C173.
   b. Air content tests will be made on samples from the first three batches in the placement and until three consecutive batches have air contents within the range specified, at which time every fifth batch will be tested. This test frequency will be maintained until a batch is not within the range specified, at which time testing of each batch will be resumed until three consecutive batches have air contents within the range specified. Air content tests may be taken on composite samples or on samples from the batch at any time after discharge of 1/4 yd^3 of concrete.
9. Temperature
   a. Testing: ASTM C1064.
10. Testing Agency Reports:
    a. Include location in the work where the batch represented by test was deposited and the batch ticket number on strength test reports.
    b. Include detailed information of storage and curing of specimens before testing on strength test reports.
    c. Provide final reports within 7days of test completion.

H. Additional Tests:
1. General: Tests on hardened concrete will be performed when concrete test results as placed fail to satisfy the specification requirements. Testing will be performed by Owner's Testing Agency at Contractor's expense. Strength tests shall be considered satisfactory if the requirements of ACI 318 Section 5.6.3.3 are satisfied. If in the opinion of the Engineer, results of tests on concrete cylinders indicate the possibility of substandard concrete in the structure, cored samples may be required to be taken from the concrete
2. Nondestructive tests: The use of the rebound hammer, pulse-velocity method, or other nondestructive tests are permitted in evaluating
3. the uniformity or for selecting areas to be cored; however, only core tests will be permitted for verifying the concrete strength in place.
4. Core tests: Obtain cores in accordance with ASTM C42. Wipe cores surface-dry immediately after coring and allow to dry in air for a period not exceeding 1 hour after drilling. Seal cores in plastic bags or nonabsorbent containers until testing. At least three representative cores shall be taken from each member or area of concrete in place that is considered potentially deficient. Submit the location of cores for favorable review by Engineer before testing. Fill core holes with low-slump concrete or mortar of a strength equal to or greater than the original concrete. The Engineer will investigate low-strength test results in accordance with the requirements of ACI 318 Section 5.6.5; however, the requirements of Section 5.6.5.4 are not applicable.
5. Repair: Repair rejected concrete by removing and replacing or other acceptable repair methods as required by Engineer. To bring rejected concrete into compliance, use repair methods that meet specification requirements for strength, function, durability, dimensional tolerances, and appearance. Submit for acceptance the proposed repair methods, materials, and modifications. The Contractor is responsible to bring concrete into compliance with the requirements of the Contract Documents.

1.05 DELIVERY, STORAGE AND HANDLING

A. Cementitious Materials: Store cementitious materials in dry, weather-tight buildings, bins, or silos that will exclude contaminants. If required to be stored at the site, store immediately after delivery in a dry, weather-tight, properly ventilated structure, with adequate provisions for prevention of moisture absorption and overheating of the cement.

B. Aggregates: Store and handle aggregate in a manner that will avoid segregation and prevent contamination with other materials or other sizes of aggregates. Store aggregates to drain freely. Do not use aggregates that contain frozen lumps. If required at site, store in piles which afford good drainage and which are protected to prevent the inclusion of foreign material. Stockpile the various sizes or gradations of aggregates separately. Site stored aggregates shall be tested for moisture content on each day of batching operations.

C. Admixtures: Protect stored admixtures against contamination, evaporation, or damage. Provide agitating equipment for admixtures used in the form of suspensions or unstable solutions to ensure thorough distribution of the ingredients. Protect liquid admixtures from freezing and from temperature changes that would adversely affect their characteristics.

PART 2 - PRODUCTS

2.01 GENERAL

A. Qualify proposed materials and establish mixture proportions.

B. Obtain materials from an NCRMA certified manufacturer or supplier or one qualified through ASTM C94. Unless allowed otherwise, all materials shall be new..

2.02 CONCRETE MATERIALS

A. Cementitious Materials:
   1. General: Use cementitious materials that are of the same brand and type and from the same plant of manufacture as the cementitious materials used in the concrete represented by the submitted test records or used in the trial mixtures. The color shall not significantly alter the typical grey concrete color.
   2. Portland Cement: As indicated in mix proportion table in Paragraph 2.05.B below. Comply with the requirements for low alkali cement in ASTM C150 Table 2.
   3. Pozzolan: ASTM C618, Mineral Admixture Class N.
   4. Blended Cement: ASTM C595 Type 1P(MS).
   5. Fly ash: ASTM C618, Class F, with the following restrictions:
      a. Loss on Ignition: 4% maximum
      b. SO3 Content: 3% maximum
      c. Moisture Content: 1% maximum
   6. Ground Granulated Blast-Furnace Slag: ASTM C989.
   7. Silica Fume: ASTM C1240.

B. Concrete Aggregates:
   1. General: ASTM C33:

a. Aggregates used in concrete shall be obtained from the same sources and have the same size ranges as the aggregates used in the concrete represented by submitted historical data or used in trial mixtures.
b. Provide test results confirming conformance with applicable specifications not more than 90 days old. Test results for aggregate soundness, abrasion, and reactivity may be older than 90 days, but not older than 1 year, provided test results for the other properties specified in ASTM C33 indicate that the aggregate quality has not changed.
c. Provide free from organic materials, waste products, clay balls, shale, and mica and thoroughly washed before use.
d. Provide aggregate meeting the combined gradation requirements below as specified in Paragraph 2.05.B. For thin sections, such as slabs or walls 10 inches thick or less, or for sections that require special placement due to shape, form or congestion of reinforcing, provide 1-inch maximum size.
e. Nominal maximum size of coarse aggregate shall not exceed three-fourths of the minimum clear spacing between reinforcing bars, one-fifth of the narrowest dimension between sides of forms, and one-third of the thickness of slabs or toppings.
f. Provide aggregates that do not deleteriously react with the alkalies in the cement.
g. Grading: ASTM C136. Submit results of sieve analysis.
h. Reactivity: ASTM C289. Submit graphical data showing compliance.

2. Coarse Aggregates:
   a. Provide clean, hard, durable gravel, crushed gravel, crushed rock, or combinations.
   b. Deleterious substances: Submit compliance with ASTM C33, Table 3 and as follows:
      1) Clay lumps and friable particles: ASTM C142. Not more than 5%.
      2) Abrasion: ASTM C131. Not more than 45%.
      3) Soundness: ASTM C88. Not more than 10%.
      4) Cleanness: Caltrans Test 227: For three tests, not less than 70, with an average greater than 75. Max friable/clay materials in coarse aggregate at 2% for exposed architectural concrete, 3% for liquid retaining concrete structures, and 5% for all other structural concrete.
   c. Do not use aggregate containing more than 10% of inferior materials, including: flat or elongated particles, cracked or laminated rock, or rock than can be readily broken after immersion in water for one hour.
3. Fine Aggregate:
   a. Provide natural sand or a combination of natural and manufactured sand, of siliceous, granitic or igneous origin, hard and durable.
   b. Deleterious substances: Submit compliance with ASTM C33 Table 1 and as follows:
      1) Organic impurities: ASTM C40 and C87. Not less than 95% relative strength by ASTM C87.
      2) Sand equivalent: CALTRANS Test 217. For three tests not less than 70, with an average greater than 75.

C. Combined Aggregates: Provide a mixture of fine aggregate and coarse aggregate uniformly graded between the screen sizes specified below.

Sieve Size	Percentage Passing	
	1-1/2-Inch Gradation	1-inch Gradation
2"	100	--
1-1/2"	90-100	100
1"	50-96	90-100
3/4"	45-80	55-100
3/8"	38-55	45-75
No. 4	30-45	35-60
No. 8	23-38	27-45
No. 16	17-33	20-35
No. 30	10-22	12-25
No. 50	3-10	3-15
No. 100	0-3	0-5
No. 200	0-2	0-2

2.03 WATER

A. Mixing water for concrete and water used to make ice shall be potable water unless alternative sources of water complying with ASTM C1602 are available. Water for washing aggregates, for mixing concrete, for patching grout and for curing shall be free from oil and contain not more than 1,000 parts per million (ppm) of chlorides as Cl, nor more than 1,300 ppm of sulfates as SO_4. Do not allow impurities that will cause a change in the setting time of the Portland Cement of more than 25%, nor a reduction in the compressive strength of mortar at 14 days of more than 5%, when compared to the results obtained with distilled water.

B. Do not allow impurities that cause discoloration of the concrete or produce etching of the surface.

C. The Engineer may require tests of the water should there be a question of the quality. Costs of such tests would be borne by the Owner, unless the quality does not meet the requirements in Paragraph A above.

2.04 ADMIXTURES

A. Admixtures used in concrete shall be the same as those used in the concrete represented by submitted test records or used in trial mixtures.

B. Air Entraining: ASTM C260, MB AE 90 by BASF or equal. AEA-92 or 92S by Euclid.

C. Accelerating: ASTM C494, Type C or E: POZZOLITH® NC 534 by BASF. Accelguard 80 by Euclid. Or equal

D. Retarding: ASTM C494, Type D: Daratard 17 by Grace. Eucon Retarder 75 by Euclid. Or Equal.

E. Water Reducing: ASTM C494, Type A: WRDA 64 by Grace. Pozzolith 200N by BASF, Eucon WR-91 by Euclid or equal.

F. High Range Water Reducing: ASTM C494, Types F or G, second or third generation type. Add at the batch plant, after all other ingredients have been mixed and initial slump has been verified. ADVA 190 by Grace. Glenium 3030 NS by BASF, Eucon 1037 by Euclid or equal.

G. Shrinkage Reducing: ASTM C157.

H. Corrosion Inhibition and Permeability Reduction (Silica Fume): ASTM C1240.

I. Controlled Low Strength Material (CLSM) Admixture: ASTM C869. DaraFill by W.R.Grace, Rheocell by Master Builders, or equal.

J. When two or more admixtures are used, they must be added to the mix separately (through dispensers or manually) and must not be mixed with each other prior to adding to the concrete mix. Add admixtures to concrete mix ingredients in liquid form by a special dispensing unit, approved by the manufacturer of the admixture as suitable for accurately dispensing the admixture. Install an alarm or indicator, which will immediately inform the batch plant operator if the dispensing unit malfunctions. Dispense admixtures uniformly into the mixing water as it is added to the concrete batch.

K. When two or more admixtures are used, manufacturer shall certify that the admixtures are compatible with each other and will not detrimentally impact the performance of other admixtures.

L. Admixtures containing calcium chloride or any chloride ions are prohibhited.

M. Manufacturers: WR Grace & Co., Master Builders, Inc., or equal.

2.05 CONCRETE MIX DESIGN

A. General:
   1. Employ an independent commercial testing laboratory complying with ASTM C1077 and favorably reviewed by the Engineer to design all concrete mixes and carry out all necessary testing. Concrete mix design proportions shall be established on the basis of field experience and trial mixtures with the materials to be employed in accordance with ACI 318 Section 5.3.
   2. When the testing laboratory has mix designs meeting the specifications that are available from prior projects, submit material and mixture proportions with supporting test results and test record statistics to demonstrate compliance with the requirements of this Section and ACI 318 Section 5.3. Include calculations for f'cr based on source quality test records.
   3. If new mix designs are required, prepare a range of trial batches for each design and submit the mixes that demonstrate satisfactory test results in accordance with ACI 318 Section 5.3.
   4. Allow for the variability of concrete strength from test to test by increasing the required average compressive strength over the specified strength as specified in ACI 318 Section 5.3.
   5. From results of these tests, plot a curve showing the relationship between w/cm and compressive strength. From the curve of w/cm versus compressive strength,select the w/cm corresponding to the required average compressive strength fcr′.This is the maximum w/cm that shall be used to establish mixture proportions, unless a lower w/cm is specified in the mix proportions table below. Establish mixture proportions so that the maximum w/cm is not exceeded when slump is at the maximum specified.
   6. Design the mixes far enough ahead of concrete placement to allow completion of trial batch testing and submittal of the test results and mix design to the Engineer for review.
   7. Take sole responsibility for selection of laboratory, submittal of materials to laboratory in time for all tests, and overall timing of all aspects of testing program, including submittals.

8. Prepare mix designs for concrete placement by the batch process and/or by pumping, as required, and state the process on the design submittal.
9. Allow for the hot or cold weather and the time required to transport the concrete from the mixer to the site and to place within the forms. If accelerating or retarding admixtures will be required for only a proportion of the concrete placements, submit test results that include the full range of options.
10. Do not exceed the water-cementitious material ratios. Vary the water-reducing admixtures to accomplish an increase in slump or workability time.
11. Proportion cementitious materials, aggregates, and water by weight.
12. Check periodically the weight of moisture contained within the stockpiled aggregates. Compensate for this water when proportioning the concrete mix and adjust when change occurs. Frequency shall comply with ASTM C94.
13. Do not use chlorides in any concrete mix.
14. Submit any adjustments to mixture proportions or changes in materials, along with supporting documentation, made during the course of the work. If it is necessary to increase the cementitious materials content, submit a request for acceptance of the proposed revised mixture with higher cementitious materials content. Confirm the adequacy of modified proportions has been verified through the submittal of a set of new test data.
15. Resubmit mix design for review for each class of concrete when modification of the mix design is required by ACI 350 or 318 Chapter 5.3. If a class of concrete requires modification based on low strength tests, contractor shall discontinue use of mix design until corrective action can be taken, and a revised mix design is favorably reviewed.

B. Mix Proportions:

	Concrete Type		
Mix Design Requirements	B*	C	E
Specified 28-Day Compressive Strength (lb/in2)	4,500	4,000	2,500
Combined Aggregate Gradation (in)	1-1/2	1	1
Air Content at Point of Placement (%)	5-1/2	1	1
Maximum Water-Cementitious Material Ratio	0.42	0.50	0.55
Minimum Cementitious Material Content (lb/yd3)	590	570	510
Maximum 28-Day Drying Shrinkage (%) – Mix Test	0.05	--	--
Maximum 28-Day Drying Shrinkage (%) – Field Test	0.065	--	--
Cement Type	V OR **II**	II	II
Unit Weight (lb/ft3)	--	--	--
NSF 61 Certification Required	Y	N	N

*See Paragraph 2.05.E for additional requirements for Mix Type B

C. Cementitious Material: Either Portland Cement, cement with fly ash, cement with natural Pozzolan, blended cement, or cement with slag.

D. Pozzolan, Slag or Fly ash: Optional. Not less than 15%, nor more than 25% of the weight of the cementitious materials. Do not use pozzolan or fly ash as an admixture in concrete made with Portland-Pozzolan cement.

E. Modified Mix Design: Provide a modified mix design of the concrete type indicated in the table above for horizontal concrete joints, as specified in Section 03100, for environmental structures consisting of the designated concrete mix with one-half of the coarse aggregate removed. The remaining constituents shall be adjusted proportionally in the modified mix design to complete the cubic yard. Modified Mix shall meet all other requirements noted for the base mix in Paragraph 2.05.B.

F. Mix Test Requirements:
   1. Testing agencies that perform testing services on concrete materials shall meet the requirements of ASTM C1077.
   2. Compression: ASTM C192 for cylinder preparation. ASTM C39 for cylinder tests. Submit 7-day and 28-day curing test results in accordance with Paragraph A above.
   3. Slump: ASTM C143. Slump range is 3 to 4 inches at point of delivery. Slump tolerances in accordance with ACI 117. When utilizing a Type I or II plasticizing admixture or a Type F or G high-range water-reducing admixture, proportion to a slump of 2 to 3 inches before the admixture is added and a maximum slump of 8 inches at the point of delivery after the admixture is added.
   4. Air Content: ASTM C231 or ASTM C173. Air content tolerance is ±1 ½%.
   5. After favorable review of the mix design, no variations of the constituents are permitted during the project without prior submittal and favorable review.
   6. Provide and pay for additional testing and inspection required because of changes in materials or mixture proportions.

2.06 READY-MIX CONCRETE

A. Supply concrete for the project using one of the following methods:
   1. Supply concrete using truck mixers and a ready-mix plant certified by the National Ready-Mix Concrete Association..
   2. Qualify the supplier according to ASTM C94 Sections 8 through 11, inclusive.

2.07 CEMENT REPAIR MORTAR

A. For repairs and patching concrete as noted in Section 03935.

B. Mix repair mortar using the same materials as concrete to be patched with no coarse aggregate. Do not use more than one part portland-cement to two parts sand by damp loose volume.

C. For repairs in exposed concrete, make trial batches and check color compatibility of repair material with surrounding concrete. Prepare several trial batches and make test samples in an inconspicuous location for review. When the repair is too dark, substitute white portland cement for a part of the gray cement to produce a color and texture closely matching the surrounding concrete.

D. Use a repair mortar at a stiff consistency with no more mixing water than is necessary for handling and placing. Mix the repair mortar and turn the mortar frequently with a trowel without adding water. Use mortar at a stiff consistency.

2.08 SOURCE QUALITY CONTROL

A. Concrete:
   1. Maintain records verifying materials used are of the specified and accepted types and sizes and are in conformance with the material requirements.
   2. Provide ready-mix batch plant delivery tickets contain all product information necessary for acceptance of the concrete delivered to site.
   3. Document and record that the mixing and trucking equipment have adequate capacity to deliver the concrete batches to site on time, thoroughly mixed and discharge without segregation.
   4. Submit new data from new trial mixtures for acceptance before use in concrete when brand, type, size, or source of cementitious materials, aggregates, water, ice, or admixtures are proposed to be changed.

PART 3 - EXECUTION

3.01 PROPORTIONING CONCRETE MATERIALS

A. Do not place concrete prior to favorable review of submittals for reinforcing steel, materials specified in this Section and the mix proposed. Unfavorable results of actual placements may require a redesign of mixes in addition to corrective work related to any defects.

B. Do not make substitutions to the constituents tested in the design of concrete mixes without favorable review of the revised mix and the new test results.

3.02 MEASURING, BATCHING AND MIXING CONCRETE MATERIALS

A. General:
   1. Measure, batch, mix, transport and deliver concrete materials and concrete in conformance with ASTM C94. If packaged dry-combined materials are used, they shall conform to the requirements of ASTM C387.
   2. Deliver completely mixed to the project site.
   3. When concrete arrives at the point of delivery with a slump below that which will result in the specified slump at the point of placement and is unsuitable for placing at that slump, the slump may be adjusted to the required value by adding water up to the amount allowed in the favorably reviewed mixture proportions. Addition of water shall be in accordance with ASTM C94. Do not exceed the specified water-cementitious material ratio (w/cm) or slump. Do not add water to concrete delivered in equipment not acceptable for mixing. After plasticizing or high-range water-reducing admixtures are added to the concrete at the site to achieve flowable concrete, do not add water to the concrete. Measure slump and air content of air-entrained concrete after slump adjustment to verify compliance with specified requirements. Do not add water unless approved by the Engineer. Do not add mixing water during hauling. Add water after delivery and only from the “hold-out” volume indicated on the mix ticket. Should water be added, revolve the mixing drum not less than 30 revolutions at mixing speed after adding and before commencing discharge.

4. Deliver each load at the job site accompanied by a ticket showing mix design number, volume of concrete, the weight of cement in pounds and the total weight of each ingredient in pounds. Also show the time at which the materials were batched and the reading of the revolution counter at the time the truck mixer was charged.
5. No retempering of partially hardened material is permitted. Do not use partially hardened concrete in the work.

B. Batching in Adverse Weather:
1. Cold Weather: In accordance with Section 03306.
2. Hot Weather: In accordance with Section 03305.

3.03 FORMWORK AND FORMWORK ACCESSORIES

A. In accordance with Section 03100.

3.04 PLACING CONCRETE AND GROUT

A. Preliminary Work:
1. Remove hardened concrete and foreign materials from the inner surface of the mixing and conveying equipment. Remove all debris from the space to be occupied by the concrete.
2. Remove water from the space to be occupied by the concrete before concrete is deposited. Divert any flow of water into an excavation through proper site drainage to a sump, or by other methods. If required by the Engineer, grout up any water vent pipes and drains after the concrete has thoroughly hardened.
3. Remove snow, ice, frost, and other foreign materials from surfaces, including reinforcement and embedded items, against which concrete will be placed.
4. Provide satisfactory redundancy in the delivery system so that work can continue in the event of a breakdown.
5. Rapidly convey concrete from mixer to final deposition by methods that prevent segregation or loss of constituents and ensure the required concrete quality.
6. Do not use aluminum materials in pumping lines, transfer hoppers or chutes . Provide conveyor belts instead of chutes when the distance is longer than 50 feet. Use a storage hopper at the start of the line.
7. For pumped concrete, provide a hose with an angle-change, to create a back-pressure at the outlet.
8. Provide illumination if necessary inside the forms, so that the placed concrete will be visible from the deck at top of formwork.
9. Before placing a concrete slab-on-grade, clean foreign materials from the subgrade and provide subgrade soils satisfying the following requirements:
   a. Well drained and of uniform loadbearing nature.
   b. Uniform in-place density throughout the area and at least the minimum required in Contract Documents.
   c. Free from frost or ice.
   d. Moist with no free water and no muddy or soft spots.

B. Embedded Items:
1. Place equipment, bolts, anchors, sleeves, inserts, structural steel members, angles and similar items which require embedment in the concrete.
2. Position and secure in place expansion joint materials, anchors, waterstops, and other embedded items.

3. Hot-dip galvanize ferrous metal sleeves, inserts, anchors, and other embedded ferrous items unless shown otherwise. Set anchor bolts for equipment in templates, carefully plumbed and checked for location and elevation with an instrument, and held in position rigidly by double-nutting to the template to prevent displacement while concrete is being placed.
4. Ensure that aluminum items inserted in the concrete are isolated by a bituminous or asphaltic coating in accordance with Section 05500.
5. Notify engineer where modifications are neccesary to avoid interference with reinforcing steel or embedded items.
6. Inspect the installation of embedded items and reinforcing.
7. Unless noted otherwise on the Drawings do not embed conduit or pipe in concrete.

C. Placing:
1. Place reinforcement in accordance with the requirements of Section 03200.
2. Do not begin to place concrete while rain, sleet, or snow is falling unless adequate protection is provided and acceptance of protection is obtained. Do not allow rain water to increase mixing water or to damage the surface of the concrete.
3. Use metal or metal-lined chutes having rounded bottoms, and sloped between one vertical section to two horizontal sections and one vertical to three horizontal sections of chute. Chutes longer than 20 ft and chutes not meeting slope requirements may be used provided the discharge is into a hopper before distributing into the forms.
4. Use pumping equipment that has sufficient capacity so that:
   a. Initial setting of previously placed concrete does not occur before subsequent placement.
   b. Discharge of pumped concrete does not result in segregation.
   c. Modification of accepted concrete mixture is not required.
5. Place concrete without separation or loss of ingredients and without displacement of the reinforcement.
6. Do not place concrete that contains foreign material.
7. Do not deposit partially hardened concrete in the work.
8. Do not subject concrete to procedures that will cause segregation.
9. Deposit concrete continuously and as near as practicable to the final position.
10. Deposit concrete in one layer or in multiple layers. Do not deposit fresh concrete on concrete that has hardened sufficiently to cause formation of cold joints. Maintain, until the completion of the placement, a plastic concrete surface, approximately horizontal.
11. Do not place concrete over columns or walls until concrete in columns and walls has reached final set. Place concrete for beams, girders, brackets, column capitals, haunches, and drop panels at the same time as the concrete for adjacent slabs.
12. Maximum height of free fall for concrete during placement:
    a. Concrete with maximum 4-inch slump: 4 feet
    b. Concrete with high-range water reducing admixture and minimum 6-inch, maximum 9-inch slump: 8 feet
13. Place concrete continuously or in layers 12 to 20 inches in depth so that no concrete will be placed on concrete that has hardened sufficiently to cause the formation of seams or planes of weakness within the section. If a section cannot be placed continuously as originally planned, locate construction joints during the placement.

14. Provide a dense, impervious, homogeneous concrete, free from voids or pockets. If honeycomb, air, or rock pockets occur, repair the structure in accordance with Section 03935, and modify the placing method or mix design, to prevent recurrence of deficient concrete. Provide such repairs and modifications at no additional cost. Honeycomb or large defects may be cause for rejection of the work.
15. When underwater placement is required, place concrete by an acceptable method. Deposit fresh concrete so that concrete enters the mass of previously placed concrete from within, displacing water with minimum disturbance of the concrete surface

D. Time Limit: Place all concrete in its final position in slab or forms within 1-1/2 hours of batching or before the drum has revolved 300 revolutions, whichever comes first in accordance with ASTM C94. Alternatively, as part of the mix design, provide admixtures that delay the initial set and state the proposed length of time in the submittal.

E. Temperature Limits: Place all concrete in its final position in slab or forms at:
1. Less than 90°F, measured in the mix.
2. When the average of the highest and lowest ambient air temperature during the period from midnight to midnight is expected to drop below 40°F for more than three successive days, deliver concrete to meet the following minimum temperatures immediately after placement:
   a. 55°F for sections less than 12 inches in the least dimension
   b. 50°F for sections 12 to 36 inches in the least dimension
   c. 45°F for sections 36 to 72 inches in the least dimension
   d. 40°F for sections greater than 72 inches in the least dimension
3. The temperature of concrete as placed shall not exceed these values by more than 20°F. These minimum requirements may be terminated when temperatures above 50°F occur during more than half of any 24-hour duration.
4. Temperature measurements above refer to on-site measurements. Refer to the vibration, concrete joints and curing sections for other requirements.
5. When the temperatures are outside these ranges, place concrete in accordance with Section 03305 and 03306.

F. Precast Items:
1. Supply and design vaults and manholes in accordance with the Division 2 sections for these items. Comply with additional requirements below.
2. Items may be cast on or off the site.
3. Apply all applicable portions of Section 03300, 03100, 03150, 03330, and 03350, including materials, forms, placement, finish and curing.
4. Take particular care when handling and placing the precast items. Lift or move after a minimum of 90% of the specified compressive strength has been attained. Use the average compressive strength of two test cylinders.

3.05 CONSOLIDATING

A. Consolidate concrete by vibration. Consolidate concrete around reinforcement and embedded items into corners of forms to eliminate honeycombing or planes of weakness due to air voids and stone pockets.

B. Use the largest and most powerful internal vibrators to consolidate the concrete. Workers shall be experienced in the use of vibrators. Do not use vibrators to move concrete within the forms. Spacing of immersion vibrator insertions shall not

exceed 1-1/2 times the vibrator's radius of action in the concrete being consolidated.

C. Furnish sufficient vibrators to complete the compaction as specified without causing delay in the depositing of concrete. Provide a minimum of 2 vibrators, and at least one unit in addition to those planned for active use.

D. Operate vibrators with vibratory element submerged in the concrete, with frequency between 8,000 and 12,000 impulses per minute when submerged.

E. Compact the concrete with high frequency, internal mechanical vibrating equipment, and when required, supplement by hand spading and tamping. Consolidate slabs 6 inches or less in depth by hand tampers, spreading and settling with a heavy leveling straightedge.

F. Vibrate by direct action in the concrete for approximately 10 seconds at approximately 12-inch intervals, not against forms or reinforcements. Vibrate the concrete around the reinforcement, and around embedded fixtures and into the corners of the forms. Penetrate 6 to 12 inches into previously placed layers as new layers are placed, provided the running vibrator penetrates by its own weight. To secure even and dense surfaces, free from aggregate pockets, honeycomb, or air pockets, supplement vibration when required by forking or spading by hand or hammering the forms lightly opposite the freshly placed concrete. Revibrate the final layer. Stop vibrating when concrete is thoroughly compacted and has ceased to decrease in volume and give off air bubbles.

G. When placing concrete with 8-inch or more slumps, reduce the time of vibration to 5 seconds and follow the admixture manufacturer's recommendations for technique.

H. Use immersion-type vibrators with nonmetallic heads when consolidating concrete around epoxy-coated reinforcement.

3.10 FIELD QUALITY CONTROL

A. Site Tests:
   1. Testing agencies that perform testing services on concrete materials shall meet the requirements of ASTM C1077.
   2. Testing Agency Reports:
      a. Include location in the work where the batch represented by test was deposited and the batch ticket number on strength test reports.
      b. Include detailed information of storage and curing of specimens before testing on strength test reports.
      c. Provide final reports within 7days of test completion.
   3. Furnish any necessary labor to assist in obtaining and handling samples at the project site or at the source of materials.

B. Inspection:
   1. Inspect concrete batching, mixing, and delivery operations.
   2. Inspect forms; foundation preparation; reinforcement; embedded items; reinforcement placing; and concrete placing, finishing, and curing operations.
   3. Concrete not within the specified limits of air entrainment, slump, and temperature shall not be used in the work.

3.11 PROTECTION OF IN-PLACE CONCRETE

A. Loading and support of concrete: Do not allow construction loads to exceed the superimposed load that the structural member, with necessary supplemental support, is capable of carrying safely and without damage.

B. Protection from mechanical injury: During the curing period, protect concrete from damaging mechanical disturbances including load stresses, shock, and harmful vibration. Protect concrete surfaces from damage by construction traffic, equipment, materials, rain or running water, and other adverse weather conditions.

END OF SECTION

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SECTION 03305

HOT WEATHER CONCRETING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Procedures for concrete to be placed, protected, and cured in hot weather.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. ACI 301 Specifications for Structural Concrete for Buildings
   2. ACI 305 Guide to Hot Weather Concreting
   3. ACI 318 Building Code Requirements for Structural Concrete
   4. ACI 350 Environmental Engineering Concrete Structures

B. ASTM International (ASTM) Standard Specification or Test Method:
   1. ASTM C31 Standard Method of Making and Curing Test Specimens in the Field
   2. ASTM C39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
   3. ASTM C156 Standard Test Method for Water Retention by Concrete Curing Materials
   4. ASTM C171 Standard Specification for Sheet Materials for Curing Concrete
   5. ASTM C309 Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
   6. ASTM C1064 Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete

C. California Building Code (CBC) 2019 Edition**.**

1.03 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Shop Drawings:
   1. Program and method of production, transportation, placement, protection, materials, curing and temperature monitoring of concrete during hot weather.

C. Quality Assurance:
   1. Site Condition Logs: Submit a copy of the ambient temperature, concrete temperature, relative humidity, wind velocity logs and evaporation rate. See FIELD QUALITY CONTROL.

1.04 QUALITY ASSURANCE

A. Contractor Qualifications: 10 years of experience on similar water containment facilities.

B. Construction Standard: Applicable requirements of the CBC, ACI 301, ACI 305, ACI 318 and ACI 350.

1.05 DELIVERY, STORAGE AND HANDLING

A. During periods of hot weather materials and equipment required for extended protection of concrete shall be available at the project site before hot weather concreting begins.

1.06 DEFINITIONS

A. Hot Weather: Job-site conditions that accelerate the rate of moisture loss or rate of cement hydration of freshly mixed concrete. These conditions include ambient temperatures above 80°F or any combination of ambient temperature, concrete temperature, low humidity and wind that combine to produce an evaporation rate that exceeds 0.2 lb/ft^2/h.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.01 PREPARATION BEFORE PLACEMENT

A. Surfaces in contact with concrete shall be within 10°F degrees of the temperature of freshly placed concrete.

B. Surfaces in contact with freshly placed concrete shall be saturated surface dry (SSD).

C. Do not place concrete against surfaces of dry absorbent materials, soil, or subgrade.

D. Do not place concrete against surfaces that have standing water.

3.02 BATCHING AND MIXING

A. Reduce the temperature of the concrete mix by using some combination of iced mixing water, refrigerated mixing water, liquid nitrogen cooled mixing water, water-spray cooled coarse aggregate, or air cooled coarse aggregate.

B. If water cooled aggregate is used to reduce mix temperature the amount of water shall be offset in the batching of the mix so as not to exceed the maximum specified water-cement ratio.

3.03 PLACING, CURING AND PROTECTION

A. Placing:
   1. Temperature of freshly placed concrete shall not exceed 80°F as measured by ASTM C1064.
   2. Should the provisions noted above not be possible or practicable, postpone the batching until favorable weather conditions prevail, consider scheduling placement at other than normal hours.
   3. Do not place concrete that has resulted in loss of slump, flash set, or cold joints due to temperature of concrete. When temperature of steel reinforcement, embedments, or forms is greater than 120°F, fog steel

reinforcement, embedments, and forms with water immediately before placing concrete. Remove standing water before placing concrete.

B. Curing:
   1. General: Refer to Specification Section 03330.
   2. Temperature of concrete shall not exceed 90°F during the specified curing period.
   3. Use water for moist curing that is no more than 20°F cooler than the temperature of the concrete.

C. Protection:
   1. Protect the concrete against thermal shrinkage cracks caused by temperature drops greater than 40°F during the first 24 hours after placement. Means of protection may include insulating blankets, batt insulation with moisture-proof covering, or multiple layers of impervious paper meeting ASTM C171.
   2. Provide shade to concrete surfaces exposed to direct sunlight during the specified wet curing period.
   3. Liquid curing compounds approved for use after the initial wet curing period shall contain white, heat-rejecting, UV-inhibiting pigment meeting the moisture retention requirements of ASTM C309. Liquid curing compounds shall limit moisture loss in a 72-hour period to 9 lb/yd^3 when tested per ASTM C156.

3.04 REMOVAL OF FORMS

A. General: Refer to Specification Section 03100.

B. For systems requiring a specified level of strength before forms and shoring can be removed, such as suspended slabs, girders, and beams, compressive strength shall be verified by additional field cured cylinders, see FIELD QUALITY CONTROL.

3.05 CONCRETE FINISHES

A. General: Refer to Section 03350.

B. Apply an evaporation retarder during the finishing operation following the manufacturer's recommendation.

3.06 FIELD QUALITY CONTROL

A. Protection and Monitoring:
   1. Monitor site conditions (air temperature, humidity, wind speed, evaporation rate) beginning no later than 1 hour before the start of concrete placement.
   2. Calculate the concrete evaporation rate in accordance with ACI 305 to assess the need for evaporation control measures.
   3. Continue monitoring at intervals of 30 minutes or less until specified curing procedures have been applied.
   4. Continue monitoring at two hour intervals during the specified curing period.
   5. Instruments for measuring field conditions shall be certified by the manufacturer to be accurate within 2°F, 5% relative humidity, and 1 mph.
   6. Monitor the temperature of protected concrete to evaluate the effectiveness of the protection and to ensure excessive heating does not occur.
   7. Temperature measuring devices embedded 2 inches below the face are ideal but surface measurements provide satisfactory results.

8. Record the temperature of the concrete at multiple locations, the daily maximum and minimum concrete temperature, location where temperature was taken, ambient temperature, relative humidity, wind speed, weather conditions, and other special conditions.
9. Submit a copy of the concrete temperature logs and evaporation rates to the Engineer for inclusion in the construction management records.

B. Additional Compressive Strength Testing:
1. During concrete placement in systems requiring a specified level of strength before shoring can be removed (i.e. suspended slabs, girders and beams), cast four (4) additional 6-inch diameter by 12-inch cylinders to be cured under field conditions in accordance with ASTM C31.
2. Test two (2) cylinders for compressive strength, in accordance with ASTM C39, at 28 days. Hold two (2) cylinders as back-ups.

END OF SECTION

SECTION 03306

COLD WEATHER CONCRETING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Concrete to be placed, protected, and cured in cold weather.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. ACI 301 Specifications for Structural Concrete for Buildings
   2. ACI 306 Guide to Cold Weather Concreting
   3. ACI 318 Building Code Requirements for Structural Concrete
   4. ACI 350 Environmental Engineering Concrete Structures

B. ASTM International (ASTM) Standard Specification or Test Method:
   1. ASTM C31 Standard Method of Making and Curing Test Specimens in the Field
   2. ASTM C39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
   3. ASTM C150 Standard Specification for Portland Cement

C. California Building Code (CBC) 2019 Edition**.**

1.03 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Product Data:
   1. Material proposed for use as insulation during protection period.

C. Shop Drawings:
   1. Program and method of production, transportation, placement, protection, curing and temperature monitoring of concrete during cold weather. Include in submittal the procedures to be implemented upon adverse changes in weather or equipment failure.

D. Quality Assurance:
   1. Submit a copy of the concrete temperature logs to the Engineer for inclusion in the permanent construction management records. See FIELD QUALITY CONTROL.

1.04 QUALITY ASSURANCE

A. Construction Standard: Applicable requirements of the IBC, ACI 301, ACI 306, ACI 318 and ACI 350.

1.05 DELIVERY, STORAGE AND HANDLING

A. During periods of cold weather all materials and equipment required for extended protection of concrete shall be available at the project site before cold weather concreting begins.

1.06 DEFINITIONS

A. Cold Weather: Cold weather is considered to exist when the temperature has fallen below, or is expected to fall below, 40°F during placement and curing.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.01 PREPARATION BEFORE PLACEMENT

A. Remove snow, ice, and frost from surfaces to be in contact with concrete. Remove any standing water created by the removal of snow and ice. Recompact subgrade disturbed by removal of snow, ice and frost.

B. Subgrade shall not be frozen.

C. Formwork, reinforcing, subgrade and embedded items shall be above 32°F.

D. Surfaces in contact with concrete shall be within 10°F of the temperature of freshly placed concrete.

E. Do not attempt to heat reinforcing, formwork, subgrade, or embedded metal items with a blow torch or by water spray.

3.02 BATCHING AND MIXING

A. Heat the materials before mixing, so that the temperature of the mix at the batch plant shall be between 65° and 80°F. Do not heat the mixing water or the cement over 180°F unless it can be reliably demonstrated that flash set is not a problem. Remove lumps of frozen material and ice from the aggregates before they are placed in the mixer.

B. Should the provisions noted above not be possible or practicable, postpone the batching until favorable weather conditions prevail.

3.03 PLACING, CURING AND PROTECTION

A. Provide adequate shelter and equipment for heating the placed concrete during cold weather:
   1. Maintain freshly placed concrete at the temperature listed in column 2 of Table 3.03-A for the specified protection period.

1	2	3
Least dimension of section, inches	Minimum temperature of concrete as placed and maintained during protection period, °F	Maximum temperature drop (ΔT) per 24 h period after end of protection, °F
Less than 12	55	50
12 to less than 36	50	40
Greater than 36	45	30

2. Concrete placement temperature shall not exceed the temperatures in column 2 of Table 3.03-A by more than 20°F.
3. Keep the housing, covering, or other protection in place and intact at least 24 hours after the artificial heating is discontinued to allow for a gradual decrease in temperature. The maximum decrease in temperature in a 24 hour period shall not exceed the values shown in column 3 of Table 3.03-A. Do not exceed these limits until the concrete is within 20°F of the ambient temperature.
4. Do not use manure, salt, calcium chloride, or other chemicals on the concrete surface to prevent freezing.

B. Protection period
1. Keep cold weather protection in place and maintain concrete within the temperature limits specified in Paragraph A for a minimum of:

a.	Footings, foundations, piers	2 days
b.	Slabs on grade, below grade walls	3 days
c.	Above grade walls	6 days
d.	Suspended slabs, girders, beams	Full design compressive strength to be verified by additional field cured cylinders, see FIELD QUALITY CONTROL.

2. Increase the protection period if the temperature requirements were not met during the specified protection period in accordance with ACI 305.
3. During periods <u>not</u> defined as cold weather all freshly placed concrete surfaces shall be protected from unexpected freezing for at least the first 24 hours after placement.

C. Heating
1. Vent flue gasses to the outside of the enclosure if combustion heaters are used.
2. Place and direct heaters and ducts to prevent overheating and drying of the concrete surface
3. For the duration of the protection period, do not expose concrete to air temperatures 20°F greater than those listed in column 2 of the table above.

3.04 REMOVAL OF FORMS

A. Forms shall remain in place for the full protection period.

B. Engineer may increase the time for form removal in conjunction with the protection period if the specified temperature and temperature monitoring requirements were not met during the protection period.

3.05 CONCRETE FINISHES

A. Refer to Specification Section 03350.

3.06 FIELD QUALITY CONTROL

A. Protection and Monitoring:
1. Verify procedures have been submitted and equipment is available for controlling concrete temperature during cold weather conditions.
2. Verify actual time of application of protection measures for each placement.

3. Monitor the temperature of protected concrete to evaluate the effectiveness of the protection and to ensure excessive heating does not occur.
4. Temperature measuring devices embedded 2 inches below the face are ideal but surface measurements provide satisfactory results.
5. Record at least twice a day, for the specified period of protection, the temperature of the concrete at multiple locations including both interior and edges with priority given to corners, the daily maximum and minimum concrete temperature, location where temperature was taken, air temperature, weather conditions, and other special conditions.
6. Submit a copy of the temperature logs to the Engineer for inclusion in the construction management records.

B. Additional Compressive Strength Testing:
1. During concrete placement in systems requiring a specified level of strength before shoring can be removed (i.e. suspended slabs, girders and beams), cast a set of four (4) additional 6-inch diameter by 12-inch cylinders to be cured under field conditions in accordance with ASTM C31.
2. Test two (2) cylinders for compressive strength, in accordance with ASTM C39, at 28 days. Hold two (2) cylinders as back-ups.

END OF SECTION

SECTION 03330

CONCRETE CURING AND PROTECTION

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Curing compounds, materials, methods and program.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. ACI 301 Specifications for Structural Concrete for Buildings
   2. ACI 306 Guide to Cold Weather Concreting
   3. ACI 318 Building Code Requirements for Structural Concrete
   4. ACI 350 Environmental Engineering Concrete Structures

B. ASTM International (ASTM) Standard Specification or Test Method:
   1. ASTM C156 Water Retention by Concrete Curing Materials
   2. ASTM C171 Sheet Materials for Curing Concrete
   3. ASTM C309 Liquid Membrane Forming Compounds for Curing Concrete
   4. ASTM C1315 Liquid Membrane Forming Compounds Having Special Properties for Curing and Sealing Concrete
   5. ASTM D471 Standard Test Method for Rubber Property-Effect of Liquids
   6. ASTM D1056 Flexible Cellular Materials - Sponge or Expanded Rubber
   7. ASTM E96 Water Vapor Transmission of Materials

C. International Building Code (IBC) 2012 Edition and California Building Code (CBC) 2013 Edition**.**

D. International Code Council (ICC)

1.03 DEFINITIONS

A. Water Containment Structure(s): A reservoir, basin, tank, channel, sump, or conduit to be tightness tested regardless of whether it has a closed or open top or is constructed partially or entirely of concrete.

1.04 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Product Data:
   1. Curing program, including method selected, materials proposed for use and timing of water and product application, demonstrating compliance with requirements herein.
   2. Curing products: Submit technical data including installation instructions, independent laboratory test reports (ICC), handling and storage instructions.
      a. Curing materials, including sheet materials and wet blankets if applicable
      b. Liquid applied curing compounds
      c. Evaporation Retardant

C. Samples: Submit any item of Product Data not fully assembled by a single manufacturer.

1.05 QUALITY ASSURANCE

A. Contractor Qualifications: See Section 03300.

B. Construction Standard: Applicable requirements of the CBC, ACI 301, ACI 318 and ACI 350.

C. Preconstruction Meeting: See Section 03300.

1.06 DELIVERY, STORAGE AND HANDLING

A. Store liquid curing compounds in accordance with the manufacturer's recommendations and do not allow to freeze.

B. Store and handle products to retain original quality. Do not use products stored beyond the manufacturer's recommended shelf life.

PART 2 - PRODUCTS

2.01 GENERAL

A. Obtain materials from an established and experienced manufacturer or supplier. Provide new materials of first-class ingredients guaranteed to perform the service required.

2.02 CURING MATERIALS

A. Cure by fog spray, or by one of the following methods after discontinuance of the fog spray. Slabs shall be continuously wet cured with sheet materials or wet blankets after discontinuance of the fog spray; liquid curing compound alone is insufficient.

B. Liquid Curing Compound: A water-based membrane-forming resin suitable for exterior or interior use as a curing and hardening compound on freshly placed concrete.
   1. Provide an emulsion of synthetic resinous solids dispersed in water containing no waxes, paraffins or oils. Provide the fugitive type that will oxidize and disintegrate completely within 60 days when exposed to sunlight in exterior applications or that can be removed by washing with dilute muriatic acid or TSP in interior applications.
   2. Water retention requirements: ASTM C309, Type I or II, Class B, when tested in accordance with ASTM C156.
   3. Use white pigmented material for exterior applications (exposed to sunlight when applied or within 30 days thereafter) and clear material for interior applications.
   4. Comply with the applicable local air quality district.
   5. Exterior surfaces: Aqua Resin Cure-White by Dayton-Superior; 1200-White by W.R. Meadows; or equal.
   6. Interior surfaces: Spartan-Cote by Dayton-Superior; Vocomp 20 by W.R. Meadows; or equal.
   7. Exterior surfaces are surfaces exposed to sunlight during the curing process, which includes portions of structures which will be interior surfaces upon completion of the structure, but do not have shade or sunlight protection during the curing process.

C. Sheet Materials: ASTM C171. Waterproof paper, plastic sheeting or white burlap-polyethylene sheet.
   1. Plastic sheeting: fungus-resistant, minimum 4-mil thick, clear and free of defects, having ASTM E96 perm rating of not more than 0.5.
   2. Waterproof paper: Two layers of non-staining kraft paper laminated with latex adhesive and reinforced with glass in both directions. Seal joints with 2-inch-wide tape with water-resistant adhesive.

D. Wet Blankets: Clean cotton mats (burlap, except for white burlap-polyethylene sheeting noted above, is unacceptable). Provide material free from any substance that will have a deleterious effect on the concrete. Use a thickness sufficient to retain moisture between programmed applications of water.

E. Evaporation Retardant: Eucobar by the Euclid Chemical Company; E-CON by L&M Construction Chemicals, Inc.; or equal.

PART 3 - EXECUTION

3.01 CURING AND PROTECTION

A. General:
   1. Maintain concrete above 50°F and below 90°F in a moist condition and without external loadings for 14 days after placement.
   2. Allow building material storage only after conclusion of cure time and only on plywood sheets and wood sleepers that spread the load and protect the finish.
   3. When high evaporative conditions necessitate protection of concrete immediately after placing or finishing, make provisions in advance of concrete placement for wind-breaks, shading, fogging, sprinkling, ponding, or wet covering.

B. Wet Cure:
   1. Initial moist cure: Provide a 36-hour uniform spray treatment immediately following final troweling and before the surface can dry out, but after bleeding has stopped. Use clean water and special fog spray nozzles of type and number required to keep entire surface moist. Keep all traffic off floors.
   2. Continued cure: After 36 hours for the balance of the 14 days, continue fog curing, or, before the surface dries out, continue curing by utilizing Sheet Membrane Cure (sheet materials or wet blankets) in order to keep the surface continuously wet. Place waterproof curing paper or polyethylene plastic sheeting as described below.
   3. Final cure: After 14 days, perform Liquid Membrane Cure, if favorably reviewed for this purpose, while slab is still damp as described below.

C. Sheet Material Cure:
   1. Cover entire surface with sheet material for 14 days.
   2. Place and secure sheet as soon as initial concrete set occurs.
   3. Place smoothly upon the moist concrete surface with all joints and edges lapped a minimum of 4 inches and continuously sealed with tape.
   4. Securely anchor sheeting to prevent wind and air from lifting the sheeting or entrapping air under the sheet.
   5. Repair, replace and reseal, torn or scuffed sheets.
   6. Do not use paper that will leave an impression on the finish.

D. Liquid Membrane Cure:
   1. Apply the compound in accordance with manufacturer's recommendation and as noted below as soon as water sheen has disappeared from the concrete surface and after finishing operations.
   2. Apply over the entire concrete surface.
   3. Agitate compound thoroughly by mechanical means during use and apply uniformly in a two coat continuous operation by appropriate power-spraying equipment.
   4. Use an application rate of not less than 1 gal. per 150 ft^2.
   5. Apply curing compound in two applications at right angles to each other.
   6. The material applied in each coat shall not be less than 1 gal. per 150 ft^2 of area.
   7. Form a uniform, continuous, coherent film that will not check, crack, or peel and free from pinholes or other imperfections. Apply an additional coat immediately to areas where the film is defective.
   8. Do not use curing compound on any surface where concrete or other material will be bonded to overlays, toppings, or future concrete placements unless the curing compound will not prevent bond or unless measures are to be taken to completely remove the curing compound from areas to receive bonded applications.
   9. Keep alternate specified covering readily available for use in the event conditions occur which prevent correct application of the compound at the proper time.
   10. Respray surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied (when slab reaches a moist condition and there is no standing water) with two additional coats of curing compound by the foregoing method and coverage.
   11. Allow foot traffic only after 36 hours of cure time and only when slab is protected with paper or sheeting.
   12. Remove curing compound sprayed on reinforcing steel and construction joints. Remove by sandblasting or other favorably reviewed method after curing is completed, or before placing the next pour. If the cones of tie holes are sprayed with curing compound, lightly ream prior to patching.

E. Curing Method Applications:
   1. Slabs for Water Containment Structures including roof or topping slabs: Wet Cure
   2. Structural Slabs (other than Water Containment Structures): Wet Cure, Sheet Material Cure, or Liquid Membrane Cure.
   3. Topping and Composite Slabs: Sheet Material Cure or Liquid Membrane Cure.
   4. Slabs on Grade and Footings (not used to contain water): Wet Cure, Sheet Material Cure, or Liquid Membrane Cure.
   5. Horizontal Surfaces which will Receive Additional Concrete, Coatings, Grout or Other Material that Requires Bond to the substrate: Wet cure.
   6. Formed Concrete Surfaces:
      a. None, if nonabsorbent forms are left in place 14 days.
      b. Keep absorbent wood forms wet until they are removed.
      c. Sheet Material Cure or Liquid Membrane Cure if forms are removed prior to 7 days.
      d. Exposed horizontal surfaces of formed walls or columns shall be Wet Cured for 14 days or until next placement of concrete is made.
   7. Concrete Joints: Wet Cure or Sheet Material Cure.

F. Other Surfaces:
   1. Provide a curing program equivalent to either slab or formed system, as appropriate.
   2. Include construction joint surfaces when applying curing compound.
   3. Cover, or protect joint openings, exposed reinforcing, surfaces to be painted and other areas where curing compound may enter and interfere with a special finish.
   4. Remove curing compound sprayed on reinforcing or construction joints by sandblasting after curing is completed, or before placing the next pour. If the cones of tie holes are sprayed with curing compound, lightly ream prior to patching.
   5. For curing of certain interior and other slabs using hardening or coloring compounds, refer to Section 03350.

G. Cold Weather Requirements: Provide adequate equipment for heating the placed concrete during freezing or near freezing weather:
   1. Whenever the surrounding air temperature is below 40°F, or may fall below 40°F within the 24-hour period after placing concrete, maintain all freshly poured concrete at not less than 50°F for 5 days, defined as the protection period.
   2. When the average of the highest and lowest ambient air temperature during the period from midnight to midnight is expected to drop below 40°F for more than three successive days, make provisions in advance of concrete placement to maintain the temperature of the concrete. Use heating, covering, or other means to adequately maintain required temperature without overheating or drying of concrete due to concentration of heat. Do not use combustion heaters unless precautions are taken to prevent exposure of the concrete to exhaust gases containing carbon dioxide.
   3. Keep the housing, covering, or other protection in place and intact at least 24 hours after the artificial heating is discontinued.
   4. Do not use manure, salt, calcium chloride, or other chemicals on the concrete to prevent freezing.

H. Hot Weather Requirements: Provide additional cooling to concrete when temperatures rise above 90°F, or low humidity, wind and temperature combine to cause high surface evaporation, over 0.2 lb/sq. ft./hour:
   1. Provide additional water if curing by fog spray or ponding or saturated blankets.
   2. Provide shade to surfaces exposed to direct sunlight.
   3. Apply an evaporation retarder during the finishing operation, following the manufacturer’s recommendation.

3.02 CONCRETE FINISHES

A. Refer to Section 03350.

3.03 FIELD QUALITY CONTROL

A. Notify Engineer when the forms are complete and ready for inspection at least 6 working hours prior to the proposed concrete placement.

B. Concrete Curing:
   1. Verify procedures and equipment is available for controlling concrete temperature during hot and cold weather conditions.

2. Verify actual time of application of evaporation retardant, fog spray and curing materials for each placement.
3. For cold weather applications, record at least twice a day for the six days of special concrete curing and protecting procedures the temperature of the concrete at multiple locations (including surfaces, edges and corners), the daily maximum and minimum concrete temperature, location where temperature was taken, air temperature, weather conditions, and other special conditions. Measure concrete temperature in accordance with ACI 306.

3.04 PROTECTION OF IN-PLACE CONCRETE

A. Loading and support of concrete: Do not allow construction loads to exceed the superimposed load that the structural member, with necessary supplemental support, is capable of carrying safely and without damage.

B. Protection from mechanical injury: During the curing period, protect concrete from damaging mechanical disturbances including load stresses, shock, and harmful vibration. Protect concrete surfaces from damage by construction traffic, equipment, materials, rain or running water, and other adverse weather conditions.

C. Immediately after placement, protect concrete from premature drying, excessively hot or cold temperatures, and mechanical injury.

D. Protect concrete during the curing period such that the concrete temperature does not fall below the specified requirements of Section 03306. Maintain the concrete protection to prevent freezing of the concrete and to ensure the necessary strength development for structural safety. Remove protection in such a manner that the maximum decrease in temperature measured at the surface of the concrete in a 24-hour period shall not exceed the following:
   1. 50°F for sections less than 12 inches in the least dimension.
   2. 40°F for sections from 12 to 36 inches in the least dimension.
   3. 30°F for sections 36 to 72 inches in the least dimension.
   4. 20°F for sections greater than 72 inches in the least dimension.

E. When the surface temperature of the concrete is within 20°F of the ambient or surrounding temperature, protection measures may be removed.

3.05 CLEANUP

A. Upon completion of all work performed under this Section, remove from the site all excess materials, storage facilities and temporary facilities. Smooth and clean of debris all areas that were used or occupied during concrete construction operations and leave in first-class condition.

B. Clean any excess curing compound off the slab after 45 day for interior occupied spaces using water and a stiff brush.

END OF SECTION

SECTION 03340

HYDROSTATIC TESTING OF CONCRETE STRUCTURES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Materials and methods for hydrostatic (leakage) testing of concrete structures.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. ACI 350.1-10 Tightness Testing of Environmental Engineering Concrete Containment Structures

B. California Building Code (CBC) 2019 Edition**.**

1.03 DEFINITIONS

A. Concrete Structure: A reservoir, basin, tank, channel, sump, or conduit to be tightness tested regardless of whether it has a closed or open top or is constructed partially or entirely of concrete.

B. Fitting: An object that passes through the concrete or is embedded in the concrete to facilitate a connection to the concrete structure.

1.04 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Narrative: Written narrative documenting materials and approach for hydrostatic testing of concrete structures.

C. Test Reports: Include description of test locations, dates of testing, water level measurements, amounts of precipitation or evaporation, measured air and water temperatures and volume corrections (if any), retest results, corrective action taken (if any), and final results. Submit final reports within 7 days of test completion.

D. Submit information on changes in flow in underdrain system, if any, after filling the concrete structure.

E. Repair Procedures: Proposed repair methods, materials and modifications to satisfy leakage requirements of this Section. See Section 03935.

1.05 QUALITY ASSURANCE

A. Contractor Qualifications: See Section 03300.

B. Preconstruction Meeting: See Section 03300.

1.06 PROJECT/SITE CONDITIONS

A. Environmental Requirements
   1. Do not schedule the quantitative part of the hydrostatic tightness test for a period when the forecast is for a difference of more than 35°F between the

ambient temperature readings at the times of the initial and final level measurements of the water surface.

2. Do not schedule the test when the weather forecast indicates the water surface could freeze before the test is completed.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.01 TESTING OF HYDRAULIC STRUCTURES

A. General:

1. Test all concrete structures designed to contain water, after all concrete has been placed for the structure, including top slabs or roof slabs, and the concrete has attained its specified compressive strength.
2. Test by filling the structure with potable water unless noted otherwise.
3. Test prior to backfilling. No backfill shall be placed on the wall footings of the structures to be tested.
4. Test prior to application of any coating system or waterproofing membrane.
5. Each cell of multi-cell concrete structures shall be considered a single concrete structure and tested individually unless otherwise noted. Test adjacent structures separately to confirm no cross leakage between structures.
6. Test in accordance with ACI 350.1-10 as modified herein.

B. Preparation:

1. Provide all water necessary for testing.
2. Provide all evaporation and level measuring devices required.
3. Provide all pumps, power, piping and any other equipment required and make all hook-ups necessary to fill structures for testing.
4. Provide access and equipment and make the measurements and observations necessary for the testing.
5. Provide access for the Owner's Representative to observe measurements and witness observations, for verification.
6. Clean the exposed concrete surfaces, including the floor, of all foreign material and debris.
7. Visually examine the concrete surfaces including joints and fittings for potential leakage points.
8. Repair areas of potential leakage before filling the structure with water.
9. Furnish and install temporary bulkheads, if required.
10. Monitor structure penetrations and pipe, channel, and conduit inlets/outlets before and during the test to verify the watertightness of these fittings. Repair seepage at these locations before test measurements. No allowance shall be made in test measurements for uncorrected known points of seepage.
11. In structures with underdrain systems beneath the floors with observation points or monitoring manholes, there shall be no flowing water or visible leakage in the discharge points from the underdrain system pipelines unless groundwater was detected prior to filling the structure with water. If flowing water is observed in the underdrain system, the tank floor shall be inspected for point sources of leakage with the tank empty and full.

12. Do not exceed a rate of 4 feet/hour for initial filling of a new concrete structure.
13. Fill the structure with water to the test level, or either 1 inch below any fixed overflow level in covered structure or 4 inches in open structure, whichever is lower.
14. Maintain full for 72 hours before beginning the test period to permit concrete absorption and adjustment of valves, slide gates, or temporary bulkheads.
15. At completion of tests remove all temporary piping and connections.
16. Dispose of water after testing is complete, including pumping if necessary. Dispose of test water without creating a nuisance or damage to adjacent property.

C. Hydrostatic Leakage Test for Open or Covered Concrete Structures
1. The hydrostatic leakage test consists of two parts: 1) a qualitative test procedure, and 2) a quantitative test procedure, expressed as the maximum allowable percent volume loss per day.
2. The quantitative criteria for the hydrostatic test shall be 0.050% volume per day.

D. Qualitative Test Procedure:
1. The exterior surfaces of the concrete structure shall be observed in both the early mornings and late afternoons during the 72-hour period before starting the Quantitative Test Procedure.
2. Mark all observed damp areas where moisture can be picked up on a dry hand or facial tissue on exposed surfaces that have not healed autogenously during the test.
3. If any water is observed on the concrete structure exterior surfaces, including joints, repaired honeycombed areas, cracks, wall-floor joints on top of the exterior wall footings, or fittings where moisture can be picked up on a dry hand, the concrete structure shall be considered to have failed the Qualitative Test Procedure of the hydrostatic test.
4. Repair all those areas. Submit acceptable procedures for favorable review prior to repairs.
5. Repairs by painting or surface treatment shall not be allowed.
6. Repairs on the exterior side or negative water side of concrete structures shall not be allowed.
7. Although the Quantitative Test Procedure may begin prior to completion of repairs observed from the Qualitative Test Procedure, all defects causing the failure of the Qualitative Test Procedure of the hydrostatic tightness test shall be repaired before acceptance of the concrete structure. No allowance shall be made in test measurements for uncorrected known points of observed flow or seepage.
8. Continue the hydrostatic leakage test and repair procedures until the concrete structure satisfies both the qualitative and quantitative test requirements.

E. Quantitative Test Procedure:
1. Measure the vertical distance to the water surface to within 1/16 inch from a fixed point on the concrete structure above the water surface.
2. Record measurements at 24-hour intervals.
3. Test Period: Five consecutive 24-hour periods totaling 5 consecutive days.
4. Take daily measurements at the same time of day at the location of the original measurements of the following.
   a. Air temperature.

b. Water temperature at a depth of 18 inches, unless otherwise specified, below the water surface at the start and end of the test.
c. Rainfall.
d. Water level at two locations 180-degrees apart.

5. Include volume corrections for water temperature differences.
6. In uncovered concrete structures, measure evaporation and precipitation. In well-ventilated covered concrete structures, measure evaporation.
7. Continue to observe the concrete structure in both the early mornings and late afternoons to verify compliance with the qualitative part of the hydrostatic tightness testing during the quantitative part of the hydrostatic test.
8. At the end of the test period, record the water surface to within 1/16-inch at the location of the original measurements. Record the water temperature and the evaporation and precipitation measurements.
9. Calculate the change in water volume in the concrete structure and correct, if necessary, for evaporation, precipitation, and temperature. Determine evaporation or precipitation measurements, using a floating, restrained, partially filled, calibrated, open container positioned in the open concrete structures, and record the water level in the container. Do not use a shallow pan-type measuring device for determining evaporation losses. Measure and deduct evaporation losses from the water loss to determine compliance with the acceptance criteria.
10. If the loss exceeds the required criterion, the concrete structure shall be considered to have failed the quantitative part of the test.
11. Continue the hydrostatic leakage test and repair procedures until the concrete structure satisfies both the qualitative and quantitative test requirements.

3.02 RETESTING

A. Restart the test when test measurements become unreliable due to unusual precipitation or other external factors.

B. If leakage from the structure exceeds the specified criteria, in each 24-hour period over a period of five consecutive days, perform a retest after completing repairs.

C. It shall be permitted to immediately retest a concrete structure failing the quantitative part of the hydrostatic test when the qualitative part is passed.

D. If the concrete structure fails the second test or if not immediately retested after the first test failure, observe the interior of the concrete structure for probable problem areas. Only retest the concrete structure after the probable problem areas are repaired.

E. Retest concrete structures until they meet the required qualitative and quantitative parts of the hydrostatic leakage test. Make repairs before each retest.

3.03 REPAIR OF DEFECTIVE CONCRETE

A. See Section 03935.

END OF SECTION

SECTION 03350

CONCRETE FINISHING (STRUCTURAL)

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Finishing formed and unformed surfaces.
   2. Sealers and hardeners for concrete.

1.02 REFERENCES

A. ASTM International (ASTM):

1.	ASTM C156	Test Method for Water Retention by Concrete Curing Materials
2.	ASTM C309	Specification for Liquid Membrane-Forming Compounds for Curing Concrete
3.	ASTM C1028	Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method
4.	ASTM E96	Test Methods for Water Vapor Transmission of Materials

B. California Building Code (CBC) 2019 Edition**.**

C. “Evaluation Reports” published by the International Code Council.

1.03 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Qualifications: A list of at least five projects completed by the proposed subcontractor within the most recent 3 years that have concrete finishes similar to those specified for this project.

C. Product Data: Describe all products proposed for use.
   1. Manufacturer’s data for chemical retarder and recommendations for use when exposed aggregate surface is specified.
   2. Provide verification of compatibility for curing compound with subsequent applied finishes, membranes and adhesives.

D. Field Samples:
   1. 2-foot-square job-prepared samples of each finish and color specified for selection and use as Control Samples. Additionally, provide the following samples for finish selection by the Owner’s Representative.
      a. Medium sandblast: One sample each with No. 60 grit and No. 30 grit sand.
         1) On smooth concrete.
         2) On textured concrete.
      b. Fine broom finish.
      c. Coarse broom finish.
   2. Provide samples of mortar for filling voids and form tie holes and grout for all finishes for formed surfaces. Samples shall be applied to an inconspicuous area for selection of color match by the Owner’s Representative prior to proceeding with finishes.

1.04 QUALITY ASSURANCE

A. Contractor Qualifications: Use skilled cement finishers to perform all work.

B. Regulatory Requirements: Comply with applicable requirements in the California Building Code, including without limitation Chapters 10, 11A, 11B and 19.

PART 2 - PRODUCTS

2.01 CURING AND SEALING COMPOUND

A. General:
   1. Water-base acrylic curing, sealing and dustproofing compound.
   2. Leave a protective clear transparent film on the concrete surface that is non-yellowing and resistant to deterioration due to exposure to ultraviolet light.
   3. ASTM C 309, Type I, Class B.
   4. AASHTO M-148, Type I, Class B.

B. Manufacturers:
   1. First coat Vocomp-20, second coat Vocomp-25-1315 by W. R. Meadows Inc.;
   2. Burke Spartan-Cote WB Cure/Seal/Hardener;
   3. or equal.

2.02 MORTAR FOR FILLING VOIDS

A. Mortar for Filling Voids: One part Portland cement, two parts sand by volume mixed with only enough water to form a ball when squeezed by hand. A mixture of white and grey Portland cement is required for color match (approximately 1 part white to 2 parts grey). Add mineral oxide colors as required to match colored concrete. Substitute non-reemulsifiable, acrylic bonding agent for one-third of mixing water. Test several different mixes for color match and obtain favorable review prior to proceeding.

PART 3 - EXECUTION

3.01 FINISHING UNFORMED SURFACES

A. General:
   1. Place concrete at a rate that allows spreading, straight-edging, and darbying or bull-floating before bleed water appears.
   2. Strike smooth the top of walls, buttresses, horizontal offsets, and other similar unformed surfaces and float them to a texture consistent with finish of adjacent formed surface.
   3. Provide a surface finish on exterior and interior horizontal concrete slabs that has a coefficient of friction when measured in accordance with ASTM C1028 not less than 0.60 for level surfaces and 0.80 for surfaces sloped 1:20 or greater.
   4. Review grades shown and recommend any adjustments necessary to achieve minimum specified slope.
      a. For exterior paving surfaces provide a minimum slope of 1% (1/8-inch per foot) to drain surface water to catch basins, drains or edges of pavement adjacent to landscaping and drainage swales.
      b. Slopes shall conform to the requirements of IBC chapter 10, 11A and 11B.

5. Slope interior floor surfaces containing floor drains to drain water to the drains. Review elevations shown on Drawings for adequate slopes before setting grades. Report any conditions that will not provide adequate drainage or that will produce excessively steep slopes before proceeding.
6. Finish slabs so they do not deviate more than ¼-inch (6.3 mm) in 10 feet from a straight edge. Finish elevations to within 1/8-inch (3.2 mm) elevations shown or required to match adjacent existing conditions. Provide "as-built" slopes for drainage no less than those shown or specified.
7. Allowed Tolerance for individual risers and treads in any flight of stairs:
    a. ¼-inch (6.3 mm) between the lowest and highest riser.
    b. 3/8-inch (9.5 mm) between the deepest and shallowest tread measured in the direction of travel.
8. Slope all treads 1/8-inch (3.2 mm) down toward the nosing for drainage.
9. Finish edges and surfaces smooth, true and clean.
10. Apply finish to slabs as soon as the concrete can support the weight of the workmen.
11. Increase the humidity of the air directly above the concrete surface, prior to and during finishing operations by adding a fine fog mist of water to the air with mist nozzles when atmospheric conditions (temperature, humidity, and wind) are such that rapid evaporation of mixing water from the concrete is likely to occur.
12. When the finish is not specified, use one of the following finishes:
    a. Scratch Finish—For surfaces intended to receive bonded cementitious mixtures.
    b. Float Finish—For walks, drives, steps, ramps, and for surfaces intended to receive waterproofing, roofing, insulation, or sand-bed terrazzo.
    c. Trowel Finish—For exposed slab surfaces in environmental basin and containment structures. For floors intended as walking surfaces, and floors in processing, storage, and warehousing areas.

B. Scratch Finish:
1. Place, consolidate, strike off, and level concrete, eliminating high and low spots.
2. Roughen the surface with stiff brushes or rakes before final setting.
3. Produce a finish that meets ACI 117 tolerances for conventional bull-floated surfaces.

C. Float Finish and Preliminary Steps for Other Finishes:
1. Applies to slab surfaces indicated to have a wood or magnesium Float finish. This finish is also the initial step for all other finishes.
2. Place, consolidate, strike off, and level concrete, eliminating high and low spots.
3. Screed to grade using a strike-off board guided on accurately set screeds.
4. Work the surface with a bull or darby float to embed large aggregate, consolidate surface mortar and create a smooth true surface
5. Do not work concrete further until it is ready for floating.
6. When surface has taken initial set and bleed water has disappeared work surface with wood floats followed by magnesium floats (if a magnesium float finish is called for) to even out slight irregularities and further consolidate surface
7. Begin floating with a hand float, a bladed power float equipped with float shoes, or a powered disk float when the bleed water sheen has disappeared

and the surface has stiffened sufficiently to permit operation of the specific float apparatus.

8. Produce a finish that will meet tolerance requirements of ACI 117 for a conventional surface. Refloat the slab immediately to a uniform texture.
9. When concrete has set further so that excess water and fine material will not be brought to the surface, either begin the first steel troweling if this is the preliminary step for other finishes or work the surface with magnesium or wood float if this is the final step in a Float finish. Work the surface sufficiently to consolidate the mortar and produce a finished surface at the proper grade that is free of voids, ripples or other defects. Apply a final swirl texture finish in a fan pattern with the wood or magnesium float. Retool slab edges and control joints. Leave a uniform smooth border around all slab edges and each side of control joints.
10. Do not overwork the surface or add dry materials such as sand or cement.

D. Trowel Finish:
   1. Applies to all slabs indicated to receive a Trowel finish.
   2. Complete the work required under “Preliminary Steps for Other Finishes.”
   3. Apply a second steel troweling after the concrete has set sufficiently so mortar does not adhere to the edge of the trowel and sufficient pressure can be applied to further consolidate the surface.
   4. Apply a third steel troweling when the concrete has set sufficiently so the trowel produces a ringing sound. Apply sufficient pressure so the trailing edge of the trowel will produce a dense smooth surface without burning.
   5. Apply a fourth troweling and additional trowelings as required to produce a dense smooth finish.
   6. Produce a finish that meets ACI 117 tolerances for concrete floors for a moderately flat surface.
   7. Addition of water to surface during finishing is prohibited.

E. Broom Finish:
   1. Applies to all slabs indicated to receive a Broom finish.
   2. Complete work required under “Preliminary Steps for Other Finishes.”
   3. Apply second and third steel trowelings after the concrete has set sufficiently so mortar does not adhere to the edge of the trowel and sufficient pressure can be applied to further consolidate the surface.
   4. Broom texture the surface of the slab at right angles to the normal direction of traffic. Use a stiff fiber bristled broom for Coarse Broom Finish and a fine hair broom for Fine Broom Finish. Match selected control sample.

F. Detail Work: Applies to all concrete flatwork and to exposed top edges of all formed concrete.
   1. Edging Slabs: Tool a 3/8-inch radius on all exposed edges of slabs, stair treads, curbs and other exposed horizontal edges unless a formed chamfered edge is indicated, or as otherwise noted on the Drawings. Repeat tooling with each floating or troweling operation.
   2. Apply a Trowel finish to the top of the formed walls, curbs and machine bases.
   3. Control Joints and Feature Grooves:
      a. Cut 1-inch-deep control joints with rounded edges in all paving slabs where indicated but not more than 8 feet apart in each direction. Repeat tooling with each floating or troweling operation.
      b. Run decorative feature grooves with a ¼-inch-deep rounded tool before the final troweling in paving where shown.

G. Cement Finishers Finish:
1. Use for curb faces, stair risers and other vertical formed surfaces customarily stripped and finished the same day they are placed and before the concrete fully sets.
2. Use form work specially designed for removal before the concrete sets.
3. Remove forms when concrete has achieved initial set and is stiff enough to retain its own shape but before it fully sets.
4. Work over surface with a moist wood or rubber float and cement paste to fill minor voids and consolidate the surface. Fill holes and larger voids with mortar but do not build up a coating of mortar over the entire formed surface. Finish with a fine hair brush.

3.02 FINISHING FORMED SURFACES

A. General:
1. After form removal, give each formed surface one or more of the finishes specified on Drawings or in the Schedule of Concrete Finishes and as described below.
2. See the Schedule of Concrete Finishes at the end of this Section and notes and schedules on Architectural and Structural Drawings for the location, and extent and type of finish required.
3. When a finish is not specified, finish surfaces as noted below:
   a. Environmental Surface Finish 1.0 (ESF-1.0) on concrete surfaces not exposed to view.
   b. Environmental Surface Finish 2.0 (ESF-2.0) on concrete surfaces not exposed to view and expected to contain liquids, gases, or both.
   c. Environmental Surface Finish 3.0 (ESF-3.0) on concrete surfaces exposed to view.
4. Complete all patching and finishing within 10 days after the curing period is completed.
5. Where the concrete surface will be textured by sandblasting or bush-hammering, repair surface defects before texturing.
6. Use form-facing materials meeting the requirements of Section 03100.

B. As-Cast Finish:
1. Environmental Surface Finish 1.0 (ESF-1.0)
   a. Patch voids greater than 1-1/2 inch wide or 1/4 inch deep.
   b. Remove projections greater than 1/2 inch
   c. Patch tie holes.
   d. Surface tolerance Class C as specified in ACI 117.
   e. Leave surfaces with the texture imparted by the forms.
   f. The minimum taper required to correct offsets is 1:16.
2. Environmental Surface Finish 2.0 (ESF-2.0)
   a. Patch voids greater than 3/4 inch wide or 1/4 inch deep.
   b. Remove projections greater than 1/4 inch
   c. Patch tie holes.
   d. Surface tolerance Class B as specified in ACI 117
   e. The minimum taper required to correct offsets is 1:16.
3. Environmental Surface Finish 3.0 (ESF-3.0)
   a. Patch voids greater than 1/2 inch wide or 1/4 inch deep.
   b. Remove projections greater than 1/8 inch
   c. Patch tie holes.
   d. Surface tolerance Class A as specified in ACI 117.

e. The minimum taper required to correct offsets is 1:16.

C. Grout-Cleaned Rubbed Finish or Sacked Finish:
1. Complete work required for Environmental Surface Finish 3.0 (ESF-3.0).
2. Begin cleaning operations after contiguous surfaces are completed and accessible. Do not clean surfaces as work progresses.
3. Prepare grout in accordance with Part 2
4. Wet concrete surfaces and allow surface water to evaporate leaving the concrete damp but surface dry.
5. Apply grout with rubber floats to the entire surface area to be finished.
6. Work grout into and compress all air bubbles, holes, voids and surface irregularities.
7. Compress grout in voids with cork floats.
8. When grout has become stiff, but is still plastic, remove all excess from surface with rubber squeegees or cork floats.
9. After the surface whitens from drying (about 30 minutes at normal temperature) clean the surface by rubbing vigorously with clean burlap wrapped around wood blocks.
10. Keep the surface damp for 48 hours.

D. Sandblasted Finish:
1. Complete work required for a Smooth-Rubbed Finish or Filled and Rubbed finish.
2. Lightly sandblast entire surface with Nos. 60 to 30 grit sand as selected to evenly texture the surface of cement paste and fine aggregate. Match control sample.

3.03 SCHEDULE OF CONCRETE FINISHES

A.	**SLABS**		**LOCATION OF FINISH**
1.	Scratch Finish	3.01B	Applies to surfaces intended to receive bonded cementitious mixtures.
2.	Float Finish	3.01C	Applies to slab surfaces indicated to receive a "Float Finish". This finish is also the initial steps for all other finishes. Applies to walks, drives, steps, ramps, and for surfaces intended to receive waterproofing, roofing, insulation, or sand-bed terrazzo. Applies to all interior and exterior slabs scheduled to receive a bonded ceramic tile or bonded mortar finish.
3.	Trowel Finish	3.01D	Applies to slabs indicated to receive a " Trowel Finish." Applies to exposed slab surfaces in environmental basin and containment structures. Applies to floors intended as walking surfaces, and floors in processing, storage, and warehousing areas. Applies to all slabs intended to receive resilient flooring, carpet, elastomeric deck coating, roofing or a waterproofing membrane. Applies to top of formed walls, curbs, equipment pads and machine bases.
4.	Broom Finish	3.01E	Applies to slabs indicated to receive a "Broom Finish" and to all exterior paving, stair treads, not indicated to receive another finish. Broom Finish for Exterior paving, stair treads and wet process areas shall be a Coarse Broom Finish.
5.	Cement Finishers Finish	3.01G	Applies to curb faces, stair risers and other vertical formed surfaces customarily finished the same day they are placed and before the concrete fully sets.
B.	**SEALING SLABS**		

A. SLABS			LOCATION OF FINISH
			a. Apply one coat curing and sealing compound to interior building concrete intended to receive carpet or resilient flooring in accordance with the manufacturer's recommendations and at the recommended rate.
			b. Apply two coats Curing and Sealing compound to interior building concrete that will receive no other finish. Apply the first coat when the concrete is wet; apply the second coat 30 days later.
C. FORMED SURFACES			
1.	As-Cast Finish	3.02B	Applies to walls and other vertical and horizontal formed surfaces, including beams and columns indicated to receive an As-Cast Finish and to all concrete surfaces where no specific finish is indicated. When a finish is not specified, finish surfaces as noted below: a. Environmental Surface Finish 1.0 (ESF-1.0) on concrete surfaces not exposed to view. b. Environmental Surface Finish 2.0 (ESF-2.0) on concrete surfaces not exposed to view and expected to contain liquids, gases, or both. c. Environmental Surface Finish 3.0 (ESF-3.0) on concrete surfaces exposed to view.
2.	Grout-Cleaned Rubbed Finish or Sacked Finish	3.02C	Applies where indicated and to interior walls of tanks and to the bottoms and walls of water channels. All walls and ceilings of launders.
3.	Sandblasted Finish	3.02D	Applies to exterior above grade concrete not intended to receive any other concrete finish or paint finish.
D. SEE SECTION 03330 FOR CURING FORMED CONCRETE			

END OF SECTION

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SECTION 03600

GROUTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
1. Non-shrink cementitious grout (non-shrink grout).
2. Non-shrink epoxy grout.
3. Cement grout.
4. Concrete grout. (Masonry grout is covered in Section 04050.)
5. Swept-in grout.

1.02 REFERENCES

A. ASTM International (ASTM):
1. C531 Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical Resistant Mortars, Grouts and Monolithic Surfacings and Polymer Concretes.
2. C827 Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixtures.
3. 1107 Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).
4. D695 Standard Test Method for Compressive Properties of Rigid Plastics.

B. U.S. Army Corps of Engineers Standard (CRD):
1. CRD C-621 Corps of Engineers Specification for Non-shrink Grout.

1.03 SUBMITTALS

A. Product Data: Submit, in accordance with Section 01300, product data showing materials of construction and details of installation all grouts in Part 2. Product data shall include:
1. Catalog information,
2. Technical data,
3. Storage requirements,
4. Product life,
5. Working time after mixing,
6. Temperature considerations,
7. Conformity to required ASTM Standards and
8. Material Safety Data Sheet (MSDS).
9. Type and brand of the cement,
10. Gradation of the fine aggregate,
11. Proposed admixtures and
12. the proposed mix of the grout for non-packaged mixes.
13. Concrete grout: The submittal shall include data as required for concrete as delineated in Section 03300 and for fiber reinforcement as delineated in Section 03200. This includes the mix design, constituent quantities per cubic yard and the water/cement ratio.
14. Swept-in grout: The submittal shall include data as required for concrete as delineated in Section 03300 and for fiber reinforcement as delineated in

Section 03200. This includes the mix design, constituent quantities per cubic yard and the water/cement ratio.

B. Samples:
   1. Field samples for color control, if a color match is required.

C. Quality Control:
   1. Laboratory Test Reports:
      a. Submit laboratory test data as required under Section 03300 for concrete to be used as concrete grout.
   2. Qualifications:
      Submit documentation that they have at least 10 years experience in the production and use of the proposed grouts which they will supply

1.04 QUALITY CONTROL

A. Qualifications:
   1. Grout manufacturer shall have a minimum of 10 years experience in the production and use of the type of grout proposed for the work.

1.05 QUALITY ASSURANCE

A. Special inspection shall be completed by the Owner’s Representative.

1.06 DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the jobsite in original, unopened packages, clearly labeled with the manufacturer's name, product identification, batch numbers and printed instructions.

B. Store materials in full compliance with the manufacturer's recommendations. Total storage time from date of manufacture to date of installation shall be limited to 12 months or the manufacturer's recommended storage time, whichever is less.

C. Material which becomes damp or otherwise unacceptable shall be immediately removed from the site and replaced with acceptable material at no additional cost to the Owner.

D. Non-shrink cement-based grouts shall be delivered as preblended, prepackaged mixes requiring only the addition of water.

E. Non-shrink epoxy grouts shall be delivered as premeasured, prepackaged, three component systems requiring only blending as directed by the manufacturer.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Non-shrink Cementitious Grout (Non-shrink Grout):
   1. Non-shrink cementitious grouts shall meet or exceed the requirements of ASTM C1107, Grades B or C and CRD C-621. Grouts shall be Portland Cement based, contain a pre-proportioned blend of selected aggregates and shrinkage compensating agents and shall require only the addition of water. Non-shrink cementitious grouts shall not contain expansive cement or metallic particles. The grouts shall exhibit no shrinkage when tested in conformity with ASTM C827.

a. General purpose non-shrink cementitious grout shall conform to the standards stated above and shall be SikaGrout 212 by Sika Corp.; Euco NS by The Euclid Chemical Co.; Five Star Grout by Five Star Products, Inc.; or approved equal.
b. Flowable (Precision) non-shrink cementitious grout shall conform to the standards stated above and shall be Hi-Flow Grout by the Euclid Chemical Co.; SikaGrout 212 by Sika Corp.; Five Star Grout by Five Star Products Inc.; or approved equal.

B. Non-shrink Epoxy Grout:
1. Non-shrink epoxy-based grout shall be a pre-proportioned, three-component, 100 percent solids system consisting of epoxy resin, hardener, and blended aggregate. It shall have a compressive strength of 14,000 psi in 7 days when tested in conformity with ASTM D695 and have a maximum thermal expansion of 30 x 10-6 inch per inch per degree F when tested in conformity with ASTM C531. The grout shall be Five Star HP Epoxy Grout by Five Star Products.; Sikadur 42 Grout-Pak by Sika Corp.; E3-G Epoxy Grout by the Euclid Chemical Co.; or approved equal.

C. Cement Grout:
1. Cement grouts shall be a mixture of one part Portland Cement conforming to ASTM C150, Types I, II, or III and 1 to 2 parts sand conforming to ASTM C33 with sufficient water to place the grout. The water content shall be sufficient to impart workability to the grout but not to the degree that it will allow the grout to flow.

D. Concrete Grout:
1. Concrete grout shall conform to the requirements of Section 03300 except as specified herein. Proportion with Type II Portland Cement, pozzolan, coarse and fine aggregates, water, water reducer and air entraining agent to produce a mix having an average strength of 3500 psi at 28 days (2500 psi nominal strength). Coarse aggregate size shall be 3/8-inch maximum. Slump should not exceed 5 inches. Minimum cement content shall be 540 lbs per cubic yard and maximum water-to-cement ratio shall be 0.45.
2. Add synthetic reinforcing fibers as specified in Section 03200 to the concrete grout mix at the rate of 1.5 lbs of fibers per cubic yard of grout. Add fibers from the manufacturer's premeasured bags and according to the manufacturer's recommendations in a manner which will ensure complete dispersion of the fiber bundles as single monofilaments within the concrete grout.

E. Water:
1. Potable water, free from injurious amounts of oil, acid, alkali, organic matter, or other deleterious substances.

F. Grout for Grouting of Masonry:
1. See Specification Section 04050.

G. Like materials in areas of common viewing shall be the products of one manufacturer or supplier in order to provide standardization of appearance. Baseplate grout thicknesses are typically shown on the Drawings; confirm that the selected grout product is recommended for the grout thicknesses shown.

PART 3 - EXECUTION

3.01 PREPARATION

A. Place grout over cured concrete that has attained its full design strength unless otherwise approved by the District Representative.

B. Concrete surfaces to receive grout shall be clean and sound; free of ice, frost, dirt, grease, oil, curing compounds, laitance and paints and free of all loose material or foreign matter which may affect the bond or performance of the grout.

C. Roughen concrete surfaces by chipping, sandblasting, or other mechanical means to ensure bond of the grout to the concrete. Remove loose or broken concrete. Irregular voids or projecting coarse aggregate need not be removed if they are sound, free of laitance and firmly embedded into the parent concrete.
   1. Air compressors used to clean surfaces in contact with grout shall be the oilless type or equipped with an oil trap in the airline to prevent oil from being blown onto the surface.

D. Remove all loose rust, oil or other deleterious substances from metal embedments or bottom of baseplates prior to the installation of the grout.

E. Concrete surfaces shall be washed clean and then kept moist for at least 24 hours prior to the placement of cementitious or cement grout. Saturation may be achieved by covering the concrete with saturated burlap bags, use of a soaker hose, flooding the surface, or other method acceptable to the District Representative. Upon completion of the 24-hour period, visible water shall be removed from the surface prior to grouting. The use of an adhesive bonding agent in lieu of surface saturation shall only be used when approved by the District Representative for each specific location of grout installation.

F. Epoxy-based grouts do not require the saturation of the concrete substrate. Surfaces in contact with epoxy grout shall be completely dry before grouting.

G. Construct grout forms or other leakproof containment as required. Forms shall be lined or coated with release agents recommended by the grout manufacturer. Forms shall be of adequate strength, securely anchored in place and shored to resist the forces imposed by the grout and its placement.
   1. Forms for epoxy grout shall be designed to allow the formation of a hydraulic head and shall have chamfer strips built into forms.

H. Level and align the structural or equipment bearing plates in accordance with the structural requirements and the recommendations of the equipment manufacturer.

I. Equipment shall be supported during alignment and installation of grout by shims, wedges, blocks or other approved means. The shims, wedges and blocking devices shall be prevented from bonding to the grout by appropriate bond breaking coatings and removed after grouting unless otherwise approved by the District Representative.

3.02 INSTALLATION – GENERAL

A. Mix, apply and cure products in strict compliance with the manufacturer's recommendations and this Section.

B. Have sufficient manpower and equipment available for rapid and continuous mixing and placing. Keep all necessary tools and materials ready and close at hand.

C. Maintain temperatures of the foundation plate, supporting concrete, and grout between 40° and 90° F during grouting and for at least 24 hours thereafter or as recommended by the grout manufacturer, whichever is longer. Take precautions to minimize differential heating or cooling of baseplates and grout during the curing period.

D. Take special precautions for hot weather or cold weather grouting as recommended by the manufacturer when ambient temperatures and/or the temperature of the materials in contact with grout are outside of the 60° and 90° F range.

E. Install grout in a manner which will preserve the isolation between the elements on either side of the joint where grout is placed in the vicinity of an expansion or control joint.

F. Continue all existing underlying expansion, control and construction joints through the grout.

3.03 INSTALLATION – CEMENT GROUTS AND NON-SHRINK CEMENTITIOUS GROUTS

A. Mix in accordance with manufacturer's recommendations. Do not add cement, sand, pea gravel or admixtures without prior approval by the District Representative.

B. Avoid mixing by hand. Mixing in a mortar mixer (with moving blades) is recommended and will be required if required by the manufacturer. Pre-wet the mixer and empty excess water. Add premeasured amount of water for mixing, followed by the grout. Begin with the minimum amount of water recommended by the manufacturer and then add the minimum additional water required to obtain workability. Do not exceed the manufacturer's maximum recommended water content.

C. Placements greater than 3-inch in depth shall include the addition of clean, washed pea gravel to the grout mix when approved by the manufacturer. Comply with the manufacturer's recommendations for the size and amount of aggregate to be added.

D. Place grout into the designated areas in a manner which will avoid segregation or entrapment of air. Do not vibrate grout to release air or to consolidate the material. Placement should proceed in a manner which will ensure the filling of all spaces and provide full contact between the grout and adjoining surfaces. Provide grout holes as necessary.

E. Place grout rapidly and continuously to avoid cold joints. Do not place cement grouts in layers. Do not add additional water to the mix (retemper) after initial stiffening.

F. Just before the grout reaches its final set, cut back the grout to the substrate at a 45-degree angle from the lower edge of bearing plate unless otherwise approved by the District Representative. Finish this surface with a wood float (brush) finish.

G. Begin curing immediately after form removal, cutback, and finishing. Keep grout moist and within its recommended placement temperature range for at least 24 hours after placement or longer if recommended by the manufacturer. Saturate the grout surface by use of wet burlap, soaker hoses, ponding or other approved means. Provide sunshades as necessary. If drying winds inhibit the ability of a

given curing method to keep grout moist, erect wind breaks until wind is no longer a problem or curing is finished.

3.04 INSTALLATION – NON-SHRINK EPOXY GROUTS

A. Mix in accordance with the procedures recommended by the manufacturer. Do not vary the ratio of components or add solvent to change the consistency of the grout mix. Do not overmix. Mix full batches only to maintain proper proportions of resin, hardener and aggregate.

B. Monitor ambient weather conditions and contact the grout manufacturer for special placement procedures to be used for temperatures below 60° or above 90° F.

C. Place grout into the designated areas in a manner which will avoid trapping air. Placement methods shall ensure the filling of all spaces and provide full contact between the grout and adjoining surfaces. Provide grout holes as necessary.

D. Minimize "shoulder" length (extension of grout horizontally beyond base plate). In no case shall the shoulder length of the grout be greater than the grout thickness.

E. Finish grout by puddling to cover all aggregate and provide a smooth finish. Break bubbles and smooth the top surface of the grout in conformity with the manufacturer's recommendations.

F. Epoxy grouts are self curing and do not require the application of water. Maintain the formed grout within its recommended placement temperature range for at least 24 hours after placing, or longer if recommended by the manufacturer.

3.05 INSTALLATION - CONCRETE GROUT

A. Inspect slabs finished under Section 03350 and scheduled to receive concrete grout. Protect and keep the surface clean until placement of concrete grout.

B. Remove the debris and clean the surface by sweeping and vacuuming of all dirt and other foreign materials. Pressure wash the surface. Do not flush debris into structure drain piping.

C. Saturate the concrete surface for at least 24 hours prior to placement of the concrete grout by use of saturated burlap bags, soaker hoses, or ponding. Remove excess water just prior to placement of the concrete grout. Place a cement slurry immediately ahead of the concrete grout so that the slurry is moist when the grout is placed. Work the slurry over the surface with a broom until it is coated with approximately 1/16 to 1/8-inch thick cement paste. A bonding grout composed of 1-part Portland Cement, 1.5 parts fine sand, an approved bonding admixture and water, mixed to achieve the consistency of thick paint, may be substituted for the cement slurry.

D. Place concrete grout to final grade using the scraper mechanism as a guide for surface elevation and to eliminate high and low spots. Unless specifically approved by the equipment manufacturer, mechanical scraper mechanisms shall not be used as a finishing machine or screed.

E. Provide grout control joints as indicated on the Drawings.

F. Steel trowel finish as specified in Section 03350. Cure the concrete grout as specified for cast-in-place concrete in Section 03300.

3.06 SCHEDULE

A. The following list indicates where the particular types of grout are to be used:
   1. General purpose non-shrink cementitious grout: Use at all locations where non shrink grout is called for on the plans except for base plates greater in area than 3-foot wide by 3-foot long and except for the setting of anchor rods, anchor bolts or reinforcing steel in concrete.
   2. Flowable non-shrink cementitious grout: Use under all base plates greater in area than 3-foot by 3-foot. Use at all locations indicated to receive flowable non-shrink grout by the Drawings. The Contractor, at his/her option and convenience, may also substitute flowable non-shrink grout for general purpose non-shrink cementitious grout.
   3. Non-shrink epoxy grout: Use for the setting of anchor rods, anchor bolts and reinforcing steel in concrete and for all locations specifically indicated to receive epoxy grout.
   4. Cement grout: Cement grout may be used for grouting of incidental base plates for structural and miscellaneous steel such as post base plates for platforms, base plates for beams, micropiles, etc. It shall not be used when non-shrink grout is specifically called for on the Drawings or for grouting of primary structural steel members such as columns and girders.
   5. Concrete grout: Use at all locations indicated on the Drawings to receive concrete grout.

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SECTION 03935

REPAIR OF DEFECTIVE CONCRETE

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Repair of defective concrete.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. ACI 117 Standard Tolerances for Concrete Construction and Materials
   2. ACI 301 Specifications for Structural Concrete for Buildings
   3. ACI 318 Building Code Requirements for Structural Concrete
   4. ACI 347 Guide to Formwork for Concrete
   5. ACI 350 Environmental Engineering Concrete Structures

B. ASTM International (ASTM) Standard Specification or Test Method:
   1. ASTM C881 Epoxy-Resin-Base Bonding Systems for Concrete.
   2. ASTM C882 Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
   3. ASTM C883 Effective Shrinkage of Epoxy-Resin Systems Used with Concrete.
   4. ASTM D570 Water Absorption of Plastics.
   5. ASTM D638 Tensile Properties of Plastics.
   6. ASTM D695 Compressive Properties of Rigid Plastics.
   7. ASTM D732 Shear Strength of Plastics by Punch Tool.
   8. ASTM D790 Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

C. California Building Code (CBC) 2019 Edition**.**

1.03 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Product Data:
   1. When stains, rust, efflorescence, and surface deposits must be removed, submit the proposed materials and manufacturer's instructions of removal.
   2. When crack repair is required, submit the proposed materials and manufacturer's method of repair.

C. Shop Drawings:
   1. After defects are identified and investigated, submit a listing of repairs to be made and the detailed surface preparation, products, methods, curing and finishing requirements of repair to be used at each location.
   2. Submit manufacturer's technical literature on products proposed for use. Include the manufacturer's installation and/or application instructions.

D. Samples: Submit any item of Product Data not fully assembled by a single manufacturer.

1.04 QUALITY ASSURANCE

A. No existing structure or concrete shall be shifted, cut, removed, or otherwise altered until authorization is given by the Engineer.

B. When removing materials or portions of existing structures and when making openings in existing structures, take all precautions and erect all necessary barriers, shoring and bracing and other protective devices to prevent damage to the structures beyond the limits necessary for the new work, protect personnel, control dust and to prevent damage to the structures or contents by falling or flying debris. Unless otherwise permitted, shown or specified, sawing and/or line drilling will be required in cutting existing concrete.

C. Manufacturer's qualifications. Minimum of 10 years experience in the manufacture of the products specified and an ongoing program of training, certifying and technically supporting the Contractor's personnel.

D. Contractor qualifications. Complete a program of instruction in the application of the approved manufacturer's material specified in this Section and provide certification from the manufacturer attesting to their training and status as an approved applicator.

E. Certifications: Certification that the materials meet the requirements of this Section and have the manufacturer's current printed literature on the specified product.

1.05 DELIVERY, STORAGE AND HANDLING

A. Deliver the specified products in original, unopened containers displaying the manufacturer's name, labels, product identification and batch numbers.

B. Store and condition products as recommended by the manufacturer.

PART 2 - PRODUCTS

2.01 GENERAL

A. Comply with these Specifications and any state or local regulations.

B. Obtain materials from an established and experienced manufacturer or supplier. Provide new materials of first-class ingredients guaranteed to perform the service required.

2.02 CEMENT REPAIR MORTAR

A. Cement repair mortar may be either site-mixed Portland-cement repair mortar for small repairs or commercial cement repair mortar patching products for larger areas. See Section 03300.

B. Site Mixed Portland-Cement Repair Mortar:
   1. Mix repair mortar using the same materials as concrete to be patched with no coarse aggregate. Do not use more than one part Portland-cement to two parts sand by damp loose volume.

2. For repairs in exposed concrete, make trial batches and check color compatibility of repair material with surrounding concrete. Prepare several trial batches and make test samples in an inconspicuous location for review. When the repair is too dark, substitute white Portland cement for a part of the gray cement to produce a color and texture closely matching the surrounding concrete.
3. Use a repair mortar at a stiff consistency with no more mixing water than is necessary for handling and placing. Mix the repair mortar and turn the mortar frequently with a trowel without adding water. Use mortar at a stiff consistency.
4. For concrete removal resulting in cavities exceeding 3 inches in depth and 1 square foot in area, pack the void with a mixture of cement, concrete sand and pea gravel proportioned as follows:

Material	Volumes	Weights
Cement	1.0	1.0
Sand	1.0	1.0
Pea Gravel	1.5	1.5

C. Commercial Cement Repair Mortar:
1. Portland-cement mortar modified with a latex bonding agent conforming to ASTM C1059 Type II.
2. Epoxy mortars and epoxy compounds that are moisture-insensitive during application and that, after curing, embody an epoxy binder conforming to ASTM C881 Type III. The type, grade, and class shall be appropriate for the application as specified in ASTM C881.
3. Shrinkage-compensating or nonshrink Portland-cement grout conforming to ASTM C1107.
4. Packaged dry concrete repair materials conforming to ASTM C928.
5. Products: Poly-Patch by Euclid Chemical Company; Emaco R310 by BASF Chemical Company; Sikatop 122 Plus by Sika Chemical Corporation or approved equal only if approved by the Engineer for use and for color match.

D. Provide cement repair mortar with strength and modulus of elasticity compatible with the parent concrete.

2.03 EPOXY PASTE

A. Two-component, solvent-free, asbestos free, moisture insensitive epoxy resin material used to bond dissimilar materials to concrete and shall comply with the requirements of ASTM C881, Type I, Grade 3. It may also be used to patch existing surfaces where the glue line is 1/8-in or less.

B. Provide grey colored epoxy paste.

C. Products: Sikadur 31 Hi-mod Gel by Sika Corporation, Lyndhurst, NJ; Concresive Paste LPL by BASF, Shakopee, MN; or approved equal.

2.04 NON-SHRINK GROUT AND NON-SHRINK EPOXY GROUT

A. See Section 03600.

2.05 STRUCTURAL CRACK REPAIR EPOXY ADHESIVE

A. Two-component, solvent-free, moisture insensitive epoxy resin material suitable for crack grouting by injection or gravity feed. Formulated for the specific size of opening or crack being injected.

B. For standard applications: Sikadur 35 Hi-Mod LV by Sika Corporation, Lyndhurst, NJ; SCB Concresive 1380 by BASF, Shakopee, MN; or approved equal.

C. For very thin applications: Sikadur 35 Hi-Mod LV LPL by Sika Corporation, Lyndhurst, NJ; SCB Concresive 1360 by BASF, Shakopee, MN; or approved equal.

2.06 FLEXIBLE CRACK REPAIR EXPANDING POLYURETHANE CHEMICAL GROUT

A. High solids, hydrophobic polyurethane, liquid chemical grout suitable for pumping into cracks and voids (honeycombed) to stop water infiltration. Formulate for the specific size of opening or crack being injected. One component product with accelerator. Permanently flexible product.

B. Products: SikaFix HH by Sika Corporation, Lyndhurst, NJ; Concresive 1230 IUG by BASF, Shakopee, MN; or approved equal.

2.07 ADHESIVE ANCHORS

A. See Section 05090.

PART 3 - EXECUTION

3.01 GENERAL

A. Inspect concrete surfaces immediately after carefully removing forms. Repair tie holes and surface defects immediately after formwork removal. Defective work includes concrete out of line, level or plumb; cracks; poor joints; rock pockets; honeycomb; voids; spalls and exposed reinforcing. Patch minor defects, including form tie holes, before the concrete is thoroughly dry. Do not interrupt the curing program. Ensure that repairs match the existing surface for color and texture.

B. Large areas involving voids or rock pockets extending through the section may be cause for rejection of the work. If acceptable repairs can be made without adversely affecting the structural integrity of the work, cut out the section and either dry pack, or reform and re-pour to match the adjacent concrete. Do not cut the reinforcing, but cut keyways into the adjacent sound concrete to securely fasten the patch to the original work.

C. Plug tie holes except where stainless steel ties, non-corroding ties, or acceptably coated ties are used, except plug tie holes in concrete surfaces exposed to liquid. When Portland-cement patching mortar is used for plugging, clean and dampen tie holes before applying the mortar. When other materials are used, apply them in accordance with manufacturer’s recommendations.

D. Cut, repair, remove, or otherwise modify parts of the existing structures or appurtenances, as indicated on the Drawings, specified, or necessary to complete the work. Finishes, joints, reinforcements, sealants, etc., are specified in their respective sections.

E. Store, mix and apply commercial products in strict compliance with the manufacturer's recommendations.

F. Preserve the isolation between components on either side of the joint in cases where concrete is repaired in the vicinity of an expansion joint or control joint.

G. When drilling holes for dowels/bolts, stop drilling if rebar is encountered. As approved by the Engineer, relocate the hole to avoid rebar. Do not cut rebar without prior approval by the Engineer. Identify rebar at all locations where possible, prior to drilling using nondestructive rebar locator equipment so that drill hole locations may be adjusted to avoid rebar interference.

H. Keep rebar a minimum of 1-inch away from all embedded metallic piping, wall thimbles, spools, sleeves, and similar metals to avoid the creation of an electrically continuous path.

I. Remove stains, rust, efflorescence, and surface deposits.

3.02 CONCRETE REMOVAL

A. Line drilling at limits of removal followed by chipping or jack-hammering, concrete designated to be removed to specific limits as directed by the Engineer. Proceed carefully to avoid damage to reinforcement. When chipping is necessary, leave chipped edges perpendicular to the surface or slightly undercut. Do not feather edges. Remove concrete in such a manner that surrounding concrete and existing reinforcing to be left in place and existing in place equipment are not damaged. Only sawcut at limits of concrete to be removed after obtaining written approval from the Engineer.

B. Apply a coating or surface treatment of epoxy paste to a thickness of 1/4 inch where existing reinforcing is exposed due to saw cutting/core drilling and no new material is to be placed on the cut surface.

C. Saw cut to a 1 inch depth on exposed surfaces of the existing concrete where the joint between new concrete or grout and existing concrete will be exposed in the finished work

D. Repair concrete specified to be left in place by approved means.

3.03 CONCRETE SURFACE PREPARATION AND REPAIR

A. Prepare connection surfaces as specified below for concrete areas requiring patching, repairs or modification as directed by the Engineer.

B. Remove all deteriorated materials, dirt, oil, grease, and all other bond inhibiting materials from the surface by mechanical or physical means, i.e. – water blasting, chipping, etc. Uniformly roughen the concrete surface to approximately 1/4-inch amplitude with pointed chipping tools. Thoroughly clean surface of loose or weakened material by sandblasting or air blasting. Irregular voids or surface stones need not be removed if they are sound, free of laitance, and firmly embedded into parent concrete.

C. If honeycomb exists around reinforcement or if reinforcing steel is exposed, it must be mechanically cleaned to remove all loose material, contaminants, rust, etc. If half of the diameter of the reinforcing steel is exposed, chip out behind the steel. The distance chipped behind the steel shall be a minimum of 1 inch. Reinforcing to be incorporated in new concrete shall not be damaged during the removal operation.

D. The following are specific concrete surface preparation and repair "methods" to be used where directed by the Engineer.
   1. Method A - After the existing concrete surface at connection has been roughened and cleaned, thoroughly saturate with water and maintain saturation for a period of at least 12 hours. Dampen the area to be patched, plus another 6 inches around the patch area perimeter. Prepare bonding grout by mixing approximately one part cement and one part fine sand with water to the consistency of thick cream. Thoroughly brush bonding grout into the surface. When the bonding grout begins to lose water sheen, apply cement repair mortar, in accordance with Section 03300, and thoroughly consolidate mortar into place. Strike off mortar, leaving the patch slightly higher than the surrounding surface to permit initial shrinkage. Leave the patch undisturbed for 1 hour before finishing. Keep the patch damp for 7 days.
   2. Method B - After the existing concrete surface has been roughened and cleaned, apply epoxy bonding agent at connection surface. Comply with the manufacturer's recommendations for the field preparation and application of the epoxy bonding agent. Place new concrete or grout mixture within time constraints recommended by the manufacturer to ensure bond. Thicker repairs may require build-up in successive 1-1/2-inch layers on successive days. Form surfaces as required to prevent sagging.
   3. Method C – Install adhesive anchors or dowels strictly comply with the manufacturer's recommendations.
   4. Method D - Combination of Method B and C.

3.04 GROUTING

A. Grouting in accordance with Section 03600.

3.05 CRACK REPAIR

A. Repair cracks in liquid containing concrete structures with widths greater than

B. 0.010 inches and cracks 1/32 inch or wider in other surfaces. Repair leaking cracks.

C. Repair cracks on horizontal surfaces by gravity feeding crack repair epoxy adhesive into cracks per manufacturer's recommendations. Pressure inject if cracks are less than 1/16-inch in width.

D. Repair cracks on vertical surfaces by pressure injecting crack repair epoxy adhesive or expanding polyurethane chemical grout through valves sealed to surface with epoxy paste per manufacturer's recommendations.

E. For structural nonmoving cracks that require structural bonding of cracked surfaces, use epoxy adhesive injection materials and methods.

F. For leaking cracks and cracks that have movement, use expanding polyurethane chemical grouts that have been premixed and injected into the structure in accordance with manufacturers' recommendations

G. Complete crack repairs before conducting the leakage test.

3.06 CONCRETE FINISHING

A. Refer to Section 03350.

3.07 FIELD QUALITY CONTROL

A. Concrete Curing:
   1. See Section 03330.
   2. Verify procedures and equipment is available for controlling concrete temperature during hot and cold weather conditions.
   3. Verify actual time of application of curing materials for each placement.

3.08 CLEANUP

A. Upon completion of all work performed under this Section, remove from the site all excess materials, storage facilities and temporary facilities. Smooth and clean of debris all areas that were used or occupied during concrete construction operations and leave in first-class condition.

END OF SECTION

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SECTION 04050

BASIC MASONRY MATERIALS AND METHODS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Basic information about mortar materials, admixtures, grout, anchors, ties, reinforcing, and other accessories used in the installation of masonry.

B. Related Sections
   1. Section 03200: Concrete Reinforcement and Reinforcement Supports
   2. Section 04220: Concrete Masonry Units

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C94 Specification for Ready-Mixed Concrete
   2. C143 Test Method for Slump of Hydraulic Cement Concrete
   3. C144 Specification for Aggregate for Masonry Mortar
   4. C150 Specification for Portland Cement
   5. C207 Specification for Hydrated Lime for Masonry Purposes
   6. C270 Specification for Mortar for Unit Masonry
   7. C404 Specification for Aggregates for Masonry Grout
   8. C476 Specification for Grout for Masonry
   9. C780 Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry
   10. C1019 Test Method for Sampling and Testing Grout
   11. C1059 Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete
   12. C1586 Standard Guide for Quality Assurance of Mortars
   13. A615 Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement

B. International Masonry Industry All Weather Council (IMIAC): Recommended Practices and Guide Specifications for Cold Weather Masonry Construction.

C. Building Code Requirements for Masonry Structures (ACI 530/ASCE 5/TMS 402)

D. Specification for Masonry Structures (ACI 530.1/ASCE 6/TMS 602)

E. International Building Code (IBC) 2012 Edition and California Building Code (CBC) 2013 Edition.

1.03 SUBMITTALS

A. Product Data: Fully describe every item proposed for use.
   1. Mortar mix design indicating types and proportions of materials in accordance with ASTM C270.

2. Grout mix design indication types and proportions of materials in accordance with ASTM C476.
3. Aggregates for grout and mortar.
4. Cementitious materials.
5. Admixtures proposed for use in grout.
6. Grout Mix Test Results: See paragraph 2.03.A for requirements.

B. Samples:
1. Submit color charts and one complete physical color pallet of the manufacturer's standard colors for color selection by the Owner's Representative.
2. Submit two physical samples of each of the selected mortar colors. The District's Representative may select up to 4 colors for final selection.
3. Quality Control Sample: as required in Section 04220.

C. Quality Assurance/Control Submittals
1. Test Reports: Inspection and test reports for mortar and grout per ASTM C780, ASTM 1586, and ASTM C1019.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Storage and Protection: Store material under cover and protected from moisture and from contamination by dirt, mud or other foreign material.

1.05 PROJECT/SITE CONDITIONS

A. Environmental Requirements: Comply with requirements of ACI 530.1, IMIAC, and as noted below:
1. Cold Weather Requirements: When ambient temperature is below 40°F. Maintain all materials at or above 40ºF during mixing, placing, and for 48 hours after placement. Protect materials or heat materials, protect, enclose, or heat work areas. Maintain temperature of mortar and grout below 90°F.
2. Hot Weather Requirements: When ambient temperature exceeds 90°F. Maintain temperature of mortar and grout below 90°F. Fog spray new completed masonry work for 72 hours.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Admixtures: Not permitted unless approved by Engineer prior to construction.

B. Aggregate:
1. Mortar Aggregate: ASTM C144~~.~~ Uniformly grade from fine to coarse. Allow not more than 2% by weight of deleterious substances.
2. Grout Aggregate: ASTM C404 for Coarse Grout.

C. Cement: Portland cement, ASTM C150, Type II, and meeting the requirements of low alkali cement in conformance with Table 2 of ASTM C150. Masonry cement is not permitted.

D. Flyash: ASTM C618, Class F.

E. Hydrated Lime: Conform to ASTM C207, Type S.

F. Reinforcing Steel: Conform to ASTM A615, Grade 60.

G. Water: Potable and free from excess alkalis.

2.02 ACCESSORIES – NOT USED

2.03 MIXES

A. Grout:
1 Proportion Portland cement, hydrated lime, fine and coarse aggregates conforming to ASTM C476 for Coarse Grout.
4. Compressive strength: 2,500 psi, minimum at 28 days when tested per ASTM C1019.
3. Cement content of the grout shall be increased, as necessary to achieve the specified masonry assembly strength (*f'm*) and adequate workability.
4. If cementitiuos materials include flyash, provide flyash not less than 10%, nor more than 20% of the weight of the cementitious materials.
5. Slump: 8 to 10 inches in accordance with ASTM C143.

B. Mortar: Type "S" and complying with ASTM C270 Tint mortar with mineral oxide colors to match selected block color.

2.04 SOURCE QUALITY CONTROL

A. Tests, Inspection:
1. Verify that ready-mix batch plant delivery tickets contain product information necessary for acceptance of the grout delivered to site.
2. Verify that the mixing and trucking equipment have adequate capacity to deliver the grout batches to site on time, thoroughly mixed and discharge without segregation.

PART 3 - EXECUTION

3.01 PREPARATION

A. Protection: Store material protected from moisture and from contamination by dirt, mud or other foreign material. Protect materials from adverse environmental conditions in accordance with the requirements of ACI 530.1 and IMIAC.

B. Surface Preparation: Sandblast concrete foundation or slab to expose aggregate. Use bonding agent to bond the first layer of mortar setting bed to the concrete slab or foundation.

3.02 MIXING MORTAR

A. Mix mortar ingredients in accordance with ASTM C270. Proportion mortar by volume using containers of known volume.

B. Mix ingredients in a paddle type (plastic) mixer for at least 3 minutes.

C. Add only enough water to produce a plastic mix. Do not retemper mortar, which has begun to hydrate. Any mortar that is unused within 2 hours after initial mixing shall be removed from the work.

3.03 MIXING GROUT

A. Plant batch grout by weight and mix in transit in accordance with ASTM C94 or ASTM C476. Any grout that is unused within 1 ½ hours after initial mixing shall be removed from the work.

3.04 INSTALLATION

A. Seal cleanout holes with masonry units after inspection and before grouting. Use a high-pressure jet stream of water to remove mortar fins and any foreign matter from the grout space.

B. Install mortar and grout under provisions of Section 04220.

3.05 CONSTRUCTION

A. Interface with Other Work: Embedded items (bolts, etc.) shall be secured in place prior to grouting. Embed anchors, ties, and sleeves required to accommodate the work of others.

3.06 FIELD QUALITY CONTROL

A. Site Tests:
   1. Test grout for compressive strength in accordance with ASTM C1019. Test one grout sample, consisting of three cylinders, for each 5,000 square feet of wall area, but not less than one set of three specimens per project.
   2. Test mortar for compressive strength in accordance with ASTM C780. Make one mortar sample, consisting of three cylinders, at the beginning of the masonry work on three successive days and at one week interval thereafter.

3.07 CLEANING

A. See Specification 04220.

3.08 PROTECTION

A. See Specification 04220.

END OF SECTION

SECTION 04220

CONCRETE MASONRY UNITS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Manufactured concrete masonry units; both load-bearing and non-load-bearing and intended for use in masonry assemblies with mortar.
   2. Related reinforcing.

B. Related Sections
   1. Section 03200: Concrete Reinforcement and Reinforcement Supports
   2. Section 04050: Basic Masonry Materials and Methods

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C33 Specification for Concrete Aggregates
   2. C90 Specification for Loadbearing Concrete Masonry Units
   3. C140 Test Methods for Sampling and Testing Concrete Masonry Units and Related Units
   4. C150 Specification for Portland Cement
   5. C331 Specification for Lightweight Aggregates for Concrete Masonry Units
   6. C341 Test Method for Length Change of Drilled or Sawed Specimens of Hydraulic-Cement Mortar and Concrete
   7. C426 Test Method for Drying Shrinkage of Concrete Masonry Units
   8. D75 Practice for Aggregates Sampling
   9. C1388 Standard Test Methods for Compressive Strength of Laboratory Constructed Masonry Prisms

B. "Masonry Design Manual" published by the Masonry Industry Advancement Committee.

C. "2015 Design of Reinforced Masonry Structures" published by the Concrete Masonry Association of California and Nevada.

D. Building Code Requirements for Masonry Structures (ACI 530/ASCE 5/TMS 402).

E. Specification for Masonry Structures (ACI 530.1/ASCE 6/TMS 602).

F. International Masonry Industry All Weather Council (IMIAC): Recommended Practices and Guide Specifications for Cold Weather Masonry Construction.

G. International Building Code (IBC) 2012 Edition and California Building Code (CBC) 2013 Edition**.**

1.03 DEFINITIONS

A. Lift: The height of grout that is placed in a single, continuous operation before consolidation.

B. Pour: The total height of masonry that is grouted prior to erection of additional masonry.

C. Exterior Units: Concrete masonry units placed with exterior exposed surfaces.

D. Interior Units: Concrete masonry units placed with no exterior surfaces.

E. Interior Face: Any surface of concrete masonry units that are on the inside of structures and not exposed to weather.

F. Exterior Face: Any surface of concrete masonry units that is exposed to weather or buried.

1.04 SUBMITTALS

A. Submit in accordance with Section 01300:

B. Product Data: Fully describe every item proposed for use. Manufacturer's technical information for materials, systems, mixing, installation and curing procedures.

C. Shop Drawings: Submit detailed shop drawings for reinforcing steel showing the number, grade, size, length, mark, location, and bending diagrams for reinforcing steel in accordance with the ACI Detailing Manual.

D. Samples: Masonry units proposed for use on the project.

E. Colors and Samples:
1. Color charts showing manufacturer's complete line of standard color.
2. 2–inch by 2-inch (50mm by 50mm) minimum physical samples of colors and textures chosen by the Owner's Representative. The Owner's Representative will use the physical samples to select the colors for the Quality Control sample.
3. Quality Control Sample: Full size sample consisting of a minimum of 4 of each type of unit specified on the project with colored mortar in the texture and color selected by the Owner.

F. Quality Assurance/Control Submittals
1. Test Reports: Test reports for units per ASTM C140.
2. Certificates: Manufacturer's certification that masonry units were manufactured and wet cured for 28 days (or equivalent steam cure) prior to delivery.

1.05 QUALITY ASSURANCE

A. Verification of f'm of concrete masonry shall be achieved by the Unit Strength Method in accordance with TMS 602 Specification 1.4B. Comply with ASTM C140. Prior to construction, submit test results on three units. Test results must comply with TMS 602 Specification Table 2. Submit test results for mortar and grout in accordance with Section 04050.

B. All construction or work shall be subject to inspection by the local building official and the Owner's representative. The Contractor shall make work or construction accessible and exposed for inspection of the cells and for the size and placement of reinforcement, anchors, or other imbedded items.

C. See Drawings for buildings, structures or structural elements requiring special inspection. Special inspection shall be in accordance with IBC Section 1704 and shall be Level II inspection.

1.06 DELIVERY, STORAGE AND HANDLING

A. Acceptance at Site: Remove chipped, cracked, and otherwise defective units from jobsite.
   1. Storage and Protection: Store material protected from moisture and from contamination by dirt, mud or other foreign material. Concrete masonry units shall not be wetted.

1.07 COORDINATION

A. Coordinate with other trades whose items that require embedment into masonry. Build in items furnished under other sections as work progresses.

1.08 PROJECT/SITE CONDITIONS

A. Environmental Requirements: Comply with requirements of ACI 530.1 and IMIAC. See Section 04050.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Best Blocks, Inc., of Sacramento and Newark, CA; Basalite Concrete Products, Dixon, CA; or equal.

B. Angelus Block Company, Inc., of Sun Valley, CA; Air Vol Block, Inc., of San Luis Obispo, CA; Orco Block Company, Inc., of Stanton, CA; or equal.

2.02 MATERIALS

A. Hollow Load Bearing Concrete Masonry Units:
   1. Minimum compressive strength of 1,900 psi when wet cure (or equivalent steam cure) for a minimum of 28 days before delivery to the site.
   2. Maximum linear shrinkage of 0.065% from saturated to oven dry conditions, when tested in accordance with ASTM C426.
   3. Lightweight aggregate in accordance with ASTM C331.
   4. Manufacture units using concrete that weights between 85 and 105 pounds per cubic foot when measured in accordance with ASTM C140.
      Typical Masonry Units: 8x8x16 nominal.
      a. Exterior units: gray unless otherwise noted on the Drawings.
      b. Exterior surfaces smooth unless otherwise noted on the Drawings.
   5. Provide bond beam, lintel, half, pilaster, wall, cap masonry units, and other special shapes and sizes required. Provide double open-end, units unless noted otherwise on the Drawings. Use lintel masonry unit units where underside of lintel will be exposed.
   6. Special Units: Provide required special units. Where special units are not available from the supplier, cut available units and fabricate required special shapes by epoxy bonding.

B. Cleaning Materials: Sure Klean 600 Detergent, by ProSoCo, Inc. or equal. Efflorescence Control System (ECS), by ProSoCo, Inc. or equal.

C. Expansion Joint Filler: Sponge rubber complying with ASTM D1752 Type 1.

D. Sealant Materials: As specified in Section 07900.

E. Reinforcing Steel: Conform to ASTM A615, Grade 60. Detail and fabricate reinforcing steel in accordance with the requirements for reinforcing steel in Section 03200 and as shown on the Drawings.

PART 3 - EXECUTION

3.01 PREPARATION

A. Surface Preparation:
   1. Coordinate the number, size, length, and location of reinforcing dowels between concrete work and masonry.
   2. Clean reinforcement of mill scale, loose rust, oil and coatings.
   3. Sandblast concrete foundation or slab to expose aggregate.
   4. Use bonding agent to bond the first layer of mortar setting bed to the concrete slab or foundation.

B. Cut masonry units accurately and cleanly to size with power driven masonry saws.

C. Protection: Protect materials and completed work from cold and hot weather in accordance with building codes and the recommendations of the International Masonry Industry All Weather Council (IMIAC): Recommended Practices and Guide Specifications for Cold Weather Masonry Construction.

3.02 INSTALLATION OF REINFORCING

A. Conform to the requirements for reinforcing steel in Section 03200.

B. Anchor reinforcing bars in straight alignment and secure against displacement with metal positioners spaced not further apart than 200-bar diameters.

C. Lap reinforcing steel in accordance with the Drawings.

D. Tie at intersections using 16-gauge annealed wire.

E. Provide ½-inch minimum clear distance between masonry and reinforcing.

F. Should the location of the vertical dowel conflict with other work including placement of embedded items, walls of the masonry units or openings in walls notify the Owner.

3.03 CONSTRUCTION

A. General:
   1. Lay masonry unit in running bond.
   2. Lay masonry units so the vertical cells line up and are not obstructed by excess mortar
   3. Unless noted otherwise on the Drawings, provide additional vertical reinforcing bar at every corner and each side of every wall opening.
   4. Unless noted otherwise on the Drawings, construct horizontal bond beams reinforced with one bar at the top and bottom of walls and at intermediate locations where shown, but not farther apart than 2 feet.
   5. Construct bond beams over openings reinforced as shown.
   6. Fully bed webs and cross walls forming such cells in mortar to prevent leakage of grout.
   7. Grout all cells unless otherwise noted on the Drawings.

B. Cleanouts

1. Provide cleanout openings in the bottom course of cells containing vertical reinforcing. Spacing of cleanout openings shall not exceed 2 feet 8 inches.
2. Locate cleanouts on the inside face of the exterior walls; seal cleanouts with masonry units after inspection and before grouting.
3. Remove mortar fins and any foreign matter from the grout space.
4. Cleanouts may be eliminated if grout pour height is reduced to a maximum of 2 feet.

C. Joints:
1. Set units with 3/8-inch-thick mortar joints. Compress partially set mortar with a convex tool to produce a concave, dense, and smooth joint surface.
2. Set units with joints straight and uniform in width in accordance with ACI 530.1.
3. Butter head joints solid for the thickness of the face shell so that there are no voids between abutting faces. Set units in bed joints that are filled solid with mortar for the thickness of the face shell.
4. Remove mortar fins that project more than 3/8 inch into the grout cell.
5. If a unit is repositioned after placing, it shall be completely removed, cleaned and reset in fresh mortar.
6. Set lintels, capping units, and bearing plates in a full bed of mortar.
7. Locate control joints as shown on the Drawings or at 20 feet maximum spacing where not shown, but not less than 2 feet from a jamb or opening.
8. Place bond beam reinforcing continuous through expansion and control joints, wrapping bars with 1/8-inch thick bond breaking tape 2 feet both sides of joint. Do not splice bond beam reinforcing within 6 feet of an expansion or control joint.
9. Apply sealant as specified in Section 07900.

D. Grouting:
1. Limit maximum height of grout pour to 5 feet 4-inch unless otherwise favorably reviewed by the Engineer.
2. Place grout in the reinforced hollow concrete masonry unit wall after the units have been set for at least 24 hours.
3. Place grout using a method to avoid segregation.
4. Fill all cells solid with grout unless otherwise noted on the Drawings. Consolidate grout by mechanical vibration unless self-consolidating grout is specifically approved by the Engineer.
5. Consolidation of the succeeding grout lift and the reconsolidation of the previous grout lift may be done in the same operation. Reconsolidate each lift after initial water loss and settlement has occurred.
6. If grouting is done in multiple lifts stop the top surface of the grout of each lift 1½ inches below a mortar joint, except at the top of a wall. When grouting bond beams stop the grout pour ½ inch below the top of the masonry unit.
7. Form grout key between pours by terminating the grout a minimum of 1½ inches below the mortar joint. Do not form grout keys within beams.
8. Discontinue placement of grout within 90 minutes after the addition of water.

E. Interface with Other Work
1. Embedded items shall be secured in place prior to grouting.
2. Provide a minimum of 1/2-inch grout around bolts in masonry.
3. Build in or embed other work required to be built into masonry only where shown on the Drawings.
4. At openings for ducts, pipes, and conduit, cut to half or full unit dimensions.

F. Site Tolerances:
   1. Unless noted otherwise vertical wall reinforcement shall be placed at center cell within +/- ½-inch tolerance measured in the direction perpendicular to the wall plane, and within +/- 1-inch measured in the plane of the wall.
   2. Lay masonry plumb, true to line with courses level. Keep bond pattern plumb throughout. Lay masonry within ¼-inch tolerance in 10 feet maximum variation in plumb in the lines and surfaces of columns and walls and in the flutes and surfaces of fluted or split face masonry units.
   3. Other masonry unit and reinforcing tolerances shall be within the tolerances specified in ACI 530.1.

3.04 REPAIR/RESTORATION

A. Remove from exposed surfaces surplus mortar, grout, foreign material and stains.

B. Replace unevenly laid units.

C. Replace chipped or broken masonry units.

D. Point holes or defective mortar joints in exposed masonry and cut-out and re-point defective joints. Repoint cracks in mortar joints with a pointing mortar.

E. Repair cracks wider than 4 mils.

3.05 FIELD QUALITY CONTROL

A. Site Tests: Test three units for each 5,000 square-feet of wall area, but not less than one set of three units per project. Test results must comply with IBC Table 2105.2.2.1.2. Submit test results for mortar and grout in accordance with Section 04050.

B. Special Inspection: Maintain work accessible and exposed by the Owner's Representative in order to provide inspection in accordance with ACI 530 Section 1.19. The level of inspection shall be as noted on the Drawings.

3.06 CLEANING

A. Clean masonry surfaces of stains, efflorescence, mortar, and grout droppings by scrubbing with water, masonry cleaner and bristle brushes. Do not clean with muriatic acid. Do not use high pressure cleaning equipment.

3.07 PROTECTION

A. Cure mortar joints by keeping masonry units and joints damp for 10 days after laying units by applying a very fine water mist spray and covering work with polyethylene sheeting.

B. When the possibility of rain occurs prior installation of roofing or cap blocks at the top of walls, cover the tops and face of walls exposed to the weather, and concrete masonry units with sheets of polyethylene film.

END OF SECTION

SECTION 05090

STRUCTURAL METAL FASTENERS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. All anchors, including mechanical and adhesive anchors, adhesive rebar dowels, eye bolts, turnbuckles, cable clamps, bolts, nuts, washers, inserts, and other metal fasteners not specified elsewhere.

B. Related Sections:
   1. Section 03200: Concrete Reinforcement and Reinforcement Supports
   2. Section 03300: Concrete Mixtures, Handling, Placing, and Constructing
   3. Section 05100: Structural Metal Framing

1.02 REFERENCES

A. American Institute of Steel Construction Specifications:
   1. ANSI/AISC 360-16 Specification for Structural Steel Buildings

B. Research Council on Structural Connections:
   1. RCSC Specification for Structural Joints Using ASTM A325 or A490 Bolts, 2004

C. American Iron and Steel Institute (AISI)

D. American National Standards Institute:
   1. ANSI B18-2-1 Square and Hex Bolts and Screws
   2. ANSI B18-2-2 Square and Hex Nuts
   3. ANSI B18-21-1 Lock Washers
   4. ANSI B18-22-1 Plain Washers

E. ASTM International (ASTM) Standard Specifications:
   1. ASTM A123 Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products
   2. ASTM A153 Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   3. ASTM A325 Structural Bolts, Steel, Heat-Treated
   4. ASTM A370 Test Methods and Definitions for Mechanical Testing of Steel Products
   5. ASTM A500 Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
   6. ASTM A525 Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
   7. ASTM A563 Carbon and Alloy Steel Nuts
   8. ASTM B633 Electrodeposited Coatings of Zinc on Iron and Steel
   9. ASTM E8 Test Methods for Tension Testing of Metallic Materials
   10. ASTM F436 Hardened Steel Washers
   11. ASTM F844 Washers, Steel, Plain (Flat), Unhardened for General Use

12. ASTM F959 Compressible-Washer-Type Direct Tension Indicator for Use with Structural Fasteners
13. ASTM F1554 Anchors Bolts, Steel, 36, 55, and 105-ksi Yield Strength

F. International Code Council (ICC)
1. Evaluation Service Reports
2. AC 193 Acceptance Criteria for Mechanical Anchors in Concrete Elements
3. AC 308 Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements

G. California Building Code (CBC) 2019 Edition.

1.03 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Product Data:
1. Adhesive anchors, reinforcing steel dowels and expansion anchors.
2. Insulation between dissimilar metals.

C. Samples: Manufacturer's latest standard product: Specify special or unique products.

D. ICC Evaluation Service Reports for all anchors submitted demonstrating compliance with 2019 CBC and ICC AC 193 or 308 for Mechanical or Adhesive anchors respectively. Reports for concrete anchors shall demonstrate approval for use in cracked concrete in Seismic Design Categories A-F. Reports for masonry anchors shall demonstrate approval for use for seismic loads when attached to CMU.

E. List of all anchors to be used including:
1. Location, diameter, material type, number and length of anchors
2. Testing plan for anchors, including percentage of anchors to be tested and allowable loads for anchors and testing loads.
3. Certified Verification Testing Report:
a. Certified by an independent testing laboratory or registered professional engineer.
b. Detailing results of testing required in paragraph 1.04.C.2.

1.04 QUALITY ASSURANCE

A. General:
1. Furnish materials and fabricated items from an established and reputable manufacturer or supplier.
2. Supply all new materials and fabricated items made from first class ingredients and construction and guaranteed to perform the service required.
3. For adhesive anchorage, Contractor shall be trained by anchor product manufacturer representative and be provided with a certificate or card of completion, to be available upon request by the Special Inspector.

B. Codes and Standards:
1. Bolting: General: AISC Specifications.

C. Tests:
   1. General: The Owner shall provide Special Inspection, defined by CBC Chapter 17 and as noted in the ICC-ES report for the anchor. The Contractor shall provide and pay for verification testing for mechanical and adhesive anchoring systems described below. Installation inspection shall be periodic special inspection or continuous special inspection as required by the ICC ES report of by the Design or Specialty Engineer.
   2. Verification Testing for Mechanical expansion and adhesive anchoring systems:
      a. Do not begin installation until testing plan has been favorably reviewed by the engineer. Contractor shall be responsible for all damage, including damage to adjacent structural elements, resulting from use of loads not favorably reviewed by the engineer.
      b. Test required anchors to the loads in the tables in Section 3.03 for the named anchors. For all other anchors, test to loads, verified in advance by the engineer, representing twice the allowable load for the anchor, or 0.5 times the maximum strength design (ultimate) load of the anchor:
      c. Expansion and adhesive anchors shall be tested as follows:
         1) Test 10% of anchors used for sill plate bolting applications
         2) Test 50% of anchors used for non-structural applications, such as equipment anchorage.
         3) Test 100% of anchors for applications not listed above.
      d. Undercut anchors that allow visual confirmation of full set need not be tested.
      e. Visual inspection of layout including horizontal location, minimum embedment, minimum cover, minimum spacing, and minimum edge distance.
      f. Test anchors by a calibrated torque wrench, direct pull with a hydraulic jack, or a calibrated spring loaded devices. Testing shall be performed on a single anchor and shall be done in a “confined” manner, where the testing equipment prevents concrete breakout in tension. Torque wrench method shall not be used for screw anchors, or where additional torque will damage the installed condition.
      g. Anchors tested using the torque wrench shall achieve the load within ½ turn of the nut. Prior to testing, the nut shall be snug to the manufacturer’s recommended installation tightness.
      h. Anchors tested using a hydraulic ram shall be tested to the required load for a minimum of 15 seconds and shall not exhibit any discernable movement during the loading, such as loosening of the washer under the nut or an observable gap.
      i. Anchors which do not pass the test shall be considered defective work, and such failures shall be corrected at no additional cost to the owner, including any indirect costs necessary to relocate or reinstall anchors.

D. Additional Tests: Provide and pay for all necessary additional tests made on welds or bolts required to repair or replace faulty work performed during the original fabrication.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Handle, ship, and store material in a manner that will prevent distortion, rust, damage to the shop coat or any other damage.

B. Store material in a clean, properly drained location out of contact with the ground.

C. Ensure that dissimilar metals are not in contact with each other.

D. Replace or repair all damaged material in an approved manner.

PART 2 - PRODUCTS

2.01 METAL FASTENERS

A. General:
   1. For buried, submerged, or conditions where anchors or fasteners will be continuously or intermittently wet, except where otherwise shown or specified, all bolts, anchor bolts, mechanical anchors, adhesive anchors, washers, and nuts shall be 316 stainless steel .
   2. For exterior or exposed conditions provide 316 stainless steel except where otherwise shown or specified.
   3. For all other exposure conditions provide hot dipped galvanized materials, except where otherwise shown or specified.

B. Bolting – Steel:
   1. Bolts: High Strength Bolts: ASTM 325, heavy hex, Type 1 (High Strength Bolts) OR ASTM A307, Grade A (Regular Hexagon Bolts)
   2. Nuts: ASTM A563, heavy hex, Grade DH (High Strength Nuts) OR ASTM A563, Grade A (Regular Hexagon Nuts)
   3. Washers: ASTM F436, Type 1, hardened (High Strength Bolt Washers) OR ASTM F 844 (Regular Bolt Circular Washers)
   4. Lock Washers: ANSI B18.21.1
   5. High Strength Direct Tension Indicators: ASTM F959.
   6. Dimensional Requirements:
      a. Bolts: ANSI B18.2.1.
      b. Nuts: ANSI B18.2.2.

C. Bolting – Stainless Steel:
   1. Stainless Steel Bolts: AISI 316. ASTM A193 or F593.18-8 material is not acceptable.
   2. Stainless Steel Nuts: ASTM A194 or F594.
   3. Washers: AISI 316 washers meeting the dimensional requirements of ASTM F436
   4. Dimensional Requirements:
      a. Bolts: ANSI B18.2.1.
      b. Nuts: ANSI B18.2.2.

D. Cast-in-Place Anchor Bolts:
   1. Headed Anchors: ASTM F1554, Grade 36, unless Grade 55 or 105 is shown on the Drawings. High Strength anchors on Drawings shall be Grade 55 minimum.
   2. Threaded & Nutted Anchors: ASTM F1554, Grade 36 with threaded ends and double hex nuts at the anchored end, or with washer between anchoring nuts if shown on the drawings. Use heavy hex nuts for rods 1¾" diameter or greater. Provide Grade 55 or 105 if shown on the Drawings and use heavy hex nuts. High Strength anchors on Drawings shall be Grade 55 minimum.

3. Welded Headed Studs or Welded Hooked Studs: AWS D1.1, Grade B, fut = 60 ksi, fy = 50 ksi.
4. Hooked Anchors (J and L Bolts): Are not allowed unless specifically shown on the Drawings as they do not provide equivalent performance. If shown, provide ASTM F1554, Grade 36, unless Grade 55 or 105 is shown on the Drawings. High Strength anchors on Drawings shall be Grade 55 minimum.
5. Hooked anchor bolts shall not be used in concrete masonry unit construction.
6. Provide minimum embedment shown on the Drawings, or a minimum of eight bolt diameters.

E. Mechanical Anchoring Systems (friction anchors are not acceptable):
   1. Mechanical Undercut Anchoring Systems (required for overhead applications):
      a. Anchor: Undercut anchor shall be of an undercut style with brazed tungsten carbides on the embedded end that perform the self-undercutting process.
      b. Carbon Steel Bolt and Sleeve:
         1) Bolt: ISO 898, class 8.8, or SAE Grade 5.
         2) Sleeve: AISI 1010.
         3) Nuts: ASTM A563 Grade A and meeting the dimensional requirements of ANSI B18.2.2.
         4) Washers: SAE 1005-1033 or AISI 1040 and meeting the dimensional requirements of ANSI B18.2.2 Type A Plain.
         5) Plating: Zinc plated in accordance with ASTM B633, SC1, Type III Fe/Zn 5.
      c. Stainless Steel Bolt and Sleeve:
         1) Bolt: AISI 316 or 316Ti.
         2) Sleeve: AISI 316 or 316Ti or Type 304 stainless steel.
         3) Nuts: DIN 934, grade 8.
         4) Washers: DIN 6796 or Type 18-8 stainless steel.
      d. Submit a product evaluation report by ICC-ES showing Cracked Concrete testing compliance per A.C.193.
      e. Provide embedment depth, edge distance, and anchor spacing as shown on the Drawings and in accordance with manufacturer's recommendations for published allowable loads.
      f. Manufacturer: Hilti, Inc. HDA Undercut Anchor, Simpson Torq-Cut (pending ICC approval) Atomic+ Undercut by Powers Fasteners or equal.
   2. Mechanical Expansion Anchoring Systems:
      a. Anchor: Expansion anchor shall be preassembled expanding sleeve or wedge type with a single piece three section wedge. Anchors shall meet the description of Federal Specification A-A 1923A or A-A 1922A, Type 4. Anchor will bear a length identification code that is visible after installation. Provide hex head stud style unless flat or rod coupler styles are noted on Drawings.
      b. Carbon Steel Anchors:
         1) Anchor Body: ASTM A510 or AISI 1018 or AISI 12L14 or SAE J403.
         2) Nuts: ASTM A563 Grade A and meeting the dimensional requirements of ANSI B18.2.2.
         3) Washers: SAE 1005-1033 or ASTM F844 and meeting the dimensional requirements of ANSI B18.2.2 Type A Plain.
         4) Plating: Zinc plated in accordance with ASTM B633, SC1, Type III Fe/Zn 5.
      c. Stainless Steel Anchors:

1) Anchor Body and Wedges: ASTM A276 or ASTM A493 with chemical composition of either AISI 304 or 316 or 316L.
2) Nuts: ASTM F594 with chemical composition of either AISI 304 or 316 or 316L.
3) Washers: ASTM A240 with chemical composition of either AISI 304 or 316 or 316L.

d. Submit a product evaluation report by ICC-ES showing Cracked Concrete testing compliance per A.C. 193.
e. Provide embedment depth, edge distance, and anchor spacing as shown on the Drawings and in accordance with manufacturer's recommendations for published allowable loads.
f. Manufacturer: Hilti, Inc. Kwik Bolt TZ, Simpson Strong-Bolt, Powers Fasteners, Power-Stud +SD1 or Power-Stud +SD2 (except ¼ inch diameter and not for use in masonry), or equal.

3. Concrete Screw Anchoring Systems
   a. Anchor: Concrete screws shall be self tapping and heat treated. Screw anchors shall have complete contact with the base material and shall not require oversized holes for installation. Anchors will bear a length identification code that is visible after installation.
   b. Carbon Steel Anchors:
      1) Anchor Body: High Yield Strength Carbon Steel (fy > 95 ksi)
      2) Plating: Zinc plated in accordance with ASTM B633, SC1 or Mechanically galvanized per ASTM B695, Class 65, Type 1.
   c. Submit a product evaluation report by ICC-ES showing Cracked Concrete testing compliance per A.C. 193.
   d. Provide embedment depth, edge distance, and anchor spacing as shown on the Drawings and in accordance with manufacturer's recommendations for published allowable loads.
   e. Manufacturer: Simpson Strong-Tie Titen HD Concrete Screw, Hilti Kwik HUS-EZ (Pending ICC approval) or equal.

F. Adhesive Anchoring Systems:
1. Adhesive (Epoxy) Injection Anchoring Systems:
   a. Adhesive: Adhesive consisting of two-component epoxy base resin and hardener material meeting the requirements of ASTM C-881 Types I and IV, Grade 3, Class C. The adhesive shall be supplied in manufacturer's standard side-by-side cartridge and dispensed through a static-mixing nozzle supplied by the manufacturer.
   b. Anchor Rod, Reinforcing Steel or Insert: Threaded Rod or insert with chamfered threaded end for ease of starting nut on one end and 45 degree chisel or cut point on opposite end (where insert is required by manufacturer). Furnish nuts and washers to meet the requirements of the rod or insert. Unless noted otherwise on the drawings provide hot dip galvanize rods or inserts or stainless steel. Stainless steel rods or inserts shall be provided in buried or submerged locations. Reinforcing Steel shall meet the requirements of Section 03200. All Reinforcing Steel indicated to be embedded in existing concrete shall be embedded using the epoxy injection systems.
      1) ASTM A36 or A307 (standard carbon steel anchor).
      2) ASTM A193 Grade B7 (high strength carbon steel anchor).
      3) Reinforcing bars as specified in Section 03200 with chisel or cut point.

4) AISI 304/ASTM A276 or AISI 316L/ASTM A276 stainless steel meeting the mechanical requirements of ASTM F-593 (Condition CW).

c. Submit a product evaluation report by ICC-ES showing Cracked Concrete testing compliance per A.C. 308.

d. Provide embedment depth, edge distance, and anchor spacing as shown on the Drawings and in accordance with manufacturer's recommendations for published allowable loads.

e. Manufacturer: Hilti HIT RE 500 V3 Epoxy Anchoring System, Hilti HIT HY-200, Simpson Strong-Tie SET-XP Epoxy, PE1000+ by Powers Fasteners or equal.

2. Adhesive (Ester) Injection Anchoring Systems (for use in CMU only):

a. Adhesive: Adhesive consisting of methacrylate resin or acrylic based adhesive, hardener, cement and water. The injectionable adhesive shall consist of two components and a static mixing nozzle as recommended by the manufacturer.

b. Anchor Rod or Insert: Threaded Rod or insert with chamfered threaded end for ease of starting nut on one end and 45 degree chisel or cut point on opposite end (where insert is required by manufacturer). Furnish nuts and washers to meet the requirements of the rod or insert. Unless noted otherwise on the drawings provide hot dip galvanized rods or inserts or stainless steel. Stainless steel rods or inserts shall be provided in buried or submerged locations.

1) ASTM A36 or A307 (standard carbon steel anchor).

2) ASTM A193 Grade B7 (high strength carbon steel anchor).

3) Reinforcing bars as specified in Section 03200 with chisel or cut point.

4) AISI 304/ASTM A276 or AISI 316L/ASTM A276 stainless steel meeting the mechanical requirements of ASTM F-593 (Condition CW).

c. Submit a product evaluation report by ICC-ES with seismic approvals.

d. Provide embedment depth, edge distance, and anchor spacing as shown on the Drawings and in accordance with manufacturer's recommendations for published allowable loads.

e. Manufacturer: Hilti HIT HY 200 Injection Adhesive Anchor, Simpson Strong-Tie SET, AC100+ Gold by Powers Fasteners, or equal. For materials with voids and holes like hollow block provide Hilti HIT HY 20 Injection Adhesive Anchor with wire mesh screen tubes for Masonry Construction, Simpson Strong-Tie Acrylic-Tie with ATS screens, or equal.

2.02 MISCELLANEOUS ITEMS

A. Turnbuckles: ASTM F1145 and AISI C-1035.

B. Eye Bolts and Eye Nuts: ASTM F541 and AISI C-1030.

C. Clevises: AISI C-1035.

D. Threaded Rods (Tie Rods): ASTM A36 unless ASTM A572 is noted on the Drawings.

E. All metal fasteners not specified elsewhere.

2.03 GALVANIZING

A. Hot-dip galvanize all exterior and exposed steel items, except when specified otherwise.
   1. Steel hardware, nuts, bolts, washers, anchors, and threaded rods: ASTM A153.
   2. Where specified, electroplate nuts, bolts and washers with zinc coating of 0.001-inch minimum thickness in accordance with ASTM B633 Class SC4. Where specified, provide a 4-mil DFT coating of zinc silicate.
   3. Size nuts so that they screw on threaded bolts readily after galvanizing or coating.

B. Repair Materials: Gal-Viz by Thermacote Welco, Pasadena, CA; ReGalv by Rotometals, Inc., San Francisco, CA; or equal.

2.04 NON-SHRINK GROUT

A. See Section 03600.

PART 3 - EXECUTION

3.01 ERECTION

A. Structural Steel Work:
   1. Connections:
      a. Provide anchor bolts and other connections between structural steel and foundations.
      b. Set all anchor bolts by template, with provisions to hold bolts rigid and in correct position with respect to plan and elevation.
      c. Install adhesive and expansion anchorages by personnel with satisfactory previous experience using the same Products, following the manufacturer's recommendations and in compliance with the latest ICC-ES report.
      d. Detail any undesigned connections in accordance with the AISC Specification.
      e. Do not increase any hole diameter or slot length without the Engineer’s approval.
      f. Washers:
         1) Provide washers for slotted holes. Washers shall be hardened for high-strength bolts (fy > 36 ksi) and shall be 3/8-thick plate washer for long-slotted holes.
         2) Provide washers under the turned element for bolts installed with the Calibrated Wrench Pretensioning method.
         3) Provide washers for bolts installed with the Direct-Tension-Indicator Pretensioning method.
   2. Where metal is fastened to concrete, make the connections by anchor bolts, or by anchors embedded in concrete, such as adhesive, or expansion anchors.
   3. Provide grout pads below base and bearing plates of non-shrink non-metallic grout having a minimum thickness of 3/4-inch unless otherwise noted. Do not bear directly on concrete slabs or equipment bases.

4. Provide leveling nuts on anchor bolts, below base plates, and adjust prior to grouting.
5. Where anchorage requires drilling into existing concrete, contractor shall locate all reinforcing steel at least 14 days prior to drilling and shall notify Engineer of any conflicts immediately upon discovery. Contractor shall not drill through or cut any reinforcing steel without express written direction from the Engineer.

B. Mechanical Anchoring Systems: Mechanical anchoring systems shall be installed in accordance with the ICC-ES Evaluation Report for the specific anchor.
   1. Mechanical Undercut Anchoring Systems (required for overhead applications):
      a. Drill a hole in the base material using drill bit diameter and embedment depth in accordance with the manufacturer's instructions.
         CAUTION: Oversized holes in the base material will reduce the anchor's load capacity and cannot be used.
      b. Remove dust from holes with compressed air.
      c. Assemble the anchor with the nut and washer so the top of the nut is flush with the top of the anchor.
      d. Place the anchor in the fixture and drive into the hole until washer and nut are tight against the fixture.
      e. Install nut and washer and tighten to the required installation torque.
   2. Mechanical Expansion Anchoring Systems:
      a. Drill a hole in the base material using drill bit diameter and embedment depth in accordance with the manufacturer's instructions. CAUTION: Oversized holes in the base material will reduce the anchor's load capacity and cannot be used.
      b. Remove dust from holes with compressed air.
      c. Assemble the anchor with the nut and washer so the top of the nut is flush with the top of the anchor.
      d. Place the anchor in the fixture and drive into the hole until washer and nut are tight against the fixture.
      e. Install nut and washer and tighten to the required installation torque.

C. Adhesive Anchoring Systems: Adhesive anchoring systems shall be installed in accordance with the ICC-ES Evaluation Report for the specific anchor. Adhesive anchoring systems <u>are not allowed</u> in overhead applications.
   1. Adhesive (Ester or Epoxy) Injection Anchoring Systems:
      a. Drill a hole to the specified depth and diameter.
      b. Clean hole with a wire brush. Remove dust from holes with oil-free compressed air. Jetting holes with water is not permitted.
      c. Install adhesives only in clean holes free of standing water.
         1) Dispense portion of adhesive off to the side to check for proper mixture, and consistent color before using.
         2) Fill hole halfway to 2/3rds, starting from bottom of hole to prevent air pockets. Withdraw nozzle as hole fills up.
         3) Substrate temperature should be kept above the minimum allowed temperature as specified by the manufacturer for the entire curing process.
         4) Insert anchor, turning slowly until the anchor contacts the bottom of the hole. Do not disturb anchor during the specified cure time.
         5) For holes 10" and deeper contractor shall use a piston plug for adhesive anchor installation

D. Repair of Connections: The Contractor shall pay for all necessary additional tests made on weld or bolts required to repair or replace faulty work performed during the original fabrication or during erection.

E. Repair of Galvanized Coating:
   1. Repair surfaces damaged by cutting or welding by the heated repair method. Repair handrails or other surfaces that will not be painted and that are field welded or damaged by the heated galvanize repair method.
   2. Heat substrate to 600°F, or apply hot process touch-up material right after welding before metal has cooled below 600°F.
   3. Rub bar of specified galvanize repair material over surface of hot substrate to apply a uniform coating of zinc. Wire brush hot coating with a clean wire brush to smooth out and bond zinc coating to substrate to apply a uniform coating of zinc.

3.02 FIELD QUALITY CONTROL

A. Mechanical and Adhesive Anchoring Systems:
   1. Anchoring systems shall be installed in accordance with the ICC-ES Evaluation Report for the specific anchor. All anchors shall be tested in accordance with paragraph 1.04C.
   2. Set torque-controlled expansion-type anchors to the recommended installation torque using a calibrated torque wrench. Following attainment of 10% of the specified torque, 100% of the specified torque shall be reached within 7 or fewer complete turns of the nut. If the specified torque is not achieved within the required number of turns, the anchor shall be removed or abandoned.
   3. Set displacement-controlled expansion-type anchors to the recommended displacement. If the concrete cracks during installation of the anchor, the anchor shall be removed or abandoned.
   4. Anchors should exhibit no discernable movement during load testing.
   5. Holes drilled for anchors that do not set properly or fail in a tension test may not be reused, and shall be filled with non-shrink grout.

B. Erection Sequence: Verify each stage is completed before proceeding to the next.

C. Tolerances: AISC Standard Practice.

3.03 LOAD TESTING TABLES

A. Load Testing Tables below are based on the following assumptions. Testing where these assumptions are not valid could result in damage to the structure or other elements, which shall be repaired by the Contractor at no additional cost to the Owner.
   1. Concrete shall have a minimum compressive strength of 2500 psi.
   2. Embedment Depths and Edge distances shall be as noted in the table and shall not be outside the parameters specified by the anchor manufacturer.
   3. Tests shall be performed on a single anchor and no intermediate members shall be placed between the testing apparatus.
   4. All Values are in inches and pounds unless otherwise noted.

Table 1 - Test Loading for Simpson Set XP Anchors						
Embedment (in)	Edge Distance (in)	Diameter				
		½"	5/8"	¾"	7/8"	1"
he ≥8"	$4>c_{min}\geq1.75$	180	100	140	60	90
	$6\geq c_{min}>4$	1200	800	1000	600	700
	$6\leq c_{min}$	2000	2000	2200	1500	1800
7≤he<8"	$4>c_{min}\geq1.75$	100	100	100	100	Note 1
	$6\geq c_{min}>4$	1200	800	1000	600	Note 1
	$6\leq c_{min}$	200	200	2200	1500	Note 1
6≤he<7"	$4>c_{min}\geq1.75$	100	100	100	Note 1	Note 1
	$6\geq c_{min}>4$	1000	1500	800	Note 1	Note 1
	$6\leq c_{min}$	2100	1500	1900	Note 1	Note 1
5≤he<6"	$4>c_{min}\geq1.75$	100	100	Note 1	Note 1	Note 1
	$6\geq c_{min}>4$	800	600	Note 1	Note 1	Note 1
	$6\leq c_{min}$	1900	1300	Note 1	Note 1	Note 1
4≤he<5"	$4>c_{min}\geq1.75$	100	Note 1	Note 1	Note 1	Note 1
	$6\geq c_{min}>4$	900	Note 1	Note 1	Note 1	Note 1
	$6\leq c_{min}$	2000	Note 1	Note 1	Note 1	Note 1
Note 1: Configuration requires special approval and consideration from the Engineer. Contractor shall not install or test this configuration without favorable review from Engineer.						

END OF SECTION

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SECTION 05100

STRUCTURAL METAL FRAMING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
1. Structural steel, stainless steel or aluminum, such as beams, channels, angles, tees, bars, pipe, tubing and plates (connection and base plates).
2. Fabricated metal items, such as pipe supports, brackets, hangers, equipment supports, and lift hooks.
3. All anchors, eye bolts, turnbuckles, cable clamps, bolts, nuts, washers, inserts, and other metal items not specified elsewhere.
4. Fabricated tanks, hoppers, and similar structures, if not specified elsewhere.
5. All structural metal framing.

B. Related Sections:
1. Section 05090: Structural Metal Fasteners
2. Section 09960: Protective Coatings

1.02 REFERENCES

A. Aluminum Association:
1. AA Manual-Aluminum Design Manual

B. American Institute of Steel Construction Specifications:
1. ANSI/AISC 360-16 Specification for Structural Steel Buildings

C. Research Council on Structural Connections:
1. RCSC Specification for Structural Joints Using ASTM A325 or A490 Bolts, 2004

D. American Iron and Steel Institute (AISI).

E. American National Standards Institute:
1. ANSI H35-1 Alloy and Temper Designation Systems for Aluminum

F. ASTM International (ASTM) Standard Specifications:
1. ASTM A36 Structural Steel
2. ASTM A53 Pipe, Steel, Black and Hot-dipped, Zinc-coated Welded and Seamless
3. ASTM A108 Specification for Steel Bars, Carbon, Cold-Finished, Standard Quality
4. ASTM A123 Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products
5. ASTM A153 Zinc Coating (Hot-Dip) on Iron and Steel Hardware
6. ASTM A276 Stainless Steel Bars and Shapes
7. ASTM A370 Test Methods and Definitions for Mechanical Testing of Steel Products
8. ASTM A385 Practice for Providing High-Quality Zinc Coatings (Hot-Dip)
9. ASTM A500 Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
10. ASTM A572 Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel

11.	ASTM A653	Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
12.	ASTM A780	Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
13.	ASTM A992	Specification for Steel for Structural Shapes for Use in Building Framing
14.	ASTM B633	Electrodeposited Coatings of Zinc on Iron and Steel
15.	ASTM C827	Test Method for Early Volume Change of Cementitious Mixtures
16.	ASTM C1107	Packaged Dry, Hydraulic-Cement Grout (Non-shrink)
17.	ASTM E8	Test Methods for Tension Testing of Metallic Materials
18.	ASTM E165	Practice for Liquid Penetrant Inspection
19.	ASTM E709	Practice for Magnetic Particle Examination
20.	ASTM F2329	Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

G. American Welding Society (AWS):

1.	AWS D1.1	Structural Welding Code - Steel
2.	AWS D1.2	Structural Welding Code - Aluminum
3.	AWS D10.4	Recommended Practices for Welding Austenitic Chromium-Nickel Stainless Steel Piping and Tubing
4.	AWS A4.3-93R	Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding
5.	AWS A5.1	Mild Steel Covered Arc Welding Electrodes
6.	AWS A5.3	Aluminum and Aluminum Alloy Electrodes for Shielded Metal Arc Welding
7.	AWS A5.4	Covered Corrosion-Resisting Chromium-Nickel Steel Welding Electrodes
8.	AWS A5.5	Low Alloy Steel Covered Arc Welding Electrodes
9.	AWS A5.9	Corrosion-Resisting Chromium-Nickel Steel Base and Composite Metal Cored and Stranded Welding Electrodes and Welding Rods
10.	AWS A5.10	Aluminum and Aluminum Alloy Bare Welding Rods and Electrodes
11.	ANSI/AWS B4.0-98	Standard Methods for Mechanical Testing of Welds – U.S. Customary
12.	AWS B5.1-2003	Standard for the Qualification of Welding Inspectors
13.	AWS C4.1	Oxygen Cutting Surface Roughness Gauge and Wall Chart for Criteria Describing Oxygen-Cut Surfaces

H. American Society for Nondestructive Testing (ASNT):

1.	ASNT SNT TC-1a-2001	Recommended Practice for the Training and Testing of Nondestructive Testing Personnel
2.	ANSI/ASNT CP-189-2001	Standard for the Qualification and Certification of Nondestructive Testing Personnel

I. International Code Council (ICC)

J. California Building Code (CBC) 2019 Edition.

1.03 SUBMITTALS

A. Submit in Accordance with Section 01300.

B. Product Data:
   1. Hangers, pipe and equipment supports (shelf items).
   2. Stainless steel and aluminum items (not fabricated).
   3. Certified mill test results on structural metals.
   4. Electrode manufacturer’s data and product data, including electrodes to be used for dissimilar metals.
   5. Insulation between dissimilar metals.
   6. Manufacturer’s product data sheets or catalog data for SMAW, FCAW and GMAW composite (cored) filler metals to be used.
   7. Non-shrink grout.

C. Samples: Manufacturer's latest standard product.
   1. Structural framing.
   2. Connection material specifications.
   3. Locations and dimensions of protected zones.
   4. Gusset and base plates drawn to scale.
   5. Locations of pretensioned bolts.
   6. Field assembly or erection sequence.

D. Quality Assurance:
   1. Welder performance qualification test records “welder’s certification”.
   2. Written Welding Procedure Specifications (WPSs) in accordance with AWS D1.1 requirements for each different welded joint proposed for use whether prequalified or qualified by testing.
   3. Procedure Qualification Record (PQR) in accordance with AWS 1.1 for all procedures qualified by testing.
   4. Fabricator’s and Erector’s AISC Certifications.

1.04 QUALITY ASSURANCE

A. General:
   1. Furnish materials and fabricated items from an established and reputable manufacturer or supplier. Fabricator and Erector shall both be AISC certified for the work that they are performing.
   2. Supply all new materials and fabricated items made from first class ingredients and construction and guaranteed to perform the service required.
   3. The Contractor is responsible for preparing and submitting written WPSs. WPSs for each joint type shall indicate proper AWS qualification and be available where welding is performed. WPSs shall be included with any shop drawings referencing welds. WPSs shall include the manufacturer and specific electrode.
   4. Quality control and quality assurance shall be provided in accordance with AISC 360 Chapter N.

B. Codes and Standards:
   1. Metalwork:
      a. Steel: AISC Specification.
      b. Aluminum: AA Manual.
   2. Welding:
      a. Steel: AWS D1.1.
      b. Aluminum: AWS D1.2.
      c. Stainless Steel: AWS D10.4.
   3. Welders:

a. Qualify welders in accordance with AWS D1.1 for each process, position, and joint configuration.
b. All welding operators are subject to examination for requalification at any time during the progress of the work.

C. Tests:
1. General: The Owner will provide Special Inspection, defined by CBC Section 1704, for welding and high-strength bolting. Visual welding inspection and nondestructive testing (NDT) shall be conducted in accordance with a written practice by personnel qualified in accordance with AISC 360 Chapter N.
2. Weld Tests: By a testing laboratory, selected by Engineer and paid by Owner.
a. Visual inspection:
1) Check fit-up of joint materials. Verify satisfactory alignment of material. Verify gaps and bevels of penetration welds.
2) Check during welding. Verify satisfactory technique is used.
3) Check after welding completed and cleaned by wire brush or chipping hammer.
4) Inspect with magnification when necessary and under strong, adequate light.
5) Inspect for the following defects:
a) Surface cracking.
b) Porosity.
c) Excessive roughness.
d) Unfilled craters.
e) Gas pockets.
f) Undercuts.
g) Overlaps.
h) Size.
i) Insufficient throat and concavity.
b. Nondestructive testing: Ultrasonic testing, except where not feasible due to the type or location of the weld. Magnetic particle, liquid penetrant or radiograph tests when ultrasonic testing is not feasible.
1) Ultrasonic inspection technique and standards: AWS D1.1 Part C.
2) Particle inspection method: ASTM E709.
3) Penetrant inspection method: ASTM E165.
4) Radiography tests: AWS D1.1, Part B.
5) Charpy V-Notch (CVN).
a) When they are used as members in the Seismic Resisting Force System, ASTM A6, Group 3 shapes with flanges 1½ inches thick and thicker, ASTM A6 Groups 4 and 5 shapes, and plates that are 1½-inch thick or thicker in built-up cross sections shall have a minimum CVN toughness of 20 ft-lbs. at 70ºF.
b) All complete joint penetration groove welds used in the Seismic Force Resisting System shall be made with a filler metal that has a minimum CVN toughness of 20 ft-lbs at minus 20ºF, as determined by AWS classification or manufacturer certification Ultrasonic inspection technique and standards: AWS D1.1 Part C.
c. Extent of testing:
1) Visual inspection of all welds.

2) Measurement of weld profiles for 25% of all welds at random.
3) Magnetic particle examination or liquid penetrant examination performed on root pass and on finished welds for 25% of all shear plate, stiffener plate, column base plate, gusset plate, and miscellaneous fillet welds.
4) Ultrasonic contact examination on all complete joint penetration (CJP) welds. See Drawings for CJP welded beam or girder to column moment connections. Defective welds shall be repaired and costs of retesting defective welds shall be borne by the Contractor.

D. Additional Tests: Provide and pay for all necessary additional tests made on welds or bolts required to repair or replace faulty work performed during the original fabrication.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Handle, ship, and store material in a manner that will prevent distortion, rust, damage to the shop coat or any other damage.

B. Store material in a clean, properly drained location out of contact with the ground.

C. Ensure that dissimilar metals are not in contact with each other.

D. Replace or repair all damaged material in an approved manner.

PART 2 - PRODUCTS

2.01 STRUCTURAL STEEL MEMBERS

A. W-Shapes and WT-Shapes: ASTM A992, f_y = 50 ksi, f_u = 65 ksi.

B. M-, S-, and HP-Shapes and Channels, Angles, Structural Tees, Plates and Similar Items: ASTM A36, f_y = 36 ksi, f_u = 58 ksi. Except plates for W-Shapes and WT-Shapes ASTM A572, Grade 50.

C. Hollow Structural Sections (HSS): Rectangular and square, ASTM A500, Grade B, f_y = 46 ksi, f_u = 58 ksi. Round, ASTM A500, Grade B, f_y = 42 ksi, f_u = 58 ksi.

D. Steel Pipe: ASTM A53 Type E or S, Grade B, f_y = 35 ksi, f_u = 60 ksi.

2.02 STAINLESS STEEL ARTICLES

A. Material: AISI Type 304, unless Type 316 is specifically specified.

B. Channels, Angles and Structural Tees: ASTM A276.

2.03 FABRICATED ALUMINUM ITEMS

A. Material: ANSI H35-1 Alloy and Temper 6061-T6 with an anodized finish.

B. Surfaces in Contact With Concrete or Masonry: Shop prime with a bituminous mastic or zinc chromate coating.

C. Bolted Connections: Provide stainless steel fasteners.

2.04 METAL FASTENINGS

A. See Section 05090.

2.05 WELDING ELECTRODES, FILLER METALS

A. Steel:
   1. AWS A5.1 or A5.5, E70XX category.
   2. AWS A5.20, A5.29, E7XTX-X except -2, -3, -10, -GS for FCAW.
   3. AWS A5.17 or A5.23, F7XX-EXXX for SAW.

B. Stainless Steel: AWS A5.4 or A5.9.

C. Aluminum: AWS A5.3 or A5.10.

D. For welding dissimilar metals, submit the appropriate electrodes for Product Review.

2.06 GALVANIZING

A. Hot-dip galvanize all exterior and exposed steel items, except when specified otherwise.
   1. Sheet steel, plain or shaped: ASTM A653, coating designation G 90, commercial grade.
   2. Products fabricated from rolled, pressed and forged steel shapes, plates, bars and strip 1/8-inch-thick or heavier: ASTM A123.
   3. Structural tubing and pipe: ASTM A53
   4. Grind smooth fabricated items at welded joints, edges, and corners, and galvanize after fabrication. Fabricated items shall be detailed and prepared in accordance with ASTM A385.
   5. Items that are specified to receive paint or a coating after galvanizing shall receive no post treatment baths and shall not be stacked or stored in a wet environment until coated.

B. Repair Materials: Gal-Viz by Thermacote Welco, Pasadena, CA; ReGalv by Rotometals, Inc., San Francisco, CA; or equal.

2.07 NON-SHRINK GROUT

A. ASTM C1107 with no shrinkage as measured by ASTM C827. Furnish a pre-mixed product consisting of properly proportioned amounts of non-metallic dimensionally stable material to which water is added.

2.08 MISCELLANEOUS ITEMS

A. Furnish all items required to complete the Project.

2.09 FABRICATION

A. Structural Steel Work: Comply with the applicable provisions of the AISC Specification, the AISC Standard Practice and AWS D1.1. Weld only in accordance with favorably reviewed WPSs, which are to be available to welders and inspectors during the production process. Provide workmanship equal to standard commercial practice in modern structural shops.
   1. Fabricate and assemble in the shop to the greatest extent possible, and deliver to the project as a unit ready for installation. Coordinate the work, making all provisions necessary for the passage of all applicable work into, and attachment to, the structures. Make joints carefully and neatly, with corners mitered and spliced, bolted, screwed, or welded together.
   2. Make proper allowance for the expansion and contraction of the metals, and of the materials to which they are fastened.

3. Make completely watertight joints on exterior work.
4. Shape all members correctly, with no kinks, twists, dents, or other blemishes prior to erection. Evenly spring all curved work.
5. Make exposed edges free of burrs, sharp edges or corners. Make corners rounded or chamfered. Grind exposed welds smooth when specified.
6. Include supplementary parts necessary to complete each item, even though such work may not be definitely specified. Provide all such miscellaneous metalwork required by the project in accordance with good accepted standard practice.
7. Shop prime all items that are not galvanized or epoxy coated, including connection angles, using a material compatible with the finish coat, as specified in Section 09960. Provide finish paint coats as specified in Section 09960.

B. Stainless Steel Work:
1. Use the proper type of stainless steel electrodes or welding rods complying with AWS D10.4. Grind all welded joints smooth and polished, using wheels never used on carbon steel. Provide welds that eliminate injury to stainless steel parts in appearance, strength and resistance to corrosion.
2. Remove by grinding and polishing, all scratches, marks, pits and other blemishes on exposed surfaces incurred during fabrication of the material, until the entire surface possesses the same finish as the adjacent work.

C. Aluminum Work:
1. Comply with the applicable provisions of the AA Manual and AWS D1.2.
2. Back painting: When aluminum is in contact, such as with concrete, mortar, masonry, or adsorptive materials subject to wetting, including condensation, give the contact surfaces a brush coat of cut-back asphaltic, or coal tar paint. Submit paint for favorable review.
3. Aluminum shall have an anodized finish.

D. Base and Bearing Plates: Furnish under all columns, pipe supports, including rack type, supports for tanks, equipment frames and cabinets, and similar items. Provide rounded or chamfered corners.

E. Dissimilar Metals: Insulate the faying surfaces with a brush coat of cut-back asphaltic or coal tar paint or by gasketing. Submit for favorable review.

F. Metals in contact with cementitous or other material: Provide finish coating prior to erection.

2.10 SOURCE QUALITY CONTROL

A. Material Tests: Not required for materials identified with valid mill test records.
1. Unidentified materials: Test samples from each 20 tons of each material, or fraction thereof. Perform tension and bend tests, conforming to ASTM A370 for steel. Perform tension tests conforming to ASTM E8 for aluminum.
2. Do not provide unidentified stainless steel.

B. Welding:
1. Qualify welders in accordance with AWS D1.1 for each process, position, and joint configuration.
2. Weld only in accordance with favorably reviewed WPSs, which are to be available to welders and inspectors during the production process.

C. Tolerances: AISC Standard Practice.

D. Fabrication Tests: Standard and extent: See paragraph 1.04.

PART 3 - EXECUTION

3.01 ERECTION

A. Structural Steel Work:
   1. Erect members in accordance with the AISC Specification, and the AISC Standard Practice except as modified.
   2. Incorrect fabrication or damaged members:
      a. When a condition exists whereby parts cannot be assembled or fitted properly as a result of errors in fabrication, or of deformation due to handling or transportation, report the condition immediately. The method of correction must be approved before any corrective work is done. Make the corrective work in the presence of the Engineer.
      b. Straighten plates and angles or other shapes using approved methods.
      c. Do not heat already heat-treated parts for straightening.
   3. Connections:
      a. Provide anchor bolts and other connections between structural steel and foundations. See Specification Section 05090 for additional connection requirements.
      b. Set all anchor bolts by template, with provisions to hold bolts rigid and in correct position with respect to plan and elevation.
      c. Detail any undesigned connections in accordance with the AISC Specification
      d. Do not increase any hole diameter or slot length without the Engineer's approval.
   4. Install work anchored in sleeves set in concrete with non-metallic non-shrink grout. Allow a ¼-inch minimum clearance between items anchored and the sleeve.
   5. Where metal is fastened to concrete, make the connections by anchor bolts, or by fastenings embedded in concrete, such as adhesive, or expansion anchors, installed in accordance with Specification Section 05090. Contractor shall not substitute post-installed fasteners for cast-in-place bolts without prior written permission from the Engineer.
   6. Provide a 4-inch band of coal-tar epoxy applied, half in concrete and half in air, to galvanized or painted steel, partially embedded in concrete and subject to weathering.
   7. Provide grout pads below base and bearing plates of non-shrink non-metallic grout having a minimum thickness of ¾-inch unless otherwise noted. Do not bear directly on concrete slabs or equipment bases.
   8. Provide leveling nuts on anchor bolts, below base plates, and adjust prior to grouting.
   9. Complete the work square, plumb, straight and true, accurately fitted, and with tight joints and intersections.

B. Welding:
   1. Weld only in accordance with favorably reviewed WPSs, which are to be available to welders and inspectors during the production process. Perform all welding by the shielded electric arc method in accordance with AWS D1.1.

2. Repair and make additional inspections, at the Contractor's expense, of the weld areas which have been rejected as a result of inspection. Follow this procedure until the welds are acceptable to the Engineer.
3. Qualify welders in accordance with AWS D1.1 for each process, position, and joint configuration.
4. All tack welds shall be of the same quality as the final welds. This includes preheat requirements. All tack welds not incorporated in the final welds shall be removed.

C. Repair of Galvanized Coating:
1. Repair surfaces damaged by cutting or welding by the method of heated zinc based alloys in accordance with ASTM A780.
   a. Clean the surface and surrounding area with wire brush, light grinding, or mild blasting.
   b. Remove all weld flux residue and spatter by chipping, grinding, or power scaling.
   c. Preheat the area to between 600 and 750 degrees F. Wire brush the area during preheating and pre-flux if necessary.
   d. Apply the zinc alloy by rubbing or brushing the preheated repair area. Applied coating shall be as specified herein but shall not be less than 2.0 mils.
   e. Remove the flux residue by rinsing or wiping with a damp cloth.
   f. Measure thickness of applied coating with magnetic, electromagnetic, or eddy-current gage.
2. See Section 09960 for repair of galvanized coating for gauge metals.

3.02 FIELD QUALITY CONTROL

A. Welding:
1. Qualify welders in accordance with AWS D1.1 for each process, position, and joint configuration.
2. The Owner’s testing agency will inspect shop or field welding for conformance with AWS D1.1 requirements and will verify that welds are made in accordance with favorably reviewed WPSs.

B. Erection Sequence: Verify each stage is completed before proceeding to the next.

C. Tolerances: AISC Standard Practice.

D. Erection Tests: Standard and extent: See paragraph 1.04.

END OF SECTION

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SECTION 07190

WATER REPELLENT SEALER

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
1. A clear water repellent sealer application to all exposed above grade exterior and interior concrete, precast concrete, and concrete unit masonry surfaces of structures that enclose space for human occupancy or for machinery, equipment or storage.

1.02 REFERENCES

A. American Society for Testing Materials (ASTM):
1. C309 Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
2. C67 Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile

1.03 SUBMITTALS

A. Product Data: Fully describe all products proposed for use. Include Material Information Sheet for all products.

B. Manufacturer's ten (10)-year warranty for Water Repellent Sealer.

1.04 QUALITY ASSURANCE

A. Qualifications: Apply water repellent sealer by a licensed Waterproofing Specialty Contractor (California License No. C61 Waterproofing and Sealant Work) exclusively engaged in applying waterproofing materials, sealers and sealants.

B. Regulatory Requirements: Comply with California Building Code (CBC), adopted edition.

C. Trade Association Recommendations:
1. Comply with recommendations on waterproofing contained in the "Masonry Design Manual" published by the Masonry Industry Advancement Committee.
2. Comply with the Portland Cement Association recommendations for waterproofing architectural concrete.

1.05 DELIVERY, STORAGE AND HANDLING

A. Deliver material in labeled unopened containers.

B. Store all material on raised platforms protected from moisture and from contamination by dirt, mud or other foreign material.

1.06 COORDINATION

A. Coordinate with other trades whose work may be damaged by sealer application.

B. Protect glass and other finished surfaces with polyethylene sheeting taped in place.

1.07 SPECIAL GUARANTEE

A. Apply sealer under the supervision of the sealer manufacturer's representative.

B. Provide a signed ten (10)-year Special Guarantee, signed by the sealer manufacturer, applicator and Contractor against sealer's failure to prevent water intrusion through the treated masonry or concrete.

PART 2 - PRODUCTS

2.01 SEALER

A. Clear Sealer:
   1. Waterbased, solvent-free penetrating clear silane/siloxane water repellent sealer for lightweight concrete block and architectural concrete.
   2. Not less than 40% solids content.
   3. Meet requirements of Air Quality Management District having jurisdiction.
   4. Meet ASTM C67 submersion tests with a repellency rating of 96%.
   5. Apply at the rate recommended by the manufacturer for the density, porosity and texture of concrete and/or concrete block used,
   6. Manufacturer: Rainguard International “Micro-Seal”; Sherwin-Williams “Loxon 40% Silane Water Repellant LX31T840”; Euclid Chemical “Chemstop WB Regular / Heavy Duty”; or equal.

PART 3 - EXECUTION

3.01 APPLICATION OF CLEAR SEALER

A. Apply sealer after concrete and masonry has cured at least 30 days, and after the concrete and the masonry has been cleaned.

B. Prior to applying sealer clean down all masonry and architectural concrete of efflorescence, grout pieces, dirt and debris by hand and/or mechanical scrubbing with dry bristle brushes.

C. Inspect surface for cracks. Rout out all cracks 5 mils and wider and fill with a high performance joint sealant having a 20-year life expectancy and recommended by the water repellent sealer manufacturer for use on substrates to be sealed with his sealer. Perform joint sealant work in accordance with Section 07900.

D. Spray-Apply Sealer: Use airless spray equipment with recirculating type pump and perforated T bar applicator recommended by the sealer manufacturer. DO NOT USE pressure pot spray equipment. Operate at lowest possible pressures, 20 psi maximum. Avoid atomizing material by using a spray tip size of .035 to .051. Do not allow fogging or bounce-off except on tension break coat.

E. Protect surfaces, which are not to be coated. Cover all anodized aluminum, overhead coiling doors, metal doors, etc. with polyethylene sheeting; continuously seal all edges with tape.

F. Apply sealer material in accordance with manufacturer's instructions. Apply enough sealer so the masonry surface appears uniformly wet, for each coat, for from two to five hours after application. Spray head should be held 8 to 12 inches

from the surface so that the flood coat runs down the wall approximately 6-12 inches below the point of application.

1. Rate of Application: Coverage as recommended by the manufacturer for porous concrete block but coverage shall not exceed 40 square feet per gallon for the first coat and 70 square feet per gallon for the second coat.
2. First Coat: Apply the first coat in two passes: the first pass, a light spray to break surface tension; the second pass, a full flood coat applied in an overlapping pattern producing a 6-12 inch rundown.
3. Second Coat: After 48 hours, apply a flood coat in an overlapping pattern producing a 6-12 inch rundown.

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SECTION 07900

JOINT SEALANTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Sealant work required:
      a. For a watertight project.
      b. Required by code and not specifically covered in another section.
   2. Seal between all door frames, louvers and adjacent surfaces.
   3. Minimum standards for all sealant work whether covered in this Section or in other sections.

1.02 REFERENCES

A. American Society for Testing Materials (ASTM)
   1. C920 Standard Specification for Elastomeric Joint Sealants

B. California Building Standards Commission
   1. 2019 California Building Code (California Code of Regulations, Title 24)

1.03 SUBMITTALS

A. Product Data: Fully describe all products proposed for use.

B. Samples: Physical samples of cured sealants for selection of colors.

C. Manufacturer’s Instructions: Application instructions for all products used.

1.04 QUALITY ASSURANCE

A. Qualifications: Provide sealant work performed by a licensed Specialty Sealant and Waterproofing Contractor who is exclusively engaged in sealant application work. All work to be performed by qualified journeymen proficient in the craft of sealant application.

B. Regulatory Requirements: Comply with the California Building Code (CBC), 2019 edition.

1.05 PROJECT CONDITIONS

A. Environmental Requirements: Apply sealant only when temperature and humidity conditions are at the levels recommended by the sealant manufacturer.

1.06 SPECIAL GUARANTEE

A. Provide a written Special Guarantee covering replacement of sealant work that fails within 2 years of the date of project acceptance. Failure includes:
   1. Becomes brittle or cracking due to exposure, contraction, or expansion.
   2. Failure to resist abrasion of normal use and traffic.
   3. Tear failure due to movement within 50% of joint width for Class A sealants.
   4. Cohesive or adhesive failure due to movement within 50% of joint width for Fed. Spec. Class A sealants.
   5. Water infiltration for joints intended to exclude water, air infiltration for joints intended to exclude air.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Sealant Type "A": Exterior and interior horizontal traffic deck sealant two-part self-leveling polyurethane with a Shore "A" hardness greater than 30, conforming to ASTM C920 Type I or Type II, Class A, in color selected. Acceptable products are:
   1. Tremco "Vulkem" No. 445SSL (use with recommended primer).
   2. W.R. Meadows “Pourthane” NS used with recommended primer.
   3. Or equal.

B. Sealant Type "B": Exterior and/or interior vertical surface sealant (location as approved by manufacturer) for use in joints in concrete, metal and similar materials, conforming to ASTM C920 Type II, Class A, in color selected. Acceptable products are:
   1. One part polyurethane: Tremco "Vulkem" No. 116 (approved for exterior use only).
   2. One part polyurethane: Sika Sealant Division Sikaflex la.
   3. Or equal.

C. Sealant Type "C": Paintable silicone sealant suitable for sealing cracks, voids, joints, etc. in exterior or interior surfaces that are to be painted or left unpainted. Acceptable products are:
   1. G.E. Paintable Silicone Sealant.
   2. Dow Corning Paintable Silicone Sealant.
   3. Or equal.

D. Sealant Type "D": Silicone sealant meeting Fed. Spec. TT S 001543A, Class A for use in expansion joints in concrete. Acceptable products are:
   1. Dow Corning 795 Silicone.
   2. G.E. Silpruf SCS2000.
   3. Or equal.

E. Sealant Type "E": Mildew Resistant Silicone Sealant: One part silicone sealant for sealing non-porous interior surfaces where conditions of high humidity and temperature extremes exist. Acceptable products are:
   1. Dow Corning 786 Mildew Resistant Silicone Sealant.
   2. General Electric SCS1700 Sanitary Sealant.
   3. Or equal.

F. Sealant Type "F": Two-component, modified polyurethane sealant intended to resist up to five parts per million of chlorine or ozone in water, for interior and exterior use. Acceptable products are:
   1. Sika Corp. "Sikaflex-2C."
   2. Polymeric Systems, Inc. PSI-270/RC 270.
   3. Or equal.

G. Sealant Backup: Closed Cell Polyethylene rod stock. Acceptable products are:
   1. Dow Corning "Ethafoam."
   2. Nomaco, HBR Backer Rod.
   3. Or equal.

PART 3 - EXECUTION

3.01 CONDITION OF SUBSTRATE

A. Allow concrete and masonry to cure for at least 28 days before applying sealants.

B. Inspect substrates to receive sealant work for:
   1. Deviation beyond allowable tolerance for joint width and required clear joint depth. Joint width shall not be less than ¼ inch or the width shown.
   2. Presence of contaminants, which cannot be removed by normal joint cleaning.
   3. Presence of moisture. Joint surfaces shall be dry.

C. Do not start work until all unsatisfactory conditions have been corrected.

3.02 PREPARATION OF SURFACES

A. Clean surfaces that the sealant is to adhere:
   1. For Concrete and Masonry: Sandblast joint surfaces taking care to protect exposed finish surfaces.
   2. For Metal: Sand or scrape and solvent clean with a non-film forming solvent.

B. Ensure that cleaned surfaces are not contaminated before applying sealant.

C. Where deemed necessary, use manufacturer's recommended primers for porous and non-porous substrates and/or surfaces.

3.03 APPLICATION

A. Follow sealant manufacturer's published instructions.

B. Install sealant backup the proper distance from face of joint for joint proportioned in accordance with sealant manufacturer's recommendations. Use polyethylene rod stock larger than joint so that backup can be firmly held in place.

C. Apply primer and/or cleaner conditioner recommended by sealant manufacturer for substrate. Avoid getting primer on the face of material or on areas that will not be covered by sealant.

D. Mask edges of joint with masking tape where required to avoid contamination of exposed surfaces adjacent to joint.

E. Apply self-leveling sealant by pouring, pumping, or with a caulking gun. When using a pump or caulking gun, fill joint from the bottom up to avoid air entrapment. Fill joint flush with surface of adjacent material without overfilling or spilling sealant on exposed surfaces.

F. Apply vertical grade sealants by hand or power operated caulking gun. Use a caulking tip the proper width for the joint required. Fill the joint from the bottom up to insure a fully filled joint without entrapped air bubbles or voids. Use lubricant recommended by sealant manufacturer to tool joints. Force sealant against sides and bottom of joint and into all crevices; press out air bubbles and voids. Tool the sealant surface smooth and flush with adjacent surfaces for butt joints or to an even, straight-sided fillet of uniform width and slope for fillet joints.

G. Where the substrate or adjacent sealants are incompatible with the specified sealant, submit a sealant suitable for the required use and of equivalent life expectancy to the specified sealant.

3.04 EXPANSION JOINTS

A. Apply sealant in expansion joints when the joint opening width is approximately halfway between dimensional extremes of thermal movement.

B. Place sealant backer rod the proper distance from face of joint to ensure that sealant bead depth is never more than half the bead width at any time between dimensional extremes of joint.

3.05 CLEANUP

A. Upon completion, remove protective masking and clean any sealant from adjacent finished surfaces beyond edge of joint.

END OF SECTION

SECTION 08307

ACCESS HATCHES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Wet well access hatches.

1.02 REFERENCES

A. California Building Standards Commission
   1. 2020 California Building Code (CBC) (California Code of Regulations, Title 24)
   2. State of California Occupational Safety and Health (CALOSHA) Regulations.

B. Trade and Technical Association Standards:
   1. “Aluminum Design Manual 2015” published by The Aluminum Association.
   2. "AWS D1.2, Structural Welding Code – Aluminum” published by American Welding Society (AWS).

1.03 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Product Data: Fully describe all items proposed for use. Provide sufficient data to show that products conform to specification requirements as indicated herein.

C. Shop Drawings: Show dimensions, attachments, inserts and relationship of work to adjoining construction.

1.04 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. State of California Occupational Safety and Health (CALOSHA) Regulations.
   2. California Building Code, 2020 edition.

PART 2 - PRODUCTS

2.01 ACCESS HATCHES

A. Provide seven (7) single-leaf hatches. Minimum clear opening dimensions of each hatch shall be as shown on the Drawings or as required by the favorably reviewed pump or equipment manufacturer if larger in size; Contractor to coordinate/verify prior to ordering. Provide single leaf hatch:
   1. Single Leaf: Bilco "J-AL" series; equivalent by L.W. Products Co.; equivalent by EJ; equivalent by U.S.F. Fabrication; or equal.

B. Live load: Provide hatches to withstand H-20 vehicular loads unless otherwise noted on Drawings.

C. Door Leaves: ¼-inch thick aluminum, diamond pattern, reinforced as required to withstand the specified loads.

D. Frame: Minimum ¼-inch thick aluminum channel with anchor flange around perimeter for embedment into concrete. Provide channel to collect rain water and provide 1-1/2-inch drainage coupling for connection to drain lines. Contractor shall provide and route drain lines; drain lines shall be freely draining by gravity into wet well/tank below.

E. Doors: Doors shall open to 90 degrees and shall include an automatic hold-open arm with a positive automatic latch that will secure the door in the open position until the release handle is activated. Provide stainless steel hold-open pin through holes in hold-open arms to insure against accidental hatch closure. Attach pin to hatch with a short stainless steel chain to prevent loss. Submit details of latch for review. Door hinges shall be recessed or flush.

F. Lock: Provide a slam-lock with removable handle. Coordinate specific requirements with Owner prior to ordering.

G. Lift-Assist Mechanism: Provide stainless steel compression spring(s) or pneumatic spring(s) enclosed in sealed telescoping tube(s).

H. Safety Grate: Provide a secondary fall protection safety grate located beneath the solid hatch cover, which lifts independently from the cover and is equipped with a latch to hold it in the open position. The grate shall be manufactured from aluminum flat bars, load-rated for 300 pounds per square foot, and safety orange in color. The grate shall have a padlock hasp for locking in the closed position. The grate shall comply with OSHA Standard 1910.28 for fall protection.

I. All non-aluminum metals and hardware: Type 316 stainless steel.

J. Finish: Mill finish aluminum. All surfaces of aluminum in contact with concrete shall be coated for isolation in accordance with Section 05500.

K. Odor-Tightness: Provide EPDM or neoprene rubber gaskets to limit the transmission of odors when the hatch doors are closed. Air leakage shall not be greater than 1 cfm per liner foot of gasket at a 1-inch water column (WC) pressure differential.

L. Warning Sign:
   1. Provide a sign or decal permanently attached to the underside of hatch doors reading: "Warning: Permit Confined Space Entry."
   2. Provide a sign or decal permanently attached to the underside of hatch doors reading: "Danger: Make Sure Hold-Open Latch is Positively Engaged Before Using. Insert Pin in Holes in Hold-Open Arms to Hold Door Open."

PART 3 - EXECUTION

3.01 INSTALLATION

A. Deliver hatches to job site in time for installation in the concrete pour.

B. Coat all aluminum surfaces, which will be in contact with concrete, in accordance with Section 05500.

C. Make connection of drainage coupling to plumbing drain line prior to the concrete pour.

D. Install in conformance with the manufacturer's installation instructions. Set frame level and true to plane at all four corners, and flush with adjacent finished surfaces. Doors, when closed, shall be flush with frames and flush with each other.

E. Install specified warning signs.

END OF SECTION

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SECTION 09920

GRAFFITI RESISTANT COATING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. A clear graffiti resistant coating application to all exposed above grade exterior and interior concrete, precast concrete, and concrete unit masonry surfaces of structures that enclose space for human occupancy or for machinery, equipment, or storage to protect from graffiti, stains from pollutants, and other unwanted surface markings.

1.02 SUBMITTALS

A. Submit the following:
   1. Product Data: Fully describe all products proposed for use. Include Material Information Sheet for all products.
   2. Manufacturer's 10-year warranty for Graffiti Resistant Coating.

1.03 QUALITY ASSURANCE

A. Contractor Qualifications: In submitting his bid, the Contractor represents that he is skilled and experienced applying these coatings, has studied the material manufacturer’s application requirements for the materials specified, agrees that the materials is suitable for intended use, and has included in his bid the coat of all labor and material required to achieve a successful coating system meeting the performance requirements of the contract documents.

B. Regulatory Requirements: All work, material, procedures and practices under this Section shall conform with requirements of the Federal Standard 40 CFR on air quality control, and the requirements of the local Air Resources Board or Air Quality Management District having jurisdiction.

C. Trade Association Recommendations:
   1. Comply with recommendations on waterproofing/anti-graffiti coatings contained in the "Masonry Design Manual" published by the Masonry Industry Advancement Committee.
   2. Comply with the Portland Cement Association recommendations for waterproofing/anti-graffiti coating architectural concrete.

1.04 DELIVERY, STORAGE AND HANDLING

A. Deliver material in labeled unopened containers.

B. Store all material on raised platforms protected from moisture and from contamination by dirt, mud or other foreign material.

1.05 COORDINATION

A. Coordinate with other trades whose work may be damaged by coating application.

B. Protect glass and other finished surfaces with polyethylene sheeting taped in place.

1.06 SPECIAL GUARANTEE

A. Provide a signed ten (10) year Special Guarantee in accordance with Section 01700, signed by the coating manufacturer, applicator and Contractor against coating's failure to withstand multiple graffiti removals on the treated masonry or concrete.

PART 2 - PRODUCTS

2.01 GRAFFITI RESISTANT COATING

A. Material:
   1. Water-based urethane formulation non-sacrificial graffiti barrier for lightweight concrete block and architectural concrete.
   2. Non-yellowing, fast drying.
   3. Meet requirements of Air Quality Management District having jurisdiction.
   4. Retards the growth of mold, mildew, and algae.
   5. Apply at the rate and number of coats recommended by the manufacturer for the density, porosity and texture of concrete and/or concrete block used, and to meet warranty requirements.
   6. Manufacturer: Visual Pollution Technologies Inc. (VPT) "Crystal Clear"; Rainguard International "Vandlguard"; Sculpt Nouveau "Shields Up"; or equal.

PART 3 - EXECUTION

3.01 APPLICATION OF GRAFFITI RESISTANT COATING

A. Apply sealer after concrete and masonry has cured at least 30 days, and after any biocides of pigmented paints, coatings, and any integrally-colored stucco colorant additives are released.

B. Remove all efflorescence and excess mortar with mechanical or hand wire brushing. Final clean concrete and CMU surfaces with light water cleaning, if necessary. Allow to fully dry.

C. Inspect surface for cracks. Rout out all cracks 5 mils and wider and fill with a high performance joint sealant having a 20-year life expectancy and recommended by the graffiti resistant coating manufacturer for use on substrates to be coated with this graffiti resistant coating. Perform joint sealant work in accordance with Section 07900.

D. Spray-Apply Coating: Recommended for rough or textured surfaces (use brush and roller at smooth surfaces). Use airless spray equipment with recirculating type pump and perforated T bar applicator recommended by the coating manufacturer. DO NOT USE pressure pot spray equipment. Do not allow the coating to pool on the substrate surface.

E. Protect surfaces, which are not to be coated. Cover all glass, anodized aluminum, overhead coiling doors, metal doors, etc. with polyethylene sheeting; continuously seal all edges with tape.

F. Apply coating material in accordance with manufacturer's instructions. Apply in a fine mist, cross-hatched pattern to build up the wet coating. As soon as the entire surface has been coated, immediately repeat process with a second pass.

1. Rate of Application: Coverage as recommended by the manufacturer for porous concrete block, precast concrete, painted surfaces, etc.
2. Number of Coats: As per manufacturer's warranty requirements for substrate conditions.

END OF SECTION

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SECTION 09960

HIGH PERFORMANCE COATINGS

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Section 09960 provides the requirements for; coating systems, surface preparation, coating application, and quality assurance/quality control relative to the equipment, structures listed in the Finish Schedule/Contract Drawings.

B. Unless specified elsewhere, or shown on the Contract Drawings, the following shall not be coated:
   1. Metal completely embedded in concrete (except aluminum).
   2. Piping buried in ground or encased in concrete.
   3. Galvanized metal, including galvanized pipe supports.
   4. Chain-link fence and galvanized fence gates.
   5. Rubber.
   6. Plastic pipe, including: polyvinyl chloride and polyethylene Stainless steel.
   7. Bronze, brass.
   8. Nameplates and grease fittings.
   9. Factory finished electrical panels.
   10. Factory fusion-bonded epoxy coated items.
   11. Aluminum or galvanized ductwork.
   12. Aluminum handrail and aluminum guardrail.
   13. Fiberglass.
   14. Electrical conduit.
   15. Copper pipe.

C. Related Sections:
   1. Section 11001: General Equipment and Mechanical Requirements
   2. Section 03350: Concrete Finishes (Structural)
   3. Section 01300: Submittals.

D. The Contractor’s bid shall be based upon using the products specified. If the products specified are not available in formulations that meet applicable regulations for volatile organic compound (VOC) levels at time of application, the Contractor shall submit for review products of equivalent quality and function that comply with regulations in effect at that time. A reasonable difference in cost of material between the first named items specified and the products that are required to meet regulations that change after the bid date and are in effect at the time of application may be approved for payment by Change Order in accordance with the General Conditions.

1.02 DEFINITIONS

A. Abrasive: Material used for blast-cleaning, such as sand, grit or shot.

B. Abrasive Blast Cleaning: Cleaning/surface preparation by abrasive propelled at high speed.

C. Anchor Pattern: Profile or texture of prepared surface(s).

D. American National Standards Institute (ANSI).

E. ASTM International (ASTM).

F. Bug Holes: Small cavities, usually not exceeding 15 mm in diameter, resulting from entrapment of air bubbles in the surface of formed concrete during placement and compaction.

G. Coating/Lining Thickness: The total thickness of primer, intermediate and/or finish coats.

H. Dewpoint: Temperature of a given air/water vapor mixture at which condensation starts.

I. Dry Film Thickness (DFT): Depth of cured film, usually expressed in mils (0.001-inch). Use this definition as opposed to existing definition.

J. Drying Time: Time interval between application and curing of material.

K. Dry to Recoat: Time interval between application of material and ability to receive next coat.

L. Dry to Touch: Time interval between application of material and ability to touch lightly without damage.

M. Feather Edging: Reducing the thickness of the edge of paint.

N. Feathering: Operation of tapering off the edge of a point with a comparatively dry brush.

O. Field Coat: The application or the completion of application of the coating system after installation of the surface at the site of the work.

P. Hold Point: A defined point, specified in Section 09960, at which work shall be halted for inspection.

Q. Holiday: A discontinuity, skip, or void in coating or coating system film that exposes the underlying substrate.

R. Honeycomb: Segregated condition of hardened concrete due to non-consolidation.

S. ICRI: International Concrete Repair Institute.

T. Incompatibility: Inability of a coating to perform well over another coating because of bleeding, poor bonding, or lifting of old coating; inability of a coating to perform well on a substrate.

U. Laitance: A layer of weak, non-durable concrete containing cement fine that is brought to the surface through bleed water as a result of concrete finishing/over-finishing.

V. Mil: 0.001-inch.

W. National Association of Corrosion Engineers International (NACE).

X. Overspray: Dry spray, particularly such paint that failed to strike the intended surface.

Y. Owner: The awarding authority or entity that manages/operates the facility where the specified work will be performed. For the purposes of Section 09960, the term “Owner” may also refer to designated representatives such as the Design Engineer, The Construction Manager, or an Independent Consultant.

Z. Pinhole: A small diameter discontinuity in a coating or coating system film that is typically created by outgassing of air from a void in a concrete substrate resulting in exposure of the substrate or a void between coats.

AA. Pot Life: Time interval after mixing of components during which the coating can be satisfactorily applied.

BB. Resurfacer/Resurfacing Material: A layer of cementitious and/or resin-sed material used to fill or otherwise restore surface continuity to worn or damaged concrete surfaces.

CC. Shelf Life: Maximum storage time for which a material may be stored without losing its usefulness.

DD. Shop Coat: One or more coats applied in a shop or plant prior to shipment to the site of the work, where the field or finishing coat is applied.

EE. Spreading Rate: Surface area covered by a unit volume of paint at a specific film thickness.

FF. The Society for Protective Coatings (SSPC).

GG. Stripe Coat: A separate coat of paint applied to all weld seems, pits, nuts/bolts/ washers, and edges by brush. This coat shall not be applied until any previous coat(s) have cured and, once applied, shall be allowed to cure prior to the application of the subsequent coat(s).

HH. Surface Saturated Dry (SSD): Refers to concrete surface condition where the surface is saturated (damp) without the presence of standing water.

II. Tie Coat: An intermediate coat used to bond different types of coatings. Coatings used to improve the adhesion of a succeeding coat.

JJ. Touch-Up Painting: The application of paint on areas of painted surfaces to repair marks, scratches, and areas where the coating has deteriorated to restore the coating film to an unbroken condition.

KK. Technical Practice Committee (TPC).

LL. VOC Content: The portion of the coating that is a compound of carbon, is photo chemically reactive, and evaporates during drying or curing, expressed in grams per liter (g/l) or pounds per gallon (lb/gal).

MM. Immersion: Refers to a service condition in which the substrate is below the waterline or submerged in water or wastewater at least intermittently if not constantly.

NN. Weld Spatter: Beads of metal scattered near seam during welding.

OO. Wet Film Thickness (WFT): The primer or coating film's thickness immediately following application. Wet film thickness is measured in mils or thousandths of an inch (0.001-inch) and is abbreviated WFT.

1.03 REFERENCES

A. Section 09960 contains various guide documents, technology reports, and other industry standards relative to surface preparation, coating application, and testing methods. They are a part of Section 09960 as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of

conflict between the requirements of this section and those of the listed documents, the requirements of Section 09960 shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

C. Standards and References are included as Appendix A.

1.04 SUBMITTALS

A. Provide in accordance with Section 01300:
   1. Submit a list and description of all surfaces for which there is a question about what standard coating system to apply as part of the work covered by Section 09960 through a Request for Information.
   2. Submit a Complete Finish Schedule including the specified Finish Schedule included in paragraph 2.02 and any additional surfaces to be coated by products submitted under this Section 09960. Denote the specific products and specific manufacturers for each item (structure, equipment, or substrate plus the manufacturer's brand name, product name, and designation number for each coat of each system to be used).
      a. If materials other than those listed are submitted, provide information to justify and define the proposed substitution. The Owner may further require the Contractor to furnish additional test results from an independent paint laboratory comparing the proposed substitution with one of the named products, at no additional cost to the Owner.
      b. Submit a color card or fan deck for each manufacturer and each coating product submitted.
   3. Prior to ordering material, confirm the items included in the Complete Finish Schedule and submit the Complete Finish Schedule plus the Owner approved colors for each location (structure, equipment, substrate).
   4. Current printed recommendations and product data sheets for coatings/coating systems including:
      a. VOC data.
      b. Storage requirements.
      c. Surface preparation recommendations.
      d. Primer type, where required.
      e. Maximum dry and wet mil thickness per coat.
      f. Minimum and maximum curing time between coats, including atmospheric conditions for each.
      g. Curing time before submergence in liquid.
      h. Thinners/solvents for reduction and cleaning.
      i. Ventilation requirements.
      j. Minimum and maximum atmospheric application conditions.
      k. Allowable application methods.
      l. Maximum allowable moisture content (concrete substrates).
      m. Maximum shelf life.

5. Manufacturer's Certification that the submitted coatings meet applicable San Diego County Air Pollution Control District (APCD) regulations.as to allowable VOC content for the place of application and use intended.
6. Qualifications for Quality Control personnel to be provided on site by the Contractor including, but not limited to, the inspector's NACE and SSPC Certification numbers for the certifications requested in paragraph 1.05.E.2 of this Section 09960.
7. Material Safety Data Sheets (MSDS) for all materials to be delivered to the job site, including coating system materials, solvents, and abrasive blast media.
8. Detailed, written instructions for coating system treatment and graphic details for coating system terminations in the structures to be coated including pipe penetrations, metal embedments, grate frames and other terminations shown on the Contract Drawings.
9. A minimum of five project references, including current contact name, address, and telephone number where the Contractor has successfully performed similar coating work within the past 5 years.
10. A minimum of five project references, including current contact name, address, and telephone number where the submitted materials have been successfully applied, in similar exposures, within the past 5 years. This submittal is only required if products not listed in Section 09960 are submitted.
11. A letter from the selected and approved coating manufacturers for the project that verifies that the applicator meets the quality assurance requirements of paragraph 1.05.C of Section 09960 including application personnel training requirements.
12. Information that defines the end date for field coating application for all equipment, machinery, and piping to ensure that the maximum recoat time for the shop applied primers will not be exceeded when field applied coatings are installed.
13. Provide written confirmation by the shop and field applied coating manufacturers that compatibility between the shop and field applied coatings has been checked and approved by those manufacturers.

1.05 QUALITY ASSURANCE

A. Environmental Regulatory Requirements:
   1. All work, material, procedures, and practices under Section 09960 shall conform to requirements of the local Air Resources Board or Air Quality Management District having jurisdiction. Prime or finish coat painting done in locations other than the project site shall be in accordance with air quality regulations in effect at the place the coating is applied. Products specified herein are, to the best of the Design Engineer's knowledge, in compliance with the applicable VOC levels allowable at the date these Specifications were issued for bid.
   2. The San Diego County Air Pollution Control District (APCD) having jurisdiction may prohibit the sale or application of paints and enamels containing more than the stipulated quantities of volatile organic compounds manufactured after a stated date. Provide material meeting applicable regulations effective at the date of manufacture, or if not available, provide top of the line materials developed as replacements for specified materials and meeting applicable regulations as to VOC content.

3. If the Contractor applies coatings that have been modified or thinned other than as recommended or approved by manufacturer, the Contractor shall be responsible for any fines, costs, remedies, or legal actions that may result.
4. Surface preparation activities that result in the generation of airborne emissions shall be performed in accordance with applicable Federal, State, County, or Local regulations and ordinances. The Contractor shall be responsible for securing any and all licenses and permits required, at no additional cost to the Owner.
5. All debris (liquid or solid) generated from surface preparation or coating activities shall be disposed offsite in accordance with applicable Federal, State, County, or local regulations and ordinances. The Contractor shall be responsible for all required testing, licenses, permits, and fees, at no additional cost to the Owner.

B. Coating Manufacturer's Qualifications:
1. 1. All protective coatings furnished under Section 09960 shall:
   a. Be of a manufacturer who has been regularly engaged in the manufacture of protective coatings with a minimum of 10 years of successful experience.
   b. Demonstrate to the satisfaction of the Engineer successful performance on comparable projects.

C. Coating Applicators Qualifications:
1. The application company or entity must demonstrate with written references as required in 1.04 A. 7. and 8. a minimum of five (5) years of practical experience in the application of the specified coatings and the successful completion of a minimum of five (5) projects of similar size and complexity within the last five (5) years. This must be verified in writing by the selected coating system manufacturer.
2. The application company or entity must be QP-1 Certified by SSPC for coatings work relevant to the qualifications of QP-1.
3. For the application company's or entity's personnel: employ only those persons on the project trained in the application of the specified protective coatings. Written confirmation of this must be provided by the approved coating systems manufacturer.

D. Coatings Preconstruction Meeting:
1. The Contractor shall attend a coatings preconstruction meeting prior to commencing any surface preparation or coating application work. Parties attending the meeting shall include the General Contractor, Owner, Owner's Representative, Coating Applicator, the Coating Applicator's Q.C. lead person, and a representative of the Coating Manufacturer. The following items shall be reviewed and discussed at the coatings preconstruction meeting.
   a. Schedule
   b. Environmental requirements
   c. Surfaces to be coated and protection of surfaces not to be coated
   d. Colors
   e. Surface preparation
   f. Application
   g. Coating repair
   h. Field quality control
   i. Housekeeping

j. Disinfection (of potable water structures)
k. Protection of coating systems
l. One-year inspection
m. Coordination with other trades / work activities/schedule
n. Manufacturer's ongoing technical assistance.

E. Contractor Quality Control Requirements:
1. The Contractor is responsible for ensuring that the surface preparation and coating activities meet the requirements of this specification. Inspections by the Owner, or a representative of the coating manufacturer, will not relieve or limit the Contractor's responsibilities.
2. The specified quality control tasks shall be performed by an individual who has been properly trained and has a minimum of 5 years experience. The Contractor shall provide the Owner documentation indicating that the individual designated to perform quality control has received training similar to NACE CIP Level 3, SSPC PCI Level 2, and, has a minimum of 5 years field experience.
3. Coatings application shall conform to requirements of this specification and the standards referenced in paragraph 1.03.B. Changes in the coating system installation requirements will be allowed only with the written authorization of the Owner before work commences.
4. Contaminated, outdated, diluted materials, and/or materials from previously opened containers shall not be used.
5. For repairs, the Contractor shall provide the same products, or products recommended by the coating manufacturer, as used for the original coating.
6. The Contractor shall identify the points of access for inspection by the Owner. The Contractor shall provide ventilation, ingress and egress, and other means necessary for the Owners' personnel to safely access the work areas.
7. The Contractor shall conduct the work so that the coating system is installed as specified and shall inspect the work continually to ensure that the coating system is installed as specified. Coating system work that does not conform to the Specifications or is otherwise not acceptable shall be corrected in accordance with the coating manufacturer's written procedures.
8. The Contractor shall prepare and submit coating work daily reports for each day while on site. The coating work daily reports shall be submitted to the Owner no later than 1:00 p.m. the following workday. The coating work daily reports shall include the following:
   a. Number of coating applicator employees on site.
   b. Start and finish time of work shift.
   c. Climatic conditions at 4-hour intervals (i.e., partly cloudy, air temperature 78°F, relative humidity 63%, dew point 68°F, and WNW wind @ 4 mph).
   d. Major equipment on site regardless of utilization (i.e., trailers, air compressors, generators, spray pumps, scaffolding, aerial lifts, pressure washers, and sandblast pots).
   e. Inventory of coatings, solvents and abrasive media stored on site including information relative to deliveries received each day.
   f. Summary of work performed to include:
      1) Substrates/structures prepared (size, quantity, and location).
      2) Surface preparation methods including materials consumed and equipment utilized.
      3) Substrates/structures coated (size, quantity, and location).

4) Mixing method and time mixed (coating materials).
5) Induction time, pot life, and application start time.
6) Coating application methods including equipment utilized.
7) Application finish time.
8) Coating materials consumed [sequencing, product name, batch number(s) and manufacture date].
9) Problems encountered (i.e., equipment malfunctions or disruption/interference by other trades).
10) Accidents or near misses.
11) Quality control testing results indicated in Appendix A.

9. Mandatory quality control tests are included in Appendix A.
10. Acceptance criteria for each Quality Control test shall be as indicated on the Coating Detail Sheets, the manufacturer's published data, or elsewhere in this specification, whichever is more stringent.

F. Mandatory Hold Point Inspections:
1. Hold Point Inspections shall be performed in the Owner's presence. The Contractor shall provide the Owner a minimum 2 hours notice prior to performing a Hold Point Inspection.
2. A technical representative employed by the coating manufacturer shall participate in all scheduled Hold Point Inspections. The Contractor shall be responsible for any costs associated with this requirement.
3. Hold Point Inspections shall be performed as follows for each structure, equipment, substrate to receive coating application:
   a. Prior to surface preparation to determine if the environmental or site conditions would be detrimental to surface preparation/coating application, and if the substrate is void of detrimental defects/contamination.
   b. Upon completion of the specified surface preparation (concrete and non-ferrous substrates) or upon completion of the first full production day of surface preparation (ferrous substrates), ensure that the specified level of cleanliness and surface profile have been achieved.
   c. Upon completion of each coating system component to: ensure that no visual coating defects such as runs, sags, voids, holidays, and embedment of foreign matter are present, and ensure that the specified dry film thickness has been achieved.
   d. Upon final cure of the complete coating system to: identify visual coating defects, measure coating system dry film thickness, perform cure evaluation testing, perform holiday detection testing, and perform adhesion testing. Due to the nature and complexity of the specific testing requirements, this Hold Point may encompass between several hours to several days.
   e. Upon completion of remedial repairs (final inspection), should the coating defects be identified at the final cure Hold Point Inspection, all previously stated Hold Points will be applicable during the coating repair process after which a final inspection will be performed. Retesting will be required for the repaired areas at no additional cost to the Owner.
4. The Contractor shall indicate the execution and nature of each Hold Point Inspection in the daily report.
5. The Owner will acknowledge participation at each individual Hold Point on a Contractor prepared document appended to the daily report. The document must include a section wherein the Owner may indicate exceptions or

qualifications. It shall be the Contractor's responsibility to ensure that the Hold Point Inspection is acknowledged by the Owner.

6. Failure to comply with any or all of the Hold Point Inspection requirements may result in the rejection of all subsequent work.
7. Hold Point Inspections may only be waived by written authorization from the Owner.

1.06 ILLUMINATION

A. Provide the following minimum illumination during all phases of work:
   1. General work area: 25-Foot Candles.
   2. Surface preparation and coating application: 30-Foot Candles.
   3. Inspection: 50-Foot Candles.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver all coating materials in unopened containers with manufacturer's label, which must include name, batch number, manufacturer date, shelf life, and VOC content.

B. Store in an assigned area onsite with concurrence from the coating manufacturers. Maintain storage area clean and fire safe. Dispose of used rags, thinner and buckets daily. Store solvents in closed approved storage containers.

1.08 WARNINGS

A. Be advised that application of paint, epoxy, and protective coating materials may be hazardous. Take all necessary precautions to ensure the safety of workers and property.

B. Be advised that as a part of this work abrasive blasting is required. This may require the use of special equipment. Become familiar with the existing site conditions and take all steps necessary to protect adjacent facilities and personnel, at no additional cost to the Owner. In addition, abrasive blasting and painting is called for in, on or around mechanical equipment, which may be damaged by grit, dust, or painting overspray. Mask, wrap, enclose, and provide all protection required to safeguard this equipment at no additional cost to the Owner.

C. Perform abrasive blasting activities in a manner that will not cause nuisance to plant operations, and adjacent public and private property and equipment.

PART 2 - PRODUCTS

2.01 MATERIALS

A. The Coating Detail Sheets in Appendix B refer to specific manufacturers and have been provided as levels of quality as well as jurisdictional VOC compliance for the specified substrate and exposure conditions. Although not stated on the Coating Detail Sheets, the term "or approved equal" is applicable.

B. Coatings used in each coating system shall be the products of a single coating manufacturer. Mixed manufacturer coating systems are prohibited.

C. Alternate coating systems submitted for consideration must be of the same generic type as those specified.

D. Coatings shall not contain heavy metals that exceed the regulated levels of the jurisdiction in which the coatings will be applied.

E. Colors are to be factory mixed, using light-fast colorants proportioned by accurate measurement into proper type base.

F. Abrasive Media:
   1. Shall not be classified as a health or environmental hazard.
   2. Shall be delivered to the site in sealed bag or containers.
   3. Shall be kept clean and dry while stored on site.
   4. Shall not be reused for abrasive blasting unless specifically manufactured for reuse and appropriate recycling equipment is utilized.
   5. Shall be of an appropriate size, shape, and hardness to produce the specified surface profile(s).

2.02 COATING SYSTEMS

A. System Designations and Related Requirements:
   1. The following table provides a general list of the coating systems by both substrate and exposure conditions. Additional information regarding surface preparation, application, dry film thicknesses, and approved products by manufacturer is provided on the Coating Detail Sheets in Appendix B.
   2. It shall be the Contractor's responsibility to ensure that there is chemical compatibility between all shop applied primers or coatings on all machinery and equipment provided for the project and any field applied coatings. Compatibility shall mean that there is no chemical reactivity or physical property of the shop or field applied coatings which will cause or promote intercoat adhesion problems or proper cure problems for the shop or field applied coatings on machinery or equipment or piping. The Contractor shall provide written confirmation by the shop and field applied coating manufacturers that compatibility has been checked and approved by those manufacturers. The rework to correct any compatibility problem between shop and field applied coatings shall be solely the responsibility of the Contractor at no additional cost to the Owner.

System Identification	Substrate	Exposure
System No. 2: Zinc-Epoxy-Urethane	Metal	Atmospheric Exterior Direct Sunlight Non Immersion Mildly Corrosive
System No. 4: Blended Amine Cured Epoxy (Spray Applied)	Metal	Immersed / Non Immersed Severely Corrosive New Construction Biogenic Sulfide Corrosion

B. Coating System Detail Sheets:
   1. Coating System Detail Sheets (CDS) are included in Appendix B.

C. Finish Schedule:
   1. The Finish Schedule identifies major structures, equipment, and substrates to be coated in accordance with Section 09960. The Finish Schedule is not intended to be a complete listing of all surfaces to be coated and other requirements may be identified elsewhere in the Specifications or on the

Drawings. There may be additional surfaces for the project that require coating application which may not be listed in the Finish Schedule, and the Contractor shall be responsible for coating those surfaces in accordance with the requirements of Section 09960. The Contractor shall be responsible to identify any surfaces for which there is a question about what standard coating system to apply. Address any questions in writing in accordance with paragraph 1.04.A.2 of Section 09960. The Finish Schedule designates the coating system to be applied. Specific information relative to number of coats and film thicknesses is indicated on the Coating Detail Sheets found in Appendix B.

Structure	Substrate	Coating System	Color
Exposed Ductile Iron	Ferrous metal	No. 2	Owner Determined
Exposed Conductor Casing	Ferrous metal	No. 2	Owner Determined
Submerged Ductile Iron	Ferrous metal	No. 4	Owner Determined

2. Colors shall be selected by the Owner.
3. Refer to contract drawings details regarding coating elevation termination and transition details.

D. The Contractor shall provide 1 unopened gallon container of each color and type of coating and solvent/thinner applied during the course of the project to the Owner upon completion of the project.

PART 3 - EXECUTION

3.01 COATINGS

A. General:
1. Coating application shall not proceed until the Owner has received the VOC certifications specified in paragraph 1.04.A.4, the Owner has inspected the materials, and the coating manufacturer has trained the Contractor in the surface preparation, mixing and application of each coating system.

B. Shop and Field Coats:
1. Shop applied prime coat: Except as otherwise specified, prime coats may be shop-applied or field-applied. Shop-applied primer shall be compatible with the specified coating system and shall be applied at the minimum dry film thickness recommended by the coating manufacturer. Product data sheets identifying the shop primer used shall be provided to the on-site coating application personnel. Adhesion tests shall be performed on the shop primer as specified in paragraph 3.01.B.3. Damaged, deteriorated, and poorly applied shop coatings that do not meet the requirements of Section 09960 shall be removed and the surfaces recoated. If the shop prime coat meets the requirements of this Section, the field coating may consist of touching up the

shop prime coat and then applying the finish coats to achieve the specified film thickness and continuity.

2. Field Coats: Field coats shall consist of one or more prime coats and one or more finish coats to build up the coating to the specified dry film thickness. Unless otherwise specified, finish coats shall not be applied until other work in the area is complete and until previous coats have been inspected.
3. Adhesion Confirmation: The Contractor shall perform an adhesion test after proper cure in accordance with ASTM D3359 to demonstrate that: (1) the shop applied prime coat adheres to the substrate; and (2) the specified field coatings adhere to the shop coat. Test results showing an adhesion rating of 5A on immersed surfaces and 4A or better on other surfaces shall be considered acceptable for coatings 5 mils or more in thickness (Method A). Test results showing an adhesion rating of 5B on immersed surfaces and 4B or better on other surfaces shall be considered acceptable for coating thicknesses less than 5 mils.

C. Application Location Requirements:
1. Equipment, Non-immersed: Items of equipment, or parts of equipment which are not immersed in service, shall be shop primed and then finish coated in the field after installation with the specified or acceptable color. If the shop primer requires top coating within a specified period of time, the equipment shall be finish coated in the shop and then touch-up painted after installation. If equipment removal and reinstallation is required for the project, touch-up coating work shall be performed in the field following installation.
2. Equipment, Immersed: Items of equipment, or parts and surfaces of equipment which are immersed when in service, with the exception of pumps and valves, shall have surface preparation and coating work performed in the field. Coating systems applied to immersed equipment shall be pinhole free.

3.02 PREPARATION

A. General:
1. Surface preparations for each type of surface shall be in accordance with the specific requirements of each Coating System Detail Sheet (CDS) and the manufacturer’s requirements. In the event of a conflict, the more stringent requirement shall take precedence.
2. Surfaces to be coated shall be clean and dry. Before applying coating or surface treatments, oil, grease, dirt, rust, loose mill scale, old weathered coatings, and other foreign substances shall be removed. Oil and grease shall be removed before mechanical cleaning is started. Where mechanical cleaning is accomplished by blast cleaning, the abrasive used shall be washed, graded and free of contaminants which might interfere with the adhesion of the coatings. The air used for blast cleaning shall be sufficiently free of oil and moisture to not cause detrimental contamination of the surfaces to be coated.
3. Cleaning and coating shall be scheduled so that dust and spray from the cleaning process shall not fall on wet, newly coated surfaces. Hardware, hardware accessories, nameplates, data tags, machined surfaces, sprinkler heads, electrical fixtures, and similar uncoated items which are in contact with coated surfaces shall be removed or masked prior to surface preparation and painting operations. Following completion of coating, removed items shall be reinstalled. Equipment adjacent to walls shall be disconnected and moved to

permit cleaning and painting of equipment and walls and, following painting, shall be replaced and reconnected.

4. Containment: The Contractor shall erect and maintain protective enclosures as required to ensure that surface preparation debris, including dust, is contained within the immediate work area. All costs associated with containment shall be paid by the Contractor.
5. Dust and Contaminants: Protect substrate from excessive dust and airborne contaminants during coating application and curing. Use temporary dust barriers to close off areas being painted from areas where other work is being performed.

B. Abrasive Blast Cleaning:
   1. When abrasive blast cleaning is required to achieve the specified surface preparation the following requirements for blast cleaning materials and equipment shall be met:
      a. Used or spent blast abrasive shall not be reused on this project.
      b. The compressed air used for blast cleaning shall be filtered and shall contain no condensed water and no oil. Moisture traps shall be cleaned at least once every 4 hours or more frequently as required to prevent moisture from entering the supply air to the abrasive blasting equipment.
      c. Oil separators shall be installed just downstream of compressor discharge valves and at the discharge of the blast pot discharges. These shall be checked on the same frequency as the moisture traps as defined in Item 2 above.
      d. Regulators, gauges, filters, and separators shall be in use on compressor air lines to blasting nozzles times during this work.
      e. An air dryer or desiccant filter drying unit shall be installed which dries the compressed air prior to blast pot connections.
      f. The air dryer shall be used and maintained for the duration of surface preparation work.
      g. The Contractor shall provide ventilation for airborne particulate evacuation (meeting pertinent safety standards) to optimize visibility for both blast cleaning and inspection of the substrate during surface preparation work.
      h. If between final surface preparation work and coating system application, contamination of prepared and cleaned metallic substrates occurs, or if the prepared substrates' appearance darkens or changes color, re-cleaning by water blasting, re-blasting and abrasive blast cleaning shall be required until the specified degree of cleanliness is reclaimed.
      i. The Contractor is responsible for dust control and for protection of mechanical, electrical, and other equipment adjacent to and surrounding the work area.

C. Solvent Cleaning:
   1. Any solvent wash, solvent wipe, or cleaner used, including but not limited to those used for surface preparation in accordance with SSPC SP-1 Solvent Cleaning shall be of the emulsifying type which emits no more than 340 g/l VOCs for AIM regions, 250 g/l for CARB regions and 100 g/l for SCAQMD

regions, contains no phosphates, is biodegradable, removes no zinc, and is compatible with the specified primer.

2. Clean white cloths and clean fluids shall be used in solvent cleaning.

D. Ferrous Metal Substrates:

1. Ferrous surfaces shall be prepared in accordance with applicable surface preparation specifications of SSPC/NACE specified for each coating system. Specific surface preparation requirements are stated on the CDS. The profile depth of the surface to be coated shall be in accordance with the CDS requirements and shall be measured by Method C of ASTM D4417. Blast particle size shall be selected by the Contractor to produce the specified surface profile. The solvent in solvent cleaning operations shall be as recommended by the coating manufacturer.
2. Preparation of ferrous metal surfaces shall be based upon comparison with SSPC-VIS1, and as described in the CDS for each coating system. If dry abrasive blast cleaning is selected and to facilitate inspection, the Contractor shall, on the first day of cleaning operations, abrasive blast metal panels to the standards specified. Plates shall measure a minimum of 8-1/2 inches by 11 inches. Panels meeting the requirements of the specifications shall be initialed by the Contractor and the Owner and coated with a clear non-yellowing finish. One of these panels shall be prepared for each type of abrasive blasting and shall be used as the comparison standard throughout the project.
3. Blast cleaning requirements for steel and ductile-iron substrates are as follows:
    a. Ferrous steel piping shall be prepared in accordance with SSPC SP-6 and primed before installation.
    b. Ductile-iron piping surfaces including fittings shall be prepared in accordance with NAPF 500-03, NAPF 500-03-04, and NAPF 50.
    c. Remove traces of grit, dust, dirt, rust scale, friable material, loose corrosion products or embedded abrasive from substrate by vacuum cleaning prior to coating application.
    d. Care must be taken to prevent contamination of the surface after blasting from worker's fingerprints, deleterious substances on workers' clothing, or from atmospheric conditions.

E. Concrete Surfaces:

1. Inspection of concrete surfaces prior to surface preparation and surface preparation of concrete surfaces shall be performed in accordance with SSPC-SP13/NACE.
2. Prepare substrate cracks, areas requiring resurfacing and perform detail treatment including but not limited to, terminating edges, per coating manufacturer's recommendations. This shall precede surface preparation for degree of cleanliness and profile.
3. The surface profile for prepared concrete surfaces to be coated shall be evaluated by comparing the profile of the prepared concrete with the profile of graded abrasive paper, as described in ANSI B74.18 or by comparing the profile with the ICRI 310.2 (surface profile replicas). Surface profile requirements shall be in accordance with the CDS requirements and the coating manufacturer's recommendations.
4. Surface cleanliness of prepared concrete substrates shall be inspected after cleaning, preparation, and/or drying, but prior to making repairs or applying a

coat in the coating system. If concrete surfaces are repaired, they shall be re-inspected for surface cleanliness prior to application of the coating system.

5. Surface preparation of concrete substrates shall be accomplished using methods stated in SSPC SP-13/NACE 6. The selected cleaning method shall produce the requirements set forth below.
    a. A clean substrate that is free of calcium sulfate, loose coarse or fine aggregate, laitance, loose hydrated cement paste, and otherwise deleterious substances shall be achieved. Blast cleaning and other means necessary shall be used to open up air voids or “bug holes” to expose their complete perimeter. Leaving shelled over, hidden air voids beneath the exposed concrete surface is not acceptable. Concrete substrate must be dry prior to the application of filler/surface or coating system materials.
    b. Acceptable surface preparation must produce a concrete surface with a minimum pH of 8.0 to be confirmed by surface pH testing. If after surface preparation, the surface pH remains below 8.0, perform additional water blasting, cleaning, or abrasive blast cleaning until additional pH testing indicates an acceptable pH level.
    c. Following inspection by the Contractor of the concrete surface preparation, thoroughly vacuum clean concrete surfaces to be coated to remove loose dirt, and spent abrasive (if dry blast cleaning is used) leaving a dust-free, sound concrete substrate. Debris produced by blast cleaning shall be removed from the structures to be coated and disposed of legally off site by the Contractor.
6. Should abrasive blast cleaning or high or ultrahigh pressure water blasting not remove degraded concrete, chipping or other abrading tools shall be used to remove the deteriorated concrete until a sound, clean substrate is achieved which is free of calcium sulfate, loose coarse or fine aggregate, laitance, loose hydrated cement paste, and otherwise deleterious substances. Concrete substrates must be dry prior to the application of filler-surfacers or coating system materials.
7. Surface cleanliness of prepared concrete substrates shall be inspected after cleaning, preparation, and/or drying, but prior to application of coating materials. If concrete surfaces are repaired, they shall be re-inspected for surface cleanliness and required surface profile prior to application of the coating system.
8. Moisture content of concrete to be coated shall be tested in accordance with ASTM D4263, Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method or ASTM F1869, Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride. The ASTM D4263 plastic sheet test shall be conducted at least once for every 500 sq. ft. of surface area to be coated. The presence of any moisture on plastic sheet following test period constitutes a non-acceptable test. Concrete surfaces to be coated, which are on the negative or back side of concrete walls or structures exposed to soils (back filled) or immersed, should be waterproofed. Perform calcium chloride tests in accordance with ASTM F1869 once for each 500 sq. ft. of surface area to be coated. The Contractor shall ensure that the moisture content of the concrete is within the written parameters established by the coating system manufacturer.

3.03 APPLICATION

A. Workmanship:
   1. Coated surfaces shall be free from excessive runs, sags, drips, ridges, waves, laps, and brush marks. Coats shall be applied to produce an even film of uniform thickness completely coating corners and crevices. Minor and infrequent runs and sags which are within the total specified D.F.T. plus a few mils (no more than 10% more mils than the specified total D.F.T.) will be acceptable. However, frequent runs or sags which exceed these limits or otherwise will be detrimental to coating system performance shall not be accepted.
   2. The Contractor's spray equipment shall be designed for application of the materials specified. Compressors shall have suitable traps and filters to remove water and oils from the air. Spray equipment shall be equipped with mechanical agitators, pressure gages, and pressure regulators, and properly sized spray tips.
   3. Each coating application be applied evenly and sharply cut to line. Care shall be exercised to avoid overspray or spattering paint on surfaces not to be coated. Glass, hardware, floors, roofs, and other adjacent areas and installations shall be protected by taping, drop cloths, or other suitable measures.
   4. Coating applications method shall be as recommended by the coating manufacturer.
   5. Allow each coat to cure or dry thoroughly, according to the coating manufacturer’s printed instructions, prior to recoating.
   6. Vary color for each successive coat for coating systems when possible.
   7. When coating complex steel shapes, prior to overall coating system application, stripe coat welds, edges of structural steel shapes, metal cut-outs, pits in steel surfaces, or rough surfaces with the prime coat. This involves applying a separate coat using brushes or rollers to ensure proper coverage. Stripe coat via spray application is not permitted.

B. Coating Properties – Mixing and Thinning:
   1. Coatings, when applied, shall provide a satisfactory film and smooth even surface. Glossy undercoats shall be lightly sanded to provide a surface suitable for the proper application and adhesion of subsequent coats. Coating materials shall be thoroughly stirred, strained, and kept at a uniform consistency during application. Coatings consisting of two or more components shall be mixed in accordance with the coating manufacturer’s instructions. Where necessary to suit the conditions of the surface, temperature, weather and method of application, the coating may be thinned as recommended by the coating manufacturer immediately prior to use. The VOC of the coating as applied shall comply with prevailing air pollution control regulations. Unless otherwise specified, coatings shall not be reduced more than necessary to obtain the proper application characteristics. Thinner shall be as recommended by the coating manufacturer.
   2. Mixing of partial “kits” is strictly prohibited unless authorized in writing by the coating manufacturer and the Owner. This prohibition also applies to coatings mixed for touchup or repairs. If authorized to mix partial kits, the Contractor shall utilize containers with appropriate graduated markings/calibrated weight scales.

C. Environmental Conditions:

1. Provide adequate heat, ventilation, and dehumidification to ensure that the coating manufacturer's environmental requirements are met and to ensure no loss of production days due to failure to meet coating manufacturer's environmental requirements.
2. Provide sufficient and continuous ventilation and air movement across coated substrates to remove volatile constituents (solvent) throughout the manufacturer's published curing period.
3. Air and surface temperatures: Prepare surfaces, apply and cure coatings within air and surface temperature range recommended by coating manufacturer.
4. Relative humidity: Prepare surfaces, apply and cure coatings within relative humidity range in accordance with coating manufacturer's instructions.
5. Dew Point: Do not apply coatings unless the temperature of the dew point is 5°F or greater than the temperature of the substrate.
6. Precipitation: Do not apply coatings in rain, snow, fog, or mist.
7. Wind: Do not spray apply coatings when the wind direction and velocity are such that overspray may result in property damage.

D. Concrete Substrate Temperatures and Detail Treatment:
1. When the surface temperatures of the concrete substrates to be coated are rising or when these substrates are in direct sunlight, outgassing of air from the concrete may result in bubbling, pinhole formations, or blistering in the coating system. The application of the filler-surface and the coating system will only be allowed during periods of falling temperature. This may require that application of the filler-surfacer and coating system to occur during the cooler evening hours. Contractor shall include any cost for working outside of normal hours in the bid.
2. Should bubbles, pinholes, or discontinuities form in the applied coating system material, they shall be repaired as recommended by the coating manufacturer. Should pinholes develop in the filler-surfacer material or in the first coat of the coating material, the pinholes shall be repaired in accordance with the recommendations prior to application of the next coat of material. Whenever pinholes occur, the air void behind or beneath the pinhole shall be opened up completely and then completely filled with the specified filler-surfacer material. Next, the coated area around the pinhole repair shall be abraded and the coating reapplied over that area.
3. Perform application detail work per the coating manufacturer's current written recommendations and/or drawings.

E. Protection of Coated Surfaces:
1. Items which have been coated shall not be handled, worked on, or otherwise disturbed, until the coating is completely dry and hard. After delivery at the site, and upon permanent erection or installation, shop-coated metalwork shall be recoated or retouched with specified coating when it is necessary to maintain the integrity of the film.

F. Film Thickness and Continuity:
1. WFT of the first coat of the coating system and subsequent coats shall be verified by the Contractor, during application of each coat.
2. Coatings shall be applied to the minimum dry film thickness specified as indicated on the CDS. Dry film thickness shall be determined using the appropriate industry standard for the substrate (SSPC-PA 2, SSPC-PA 9, or ASTM D1400). Coatings determined to be above the maximum dry film

thickness as indicated on the CDS or the coating manufacturer's product data sheet, will be removed at the Owner's discretion.

3. In testing for continuity of coating about welds, projections (such as bolts and nuts), and crevices, the Owner shall determine the minimum conductivity for smooth areas of like coating where the dry mil thickness has been accepted. This conductivity shall be the minimum required for these rough or irregular areas. Pinholes and holidays shall be recoated to the required coverage.
4. The ability to obtain specified film thickness is generally compromised when brush or roller application methods are used and, therefore, more coats may be needed to be applied to achieve the specified dry film thickness.
5. For concrete substrates, the Contractor shall apply a complete skim coat of the specified filler-surfacer material over the entire substrate prior to application of the coating system. This material shall be applied such that all open air voids and "bug holes" in the concrete substrate are completely filled prior to coating application.

G. Special Requirements:
1. Before erection, the Contractor shall apply all but the final finish coat to interior surfaces of roof plates, roof rafters and supports, pipe hangers, piping in contact with hangers, and contact surfaces which are inaccessible after assembly. The final coat shall be applied after erection. Structural friction connections and high tensile bolts and nuts shall be coated after erection. Areas damaged during erection shall be hand-cleaned or power-tool cleaned and recoated with primer coat prior to the application of subsequent coats. Touch-up of surfaces shall be performed after installation. Surfaces to be coated shall be clean and dry at the time of application. Except for those to be filled with grout, the underside of equipment bases and supports that have not been galvanized shall be coated with at least two coats of primer specified for System #1 in the CDS prior to setting the equipment in place. Provide coating system terminations at leading edges and transitions to other substrates in accordance with the coating manufacturer's recommendations or detail drawings.

H. Soluble Salt Contamination of Metal Substrates:
1. Contractor shall test in accordance with SSPC Guide 15 metal substrates to be coated that have been exposed to sea water or coastal air or to industrial fallout of particulate or other sources of soluble chlorides (such as waste water exposure). If testing indicates chloride levels in excess of 25 ppm exist after the surface preparation has been completed, the Contractor shall re-clean and prepare these surfaces until chloride levels are below 25 ppm.

I. Refer to the Finish Schedule in Section 09900 for coating details of architectural coating requirements.

3.04 INSPECTION AND TESTING BY AN INDEPENDENT THIRD PARTY

A. The Owner reserves the right to engage the services of an independent third party to provide quality control inspection. Third party inspection is in addition to any inspection required to be performed by the Contractor and does not limit the Contractor's responsibility for quality workmanship or quality control as specified.

B. Third party inspection will be performed in a manner which limits interference / inhibits the Contractor's operations. Whenever feasible, the third party inspections will be performed concurrently with the Contractor's required inspections.

C. Testing Discrepancies: In the event that discrepancies occur relative to test methods or test results, the findings of the Independent Third Party shall be final. The Contractor shall not be entitled to additional monies for rework/additional work necessary to satisfy the requirements of the specification as a result of the Independent Third Parties findings.

3.05 FINAL INSPECTION

A. Contractor shall conduct a final inspection to determine whether coating system work meets the requirements of the Specifications.

B. The Owner will subsequently conduct a final inspection with the Contractor to determine the work is in conformance with requirements of the contract documents.

C. Any rework required shall be marked. Such areas shall be re-cleaned and repaired as specified at no additional cost to the Owner.

3.06 CLEANUP

A. Upon completion of the work, the Contractor shall remove and dispose of surplus materials, protective coverings, spent abrasive, and accumulated rubbish.

B. All surfaces shall be thoroughly cleaned and any damage resulting from surface preparation or coating application shall be repaired.

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SECTION 09960
APPENDIX A
STANDARDS AND REFERENCES AND MANDATORY QUALITY CONTROL TESTING

I. STANDARDS AND REFERENCES

A. American National Standards Institute (ANSI):
1. ANSI/NSF 61 Drinking Water System Components

B. ASTM International (ASTM):

1.	ASTM D16-11a	Standard Terminology for Paint, Related Coatings, Materials and Applications
2.	ASTM D3960	Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings
3.	ASTM D4262	Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces
4.	ASTM D4263	Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method
5.	ASTM D4414	Standard Practice for Measurement of Wet Film Thickness by Notch Gages
6.	ASTM D4417	Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel
7.	ASTM D4541	Standard Test Methods for Pull-Off Strength of Coatings on Metal Substrates Using Portable Adhesion Testers
8.	ASTM D4787	Standard Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates
9.	ASTM D5162	Standard Practice for Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates
10.	ASTM D7234	Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Adhesion Testers
11.	ASTM E337	Standard Test Method for Measuring Humidity With a Psychrometer
12.	ASTM F1869	Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride

C. Federal:

1.	FS 595b:	Federal Standard Colors

D. International Concrete Repair Institute (ICRI):

1.	ICRI 310.2	Guideline for Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays

E. National Association of Corrosion Engineers International (NACE):

1.	NACE Standard SP0188	Standard Recommended Practice – Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates
2.	NACE Standard RP0288	Standard Recommended Practice, Inspection of Linings on Steel and Concrete
3.	NACE Standard SP0892	Standard Recommended Practice, Linings Over Concrete in Immersion Service
4.	NACE Publication TPC2	Coatings and Linings for Immersion Service

F. National Association of Pipe Fabricators (NAPF):

1.	NAPF 500-03	Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings

G. Occupational Safety and Health Administration (OSHA):

1.	OSHA Title 29, Part 1926	Safety and Health Standards for Construction

H. Society for Protective Coatings (SSPC) [(1)]:

1.	SSPC-PA COM	Paint Application Specifications and Guides (Commentary)
2.	SSPC-AB 1	Mineral and Slag Abrasives
3.	SSPC-PA 1	Shop, Field, and Maintenance Painting of Steel
4.	SSPC-PA 2, Level 3	Measurement of Dry Coating Thickness with Magnetic Gages
5.	SSPC-PA 9	Measurement of Dry Coating Thickness on Cementitious Substrates Using Ultrasonic Gages
6.	SSPC Technology Guide 6	Guide for Containing Debris Generated During Paint Removal Operations
7.	SSPC Technology Guide 7	Guide to the Disposal of Lead-Contaminated Surface Preparation Debris
8.	SSPC-PA Guide 10	A Guide to Safety and Health Requirements for Industrial Painting Projects
9.	SSPC-PA Guide 11	Protecting Edges, Crevices, and Irregular Steel Surfaces by Stripe Coating
10.	SSPC Technology Guide 12	Guide for Illumination of Industrial Painting Projects
11.	SSPC-PA Guide 15	Field Methods for Retrieval and Analysis of Soluble Salts on Steel and other Non Porous Substrates
12.	SSPC-PA Guide 17	Procedure for Determining Conformance to Steel Profile/Surface Roughness/Peak Count Requirements
13.	SSPC-PA Guide 19	Guide to Selecting Coatings for Use Over Galvanized Steel Substrates
14.	SSPC SP1	Solvent Cleaning
15.	SSPC SP2	Hand Tool Cleaning
16.	SSPC SP3	Power Tool Cleaning
17.	SSPC SP5	White Metal Blast Cleaning
18.	SSPC SP6	Commercial Blast Cleaning
19.	SSPC SP7	Brush-Off Blast Cleaning
20.	SSPC SP10	Near-White Blast Cleaning
21.	SSPC SP11	Power Tool Cleaning to Bare Metal
22.	SSPC SP 13	Surface Preparation of Concrete
23.	SSPC SP 14	Industrial Blast Cleaning
24.	SSPC SP 15	Commercial Grade Power Tool Cleaning
25.	SSPC SP 16	Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals
26.	SSPC-TR 2/NACE 6G198	Wet Abrasive Blast Cleaning
27.	SSPC-TR3/NACE 6A192	Dehumidification and Temperature Control During Surface Preparation, Application, and

		Curing for Coatings/Linings of Steel Tanks, Vessels, and Other Enclosed Spaces
28.	SSPC-TU-3	Overcoating
29.	SSPC-VIS 1	Visual Standard for Abrasive Blast Cleaned Steel
30.	SSPC-VIS 3	Visual Standard for Power and Hand – Tool Cleaned Steel
31.	SSPC-VIS 4	Visual Standards (Waterjetting)
32.	SSPC-VIS 5	Visual Standards (Wet Abrasive Blast Cleaning)
33.	SSPC-WJ 1,2,3,4	Water Jetting Surface preparation Standards

II. MANDATORY QUALITY CONTROL TESTS

Test Requirement	Reference Standard	Interval / Frequency
Measure and Record Ambient and Surface Temperatures	N/A	During coating application and initial cure. Every 3 hours.
Measure and Record Relative Humidity and Dew Point	ASTM D 337	During coating application and initial cure. Every 3 hours,
Abrasive Cleanliness	SSPC AB-1 SSPC AB-2 ASTM D 4940	Each day abrasive blasting is performed. Immediately prior to start of abrasive blasting.
Compressed Air Cleanliness	ASTM D 4285	Each day compressed air is utilized for abrasive blasting, paint application, or to remove surface contamination; immediately prior to any of the indicated operations.
Determining Level of Cleanliness (substrate condition after the specified surface preparation has been completed)	SSPC – VIS 1 SSPC – VIS 3 SSPC - VIS 4/NACE VIS 7 SSPC - VIS 5/NACE VIS 9 SSPC - SP 1 SSPC - SP 2 SSPC - SP 3 SSPC - SP 5/NACE No. 1 SSPC - SP 6/NACE No. 3 SSPC - SP 7/NACE No. 4 SSPC - SP 10/NACE No. 2 SSPC - SP 11 SSPC - SP 13/NACE No.6 SSPC - SP 14/NACE No.8 SSPC - SP 15 SSPC - SP 16 SSPC – WJ 1,2,3,4	Each day surface preparation is performed immediately prior to coating application.
Levels of Soluble Salt Contamination (steel and other nonporous substrates)	SSPC Technology Guide 15	Each day coating application is performed; immediately prior to coating application.
Surface pH (concrete or metal)	ASTM D 4262 (use 6.1 and 6.2 for metal)	Each day coating application is performed; immediately prior to coating application.
Measurement of Surface Profile (metal substrates)	ASTM D 4417	Each day surface preparation is performed. Upon completion of shift or task.
Measurement of Surface Profile (concrete substrates)	ASTM D 7682	Each day surface preparation is performed. Upon completion of shift or task.

Test Requirement	Reference Standard	Interval / Frequency
Comparison of Surface Profile (concrete substrates)	ICRI 310.2	Each day surface preparation is performed. Upon completion of shift or task.
Moisture in Concrete (plastic sheet method)	ASTM D 4263	Upon completion of surface preparation. Whenever climatic conditions substantially change.
Relative Humidity (slabs/concrete floors)	ASTM F 2170	As recommended by coating/lining manufacturer.
Measure and Record Material Temperatures (all components)	N/A	Each day coating application is performed. Immediately prior to coating application.
Wet Film Thickness	ASTM D 4414	Each day coating application is performed. Hourly during coating application.
Dry Film Thickness (non-ferrous metal substrates)	ASTM D 1400	After coating has properly cured. After each layer (component) of the specified coating system.
Dry Film Thickness (cementitious substrates)	SSPC-PA 9	After coating has properly cured. After each layer (component) of the specified coating system.
Dry Film Thickness (destructive method – all substrates)	ASTM D 4138	Whenever verification as to the accuracy of other methods is deemed necessary.
Holiday Detection (conductive substrates)	NACE SPO 188	After coating system has properly cured. Once on entire surface and as necessary over repaired areas to verify effectiveness of the repair(s).
Holiday Detection (metal substrates)	ASTM D 5162	After coating system has properly cured. Once on entire surface and as necessary over repaired areas to verify effectiveness of the repair(s).
Adhesion Testing (metal substrates)	ASTM D 4541	After coating system has properly cured. Number of tests proportionate to surface area.
Adhesion Testing (concrete substrates)	ASTM D 7234	After coating system has properly cured. Number of tests proportionate to surface area.

Test Requirement	Reference Standard	Interval / Frequency
Final Cure (solvent rub – organic coatings)	ASTM D 5402	After coating system has been cured per manufacturer's published recommendations.

SECTION 09960

APPENDIX B – COATING DETAIL SHEETS

HIGH PERFORMANCE COATINGS

Coating Detail Sheet:	**System No. 2**
Coating Material:	Zinc-Epoxy-Polyurethane System
Surface:	Metal
Service Condition:	Exterior, exposed to direct sunlight, mildly corrosive, non-immersed.
Surface Preparation:	
General:	Shop primed surfaces which are to be incorporated in the work shall be prepared in the field by cleaning surfaces in accordance with SSPC SP-2 (Hand Tool Cleaning). Damaged shop coated areas shall be cleaned in accordance with SSPC SP-3 (Power Tool Cleaning) and recoated with the primer specified. For System No. 2 over factory coated or shop primed pumps, tanks, or other equipment, delete the zinc rich primer and use a compatible primer as recommended by the coating manufacturer.
Ferrous Metal:	Bare ferrous metal surfaces shall be prepared in accordance with SSPC SP-6 (Commercial Blast Cleaning) 2.5 – 3.0. Ductile iron surfaces to be coated shall be abrasive blast cleaned in accordance with Section 09900, paragraph 3.02.D. Ferrous metal with rust bleeding shall be cleaned in accordance with SSPC SP-11 (Power Tool Cleaning to Bare Metal). Areas of rust penetration shall be spot blasted to SSPC SP-10 (Near White Blast) and spot primed with the specified primer.
Galvanized Metal:	Damaged galvanized steel areas with exposed ferrous metal and/or rusted shall be cleaned in accordance with SSPC SP-5 (White Metal Blast Cleaning) or Power Tool Cleaned to Bare Metal in accordance with SSPC SP-11 to achieve a uniform 1.0 to 1.5 mil profile and spot primed with the primer specified. Nonferrous and galvanized metal shall be prepared in accordance with SSPC SP-16 to impart a 1.0 to 2.0 mil profile to the galvanized steel surfaces. Where this cannot be performed, prepare by abrading in accordance with SSPC SP-3, Power Tool Cleaning to impart a 1.0 to 1.5 mil profile uniformly to the galvanized steel surfaces. For System No. 2 over galvanized steel, delete the zinc rich primer.

Coating Detail Sheet:	**System No. 2**
Application:	Field
General:	Prime coat may be thinned and applied as recommended by the coating system manufacturer, provided the coating as applied complies with prevailing air pollution control regulations.
Ferrous Metal:	Prime coats shall be a zinc rich epoxy or polyurethane primer compatible for use with urethane finish coats and applied in accordance with written instructions of the coating manufacturer or in the case of CARB or SCAQMD applications, prime with specified primer that is not zinc rich. In these cases, only a two-coat system is applied.
System Thickness:	Minimum of; 3 to 4 mils of zinc rich primer, one intermediate or primer epoxy coat at 5 to 6 mils and one finish coat of polyurethane at 2 to 3 mils DFT.
Coatings:	
Primer:	One coat at the coating manufacturer's recommended dry film thickness per coat to meet the specified minimum thickness.
Intermediate:	One coat at the coating manufacturer's recommended dry film thickness per coat to meet the specified minimum thickness.
Finish	One coat at the coating manufacturer's recommended dry film thickness per coat to meet the specified minimum thickness.

Approved Manufacturers:

1. South Coast Air Quality Management District:

System Manufacturer	First / Prime Coat(s)	Intermediate Coat(s)	Finish Coat(s)
PPG	Amercoat 68HS	Amerlock 400 VOC	Amershield VOC
Carboline	859 VOC	Carbogard 890 VOC	Carbothane 134MC
Sherwin Williams	Zinc Clad III HS Primer	Macropoxy 646 100	Hi Solids Polyurethane 100
Tnemec	Series 94 H_2O	Series V69	Series 1075

* See Product Data Sheet for applicable thinners for VOC compliance or do not thin.

END OF SYSTEM NO. 2

Coating Detail Sheet:	**System No. 4**
Coating Material:	Blended Amine Cured Epoxy – Spray Applied
Surface:	Metal or Concrete
Service Condition:	Immersed, nonpotable; non-immersed, corrosive environment, color not required especially for headspace environments that are corrosive due to biogenic sulfide corrosion.
Surface Preparation:	
Ferrous Metal:	Ferrous metal surfaces shall be prepared in accordance with SSPC SP-5 (White Metal Blast Cleaning) to achieve a uniform surface profile of 3.0 to 3.5 mils. Blast Cleaning shall produce a minimum surface profile of 3.0 mils. Shop primed surfaces which are to be incorporated in the work shall be prepared in the field by cleaning surfaces in accordance with SSPC SP-11 (Power Tool Cleaning to Bare Metal). Damaged shop coated areas shall be cleaned in accordance with SSPC SP-5 (White Metal Blast Cleaning) and spot primed with the primer specified. Shop epoxy primed surfaces shall require light abrasive blasting and blow down cleaning prior to receiving finish coats. Cast or ductile iron surfaces to be coated shall be abrasive blast cleaned to a clean, gray uniform metal appearance free of variations in color and loose materials. Ductile and cast iron surfaces shall be prepared in accordance with Section 09960, paragraph 3.02.D.
Non-ferrous and Galvanized Metal:	Non-ferrous and galvanized metal shall be prepared in accordance with SSPC SP-16 to achieve a uniform surface profile of 2.0 to 2.5 mils. Galvanized metal should generally not be used in these environments.
Concrete and Masonry Surfaces:	All coating termination and transition details shall be prepared in accordance with the coating manufacturer's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, pipe penetration treatment, coating terminations at metal embedments in the concrete substrate, and other details. The coating manufacturer's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the coating manufacturer shall be required to produce one at no additional cost to the owner, the engineer, or any other party.

Coating Detail Sheet:	**System No. 4**
	If wet abrasive or water blasting surface preparation methods were used, the concrete substrate shall be allowed to dry under warm conditions (minimum of 75°F) for at least 5 days prior to coating application. Following surface preparation work and dry-out, all surfaces to be coated shall be vacuum cleaned to remove all loose dirt, dust, or other loose materials.
Concrete:	Concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the coating manufacturer. Moisture content may be tested by the Construction Manager with a Delmhorst Instrument Company moisture detector, or equal. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces by abrasive blasting and chipping, and voids and cracks shall be repaired as specified in Division 3. Surface Preparation must open up all shelled over airvoids or bug holes to fully expose the void's depth, width, and length. Concrete shall be abraded to achieve a uniform concrete surface profile of CSP-5 in accordance with ICRI 310.2. After surface preparation has been accepted, a complete skim coat of the specified filler surfacer shall be applied over all concrete surfaces and all "bug holes" (air voids) shall be completely filled using this same material. The filler/surfacer material shall be applied as a complete parge coat of the substrate. If the parge coat (filler/surfacer material) is non-polymer modified, it must be brush blast cleaned following adequate cure per coating manufacturer's instructions to produce a uniform anchor pattern of CSP-4 in accordance with ICRI 310.2 prior to coating application.
Masonry:	Masonry surfaces shall be allowed to cure for at least 28 days. Holes or other joint defects shall be filled with mortar and repointed and allowed to cure for 28 days or shall be filled with a repair material compatible with the coating system that does not require hydration cure time. Loose or splattered mortar shall be removed by scraping and chipping. Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances. Muriatic acid shall not be used. After cleaning, masonry surfaces shall be skim coated with a surfacer or block filler compatible with the specified coating system.

Coating Detail Sheet:	**System No. 4**
Application:	Field for Metal Substrates
General:	Prime coat may be thinned and applied as recommended by the coating manufacturer, provided the coating as applied complies with prevailing air pollution control regulations. Drying time between coats shall be as specified by the coating manufacturer for the site conditions. If the maximum recoat time is exceeded, surface preparation shall require solvent washing, light abrasive blasting, or other procedures per coating manufacturer's instructions.
Ferrous Metal:	If shop priming is required or field priming is necessary, the prime coat shall be an epoxy primer compatible with the specified coating system. Generally, System No. 4 is self-priming and does not require a primer unless there is a special reason to prime the steel to hold the blast cleaning from rusting back.
System Thickness:	30 to 40 mils dry film.
Coatings:	
Primer:	One coat at the coating manufacturer's recommended dry film thickness only if required by special circumstances.
Finish:	One or more coats at the coating manufacturer's recommended dry film thickness per coat to the specified system thickness.
Testing:	Holiday detection shall be performed over 100% of the coated surface area to identify any holidays or pinholes which must be repaired.
Pinhole and Holiday Repair Procedure:	Pinholes and holidays identified by Holiday Detection shall be repaired as follows: • Using a pencil grinder, remove a ½-inch-diameter area of the coating system material back to the ferrous metal substrate. The metal must be shiny. • Aggressively sand or abrade the intact coating system surface 2 inches around the complete periphery of the ½-inch-diameter removal area to produce a uniform 6 to 8 mils profile. • Vacuum clean the prepared area to remove all dust and dirt to achieve a clean, sound surface. Tape the peripheral area to prevent coating application onto unprepared surfaces.

Coating Detail Sheet:	**System No. 4**
	• Brush apply one coat of the finish coating material. Following proper recoat cure time, apply additional coats of the finish coating system to achieve 40 mils DFT at the coating removal area and feather the coating onto the roughened coated surfaces to form a neat repair outline.
Application:	Field for Concrete and Masonry Substrates
	Surfacer or filler shall be applied per coating manufacturer's recommendations prior to application of coating to fill all bug holes and voids and create a complete parge coat of the prepared substrate. This parge coat shall completely fill all bug holes and voids in the substrate, and will also completely cover the substrate unless specified otherwise above such filled voids by 1/8-inch (125 mils) of thickness.
	Drying time between coats shall be as specified by the coating manufacturer for the site conditions. If the maximum recoat time is exceeded, surface preparation shall require solvent washing, light abrasive blasting, or other procedures per coating manufacturer 's instructions
System Thickness:	60 mils dry film in addition to the parge coat.
Coatings:	
Finish:	One or more coats at coating manufacturer's recommended dry film thickness per coat to the specified system thickness.
Testing:	Holiday detection shall be performed over 100% of the coated surface area to identify any holidays or pinholes which could compromise coating system performance. Holiday testing to be performed after application and adequate cure of the spray applied epoxy coating material. Holiday detection shall be performed in accordance with NACE RP0188.
Pinhole and Holiday Repair Procedure:	Pinholes and holidays identified by Holiday Detection shall be repaired as follows:
	• Using a pencil grinder or other suitable power tool, remove the coating system at all pinholes or holidays in an area at least 2 inches in diameter or in both dimensions around the defect back to the concrete substrate.

Coating Detail Sheet: **System No. 4**

- Chip out and remove the concrete to expose the full dimensions in all three directions of the air void responsible for the defect.
- Aggressively abrade or sand the intact coating system surface at least 3 inches beyond the removal area in all directions to produce a uniform 6 to 8 mil profile in the intact coating system.
- Vacuum clean the prepared area to remove all dust, dirt, etc. leaving clean sound surfaces.
- Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area.
- Using a putty knife or other suitable tool, fill the opened void with the approved filler/surfacer material completely and strike-off. Allow to cure per coating manufacturer's recommendations.
- Apply the coating system in the number of coats necessary to achieve the specified 60 mils DFT over the defect and coating removal area and feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline. Allow to cure properly.

Approved Manufacturers:

1.
South Coast Air Quality Management District:

System Manufacturer	First / Prime Coat(s)	Finish Coat(s)
Carboline	Plasite 4550S	Plasite 4550S
Sauereisen	Sewergard 210S	Sewergard 210S
Tnemec	Series 435	Series 435

END OF SYSTEM NO. 4

SECTION 09961

HIGH SOLIDS EPOXY LINING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Lining of existing and new manholes, lift station wet wells, and emergency storage basin. The Contractor shall coordinate his work so as not to interfere with the existing sanitary sewer service. Lining shall consist of preparing the interior surface of each manhole, controlling and eliminating active groundwater infiltration via chemical grout injection, application of repair mortar where needed to restore damaged surfaces, application of epoxy primer and lining and all incidentals necessary to complete the work contained in these technical provisions in accordance with the District Standards and SSPWC Section 502.

B. Related Sections:
   1. Section 02080: Precast Concrete Sectional Manholes

1.02 SUBMITTALS

Contractor shall furnish submittals in accordance with the requirements of Section 1 – General Conditions and Section 01300. The following submittals are required:

A. Submit manufacturer's catalog literature and product data sheets, describing the colors, physical and chemical properties of the epoxy coating. Describe application and curing procedure.

B. Submit coating application test records for measuring coating thickness, adhesion, and holiday detection for each structure. Describe repair procedures.

C. Submit contractor’s personnel certification from lining manufacturer to install the lining system products.

D. The Contractor shall submit copies of manufacturer's written instructions for recommended maintenance practices. Include the following information:

   1. Product name and number.
   2. Name, address and telephone number of manufacturer and local distributer.
   3. Detailed procedures for routine maintenance and cleaning.
   4. Detailed procedures for repairs.
   5. Submit a Sewer Bypass Plan.

1.03 QUALITY ASSURANCE

A. Packaging: The Contractor shall store all products to be used in their original packaging. The packaging shall indicate the manufacturer and product contained.

B. All products to be used in the work covered by this section of the specifications shall be delivered, stored, and handled in accordance with the product manufacturer's written recommendations.

C. Manufacturer and applicator both shall demonstrate a minimum of five (5) years of experience and five (5) successfully completed projects of similar magnitude and nature as this project. Experience and project references shall include project name, project number where applicable, agency or AGENCY, contact name, phone number, and project description. All Applicators shall be certified or licensed by the protective coating materials manufacturer.

D. Provide each component of protective coating produced by a single manufacturer, including recommended underlayment and resurfacing compound, filler compounds and corrosion resistant lining.

E. Upon completion of the Work under this Section, submit a statement to Engineer, signed by Contractor and the protective Coating Applicator stating that the installed protective coating complies with the requirements of the Specifications, and that the installation and materials comply with the manufacturer's printed recommendations related to the condition of installation and use.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver material in manufacturer's original unopened and undamaged packages. Clearly identify manufacturer, brand name, manufactured date or lot number on each package. Packages showing indications of damage that may affect condition of contents are not acceptable.

B. Store materials in original packaging under protective cover and protect from damage. Stack and store all containers including fillers at temperatures recommended by the manufacturer.

C. Handle materials in such a manner as to prevent damage to products or finishes.

1.05 JOB CONDITIONS

A. Maintain proper substrate and air temperature before, during and after installation as required by Manufacturer and detailed in Manufacturer's technical data sheets and installation instructions or in writing from the Manufacturer. Provide adequate ventilation during application and curing periods.

PART 2 - MATERIALS

Epoxy material shall be 100% solids and shall be designed for use in manhole rehabilitation. Epoxy material shall be spray applied and in accordance with the manufacturer's recommendations and these specifications. Flexible epoxy lining will not be allowed. Epoxy lining shall be applied to all interior surfaces of the concrete structure including but not limited to the invert, benches, walls, cone, and grade rings to create a monolithic lining. Frame casting shall not be coated with epoxy. Minimum thickness of epoxy lining shall be as specified by manufacturer.

Provide: Epoxy lining and coating shall meet or exceed the following requirements:

A. Be a complete system for substrate repair, groundwater infiltration prevention and epoxy based corrosion protection including:

1. Chemical grout shall be injected to eliminate active groundwater infiltration.
2. Cementitous resurfacing/ underlayment compound is required, and shall be installed to fill surface irregularities and large voids in the prepared concrete.substrate; minimum application thickness 1/8”.
3. Epoxy filler compound to fill all voids and bug holes in concrete to provide a properly prepared and uniform surface for the epoxy lining.
4. 100% solids epoxy, moisture tolerant, polymer lining designed specifically for municipal wastewater exposure at a minimum thickness of 125 mils.
5. The applicator shall supply all accessory components such as sealers, chemical grout for infiltration elimination via injection method or other compounds or products as recommended by the protective lining manufacturer for maximum protective lining adherence to substrate and long-term service performance.

B. Types of protective lining system components for the corrosion protection work required, including surface treatment of prepared surfaces prior to coating application, shall include, but are not necessarily limited to trowel or gun applied, fast setting, high-early strength cementitous resurfacing/underlayment compounds, epoxy formulation filler compound for application, corrosion- resistant, moisture tolerant, 100% solids epoxy, spray or trowel applied, monolithic protective lining and miscellaneous materials.

1. Chemical Grout: Cementitous products, applied via injection, shall be used for used to stop leakage through areas included but not limited to cracked concrete, voids, joints, and pipe intrusions. Product shall have chemical resistance and be suitable for use in sewer environment. Product shall expand when it meets any source of water or moisture before curing and be capable of adhering and bonding to substrates (such as concrete, vitrified clay, etc.) in the wet or dry condition. Product shall be installed in accordance with manufacturer’s recommendations, including proper surface preparation.

   Product: Sauereisen Hydroactive Polyurethane Grout No. F-370, or approved equal

2. Underlayment Resurfacing Compound: Cementitous resurfacing products shall be used for surface leveling, large bug holes, and for general concrete

patching and shall be installed and cured according to Manufacturer's written guidelines as outlined in product technical data sheets. All voids must be completely filled and existing substrate covered in its entirety so that the finish of underlayment resurfacing compound should is uniform in appearance. Apply a "broom" finish to resurfacing compound at time of installation to create adhesion profile.

Minimum Properties:
Application Time:

Working Tine at 70F	30 minutes
Initial Set at 70F	3 hours
Color	Tan
Compressive Strength:	
@24 hours	3500 psi
@5 hours	2500 psi
@28 hours	6000 psi
Density:	
Mix Ratio (Powder to Water, by Weight)	9:1
Abrasion Resistance (ASTM C-704) Volume Loss, cm^3	5.14 cm^3
Volume Loss, %	0.65%
Freeze-thaw Durability Factor (ASTM C666-A)	87.2

Underlayment shall be a fast-setting, high early strength, Portland/Calcium Aluminate-based resurfacing material. Underlayment shall be trowelable formulation, except where Applicator recommends alternate use of sprayable, castable or gunite formulations by the same manufacturer for intended service application. Underlayment Resurfacing Compound shall to be applied to the entirety of the interior surface to fill all irregularities to provide uniform surface for the application of the epoxy corrosion resistant lining system. The underlayment may be substituted with the Epoxy Filler Compound or High Build Epoxy Filler Compound based upon contractor recommendation and site conditions at time of installation.

Product: Sauereisen RestoKrete™ Substrate Resurfacer No. F-121, or approved equal

3. Epoxy Filler Compound: Epoxy filler, where required, shall be used for filling small bug holes, static cracks and joints, and for general concrete patching, in concrete and to provide a uniform, void free surface for epoxy lining application

Minimum Properties:	
Color	Off White
Compressive Strength	10,000 psi
Density (ASTM C-905)	87.2 pcf
Flexual Strength (ASTM C-580)	4000 psi
Modulus of Elasticity (ASTM C-580)	$5.2x10^4$ psi
Tensile Strength (ASTM C-307)	2200 psi
Bond Strength to Concrete (ASTM D-4541)	Concrete Failure
Moisture Absorption (ASTM C-413)	<0.25%
Shrinkage (ASTM-531)	<0.2%
Working Time	15 min @ 70F
Topcoat	3 hrs @ 70F

Filler Compound shall be an epoxy formulation specifically designed to fill voids, irregularities and air pockets in concrete surfaces. The filler compound shall be applied to the interior substrate to provide a uniform surface for the application of the epoxy corrosion resistant lining system. Filler compound shall be confirmed by the Manufacturer as compatible with any underlayment materials and with the protective coating. The filler compound may be substituted with the Underlayment Resurfacing Compound based upon contractor recommendation and site conditions at time of installation.

Product: Sauereisen RestoKrete™ Epoxy Filler Compound No. 209, or approved equal

4. Epoxy Lining Protective Coating: Epoxy lining protective coating shall be spray applied to the entire interior surface of the sewer manhole including the walls from the manhole base up through the bottom of the manhole lid frame, and the manhole bench from the wall to the channel low flow line and cured on the properly prepared surface in accordance with Manufacturer's written guidelines as outlined in product technical data sheets. The epoxy lining should not overlap the manhole lid frame.

Minimum Properties:	
Adhesion (ASTM D4541)	Concrete Failure
Application Time (ASTM C308 modified), Working Time at 70F	30 minutes
Bond Strength to Concrete (ASTM D7234)	Concrete Failure
Bond Strength by Slant Shear (ASTM C882-Modified)	700psi (49.2kg/cm^2)

Compressive Strength (ASTM D695)	15,500psi (1089.7kg/cm^2)
Components	2 parts
Elongation (ASTM D638)	12.9%
Flexural Strength (ASTM D700) @28 days	8000psi (5624kg/cm^2)
Maximum Service Temperature (Dry)	150F (65C)
Mix Ratio (By Volume)	1 part A (Harder):3 Parts B (Resin)
Modulus of Elasticity (ASTM D700)	5.1 x 104psi
Permeability (ASTM D790)	1.32 x 10^{-10}
Shore D (ASTM D638)	95
Tensile Strength @7 days (ASTM D638)	4300psi (302.3kg/cm^2)
Recommended Thickness	100-125 mils

Epoxy lining shall be a self priming (to concrete), 100% solids, spray- applied epoxy polymer protective coating material specifically designed to protect concrete surfaces in wastewater structures subjected to municipal wastewater service conditions, including associated abrasive physical attack and chemical attack mechanisms related to hydrogen sulfide and organic acids generated by microbial sources. (Note: an alternate trowel applied formulation of the identical resin and hardener system with different fillers may be applied at the specified thickness when approved in writing by the Manufacturer.)

Product: Sauereisen SewerGard No. 210X, or approved equal

PART 3 - EXECUTION

3.01 SEWAGE FLOW AND DIVERSION

A. Provide means, labor, and equipment to divert flow from pipelines entering the manholeas necessary to prevent sewage flow from contacting surfaces to be coated.

1. Pumping: If pumping is utilized to divert flow, Contractor shall provide adequate size pump(s) to handle up to 200 percent of the maximum expected flow. The Contractor shall determine the required flow capacity. The Owner has included flow information within the Contract Documents for the Contractor. Higher flows may be encountered depending on weather and other upstream conditions.
2. Contractor shall provide 100 percent redundant by-pass pumping capability (including power supply)Contractor shall provide a full-time operator/inspector with full responsibility for the by- pass pumping operation.
3. In no case shall the Contractor allow any sewage to surcharge and backup into homes or businesses, or in any way overflow into the environment. If the by-pass pumping capacity is insufficient to prevent surcharge and/or overflow at any time, the Contractor shall pull the line plugs irrespective of the status of the application or curing process. The Contractor is responsible for all costs related to sewage spills including any regulatory fines.

4. Contractor shall submit, in accordance with Section 1 – General Conditions, Section 02070, and Section 02072, drawings and complete design data showing methods and equipment he proposes to utilize in sewer bypassing for approval by the Engineer. Approval of submitted plans for sewer connection and temporary rerouting shall in no way relieve the Contractor of their responsibility for the protection of adjacent properties, downstream drainage systems and water tributaries against sewage spill. Any litigation, claims, fines, etc. associated with any sewage spill shall be the responsibility of the Contractor. The submittal shall include the following information:
    a. Drawings indicating the scheme and location of temporary sewer plugs and bypass discharge lines. The drawings shall also show the method and location for discharging the bypass lines.
    b. Capacities of pumps, prime movers, and standby equipment.
    c. Design calculations proving adequacy of the system and selected equipment.
    d. Standby power source.
    e. Staffing plan.
    f. Show suction and discharge points with elevations & stationing on the design plans.
    g. Provide pump performance curves.
    h. Proposed noise control and exhaust control plans for pumping equipment.
    i. Bypass piping inspection plan.

B. Provide means, labor, and equipment to prevent solid waste generated during construction activities from entering the sewage flow.

C. The Contractor shall repair, without cost to the Owner, any damage that may result from their negligence, inadequate or improper installation, maintenance and operation of bypassing system, including mechanical or electrical failures.

3.02 SURFACE PREPARATION

A. Surface preparation shall be performed in accordance with the Standard Specifications for Public Works Construction and manufacturers' recommendations.

B. Contractor shall remove existing linings in their entirety prior to performing concrete rehabilitation and new lining application.

C. Existing concrete structures to receive protective coating system must be capable of withstanding imposed loads. All oil, grease and chemical contaminants must be removed from the surface. Surfaces must be firm, free of standing water, form release agents and existing coating. Suitable surface preparation methods include abrasive blasting, hydro blasting, mechanical scrapping and hand tool grinding to remove surface contaminants.

D. Existing ladder rungs within existing sewer manholes shall be removed and cut flush with the manhole interior wall such that the finished liner is smooth.

E. Existing monitoring and measurement equipment shall, under direct supervision by Owner representative, be removed, protected/stored, and replaced by the Contractor after lining installation and curing.

3.03 INFILTRATION

A. The Contractor shall identify the manholes that show any amount of groundwater infiltration. The Contractor shall submit to the Engineer a written log accompanying the recorded video which identifies the manholes and levels of infiltration.

B. Contractor is responsible to control and eliminate groundwater infiltration via chemical grout injection. The cost for this work is included in bid schedule and no additional compensation will be allowed regardless of the amount of groundwater encountered.

C. If the sewer pipes entering or exiting the manholes have an existing CIPP liner, the Contractor shall install the new manhole lining to interconnect with the end seals of the CIPP liner inside the manhole such that they are fully sealed and will prevent water entering into the manhole and/or the space between the host pipe and the liner.

3.04 LINING APPLICATION AND TESTING

A. The lining application shall be performed only by workers certified by the manufacturer as trained and experienced with the specified material. The lining shall be applied by high pressure airless equipment approved by the lining manufacturer. The equipment shall be in good working order to insure correct proportioning and mixing of the components.

B. Protective coating systems shall be installed with ambient air and surface temperatures per manufacturer's requirements. Store material within a temperature range and duration hours prior to use per manufacturer's requirements. Application and storage temperatures outside of this range will require written instruction from the Manufacturer.

C. Application in direct sunlight and/or with rising surface temperatures may result in blistering of the materials due to expansion of entrapped air or moisture (out-gassing) in the concrete. In such cases, it will be necessary to postpone the application until later in the day when the temperature of the substrate is falling. Concrete surfaces that have been in direct sunlight must be shaded for at least 24 hours prior to application and remain shaded until the initial set has taken place. Consult Manufacturer for application schedule guidelines specific to temperature conditions and possible sealer application recommendations to reduce out-gassing.

D. The lining shall be applied to a thickness of 125 mils (1/8-inch) in one continuous coat without seams, free from any holes or defects. The lining shall be installed from two (2) inches below the low-flow water level to the base of ring and cover. The lining shall be installed over dry concrete below the water level by using appropriate flow control and/or bypassing equipment. Coating in trough shall

have a smooth taper from trough to shelf.

E. During lining application, the Contractor shall record in writing all wet gauge thickness readings as required to ensure correct lining thickness, including photographs.

F. Installed epoxy lining protective coating shall be spark tested only in the presence of the Owner inspector for pinholes after a minimum 24-hour cure at a temperature of 70°F.
Pinhole testing shall be accomplished in accordance with ASTM D4787 using a Contractor provided Tinker Razor Holiday Detector, San Gabriel, CA, Model AP/W, or an approved equal device. Test voltage of 100 volts/mil of coating thickness shall be applied. All pinholes shall be marked and repaired using manufacturer's approved Patch Kit, or other approved method.

G. Adhesion testing shall be performed by the Contractor on a minimum of 25 percent of all coated structures, whichever is greater. A minimum of two tests of bond strength of the protective coating to the substrate shall be conducted in each structure or more as determined by the Engineer. The tests shall be placed at intervals (top, bottom) in an attempt to obtain an equal representation of the entire application. Adhesion testing shall be conducted after a minimum 24-hour cure of the Epoxy Lining Protective Coating at 70F. Bond strength shall be measured in accordance with ASTM D7234-05. Prior to the pull test, the tester shall utilize a scoring device to cut through the coating until the substrate is reached. The pull tests in each structure shall meet or exceed 200 psi and shall include substrate adhered to the back of the dolly or no visual signs of coating material in the test hole. Any areas detected to have less than 200 psi bond strength to concrete shall be removed and/or repaired by the Contractor in accordance with the manufacturer's recommendations and at no additional cost to the Owner. Repairs of such deficient bonded areas shall be made at the Contractor's sole expense in accordance with manufacturer's recommendations. The repair method shall be submitted to the Engineer for acceptance. All Adhesion tests shall be conducted by an independent certified testing firm that specializes in protective coating testing. The Contractor shall submit the qualifications for the independent testing firm to the Engineer for acceptance. Pull-off tests shall be performed in the presence of Owner's Inspector.

H. The uniform lining shall be free from porosity, without bubbles or pinholes and uniform in color. All areas in question shall be removed and reworked and patched in accordance with the manufacturer's recommendations and approved procedures.

I. Contractor to perform visual inspection to determine integrity of rehabilitation materials and water-tightness and verify no inflow or infiltration.

J. Before accepting the finished product, testing shall be made by the Contractor, and any defects found shall be repaired at no additional cost to the Owner.

K. Contractor to perform video inspections of post-rehabilitation condition of manhole per latest version of NASSCO MACP and submit to the Owner for review.

L. Application of the lining shall not take place when exposed to rain, fog or high winds. It is the Contractor's responsibility to insure protection of the work from the above mentioned conditions.

3.05 ADJUSTMENTS AND CLEANING

A. At the completion of the Work, Contractor shall remove all materials and debris associated with the Work of this Section.

B. Clean all surfaces not designated to receive protective coating. Restore all other work in a manner acceptable to Engineer.

C. All finished protective coating shall be protected from damage until Final Acceptance of the Work. Protective coating damaged in any manner shall be repaired or replaced at the discretion of Engineer, at no additional cost to the Owner.

D. Clean all protective coating as recommended by the manufacturer to provide finished Work acceptable to the Owner, just prior to Final Acceptance.

PART 4 - WARRANTY INSPECTIONS

A. Warranty inspections will be conducted following completion of all coating and painting Work and prior to expiration of the twenty-four (24) month warranty period (per Section 1740-1.02B) to determine the integrity of rehabilitation materials and water-tightness of the rehabilitated structure. The Contractor, Engineer and a representative of the Owner shall attend this inspection. It is anticipated the two (2) warranty inspections will take place during the 11th and 23rd months, respectively, following the Notice of Completion. The Contractor shall provide all the means to conduct the warranty inspection, including traffic control, permitting, confined space access, cleaning, and all other support services at the Contractor's expense. Inspection shall be documented by the Contractor with photos and videos per the latest version of NASSCO MACP and submitted to the Engineer for review. All defective Work shall be repaired in accordance with these Specifications. The repair shall be subject to acceptance by the Engineer. The Engineer may, by written notice to the Contractor, reschedule the warranty inspection, or may cancel the warranty inspection altogether. If a warranty inspection is not conducted, the Contractor is not relieved of its responsibilities under the Contract Documents.

END OF SECTION

SECTION 11001

GENERAL EQUIPMENT AND MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: The general requirements for all of the Equipment and Mechanical work in the scope of the Project, included in Divisions 11, 14, and 15, and elsewhere wherever specifically mentioned in these Specifications.

B. Direct the attention of all subcontractors and suppliers of equipment and related appurtenances for the work to the applicable provisions in the Contract Documents wherever they may occur.

Related Sections:

1. Section 01190: Seismic Requirements
2. Section 01300: Submittals
3. Section 01650: Facility Startup
4. Section 01700: Contract Closeout
5. Section 05090: Structural Metal Fasteners
6. Section 11002: Electric Motor Drives

1.02 REFERENCES

A. American Gear Manufacturers Association (AGMA).

B. American Institute of Steel Construction (AISC).

C. Hydraulic Institute.

D. National Electrical Manufacturers Association (NEMA).

E. Occupational Safety and Health Act (OSHA).

F. California Code of Regulations, Title 8 Industrial Relations (CAL/OSHA).

1.03 STANDARDS FOR THE WORK

A. Complete Systems: Provide pipe, fittings, wiring, and supports to produce complete, operable systems with all elements properly interconnected. If a specific dimensioned location is not shown for interconnections or smaller system elements, select appropriate locations and show them on Shop Drawing submittals for review.

B. Provide equipment and material new and without imperfections. Erect in a neat and workmanlike manner; aligned, leveled, cleaned and adjusted for satisfactory operation; installed in accordance with the recommendations of the manufacturers and the best standard practices for this type of work so that connecting and disconnecting of piping and accessories can be readily made and so that all parts are easily accessible for inspection, operation, maintenance, and repair. Locate oil and lubrication fittings clear of and away from guards, base, and equipment and within reach from the operating floor. Coordinate location of all motor connections in order to properly orient encased electrical conduits. In order to meet these requirements with equipment as furnished, minor deviation from the Drawings may be made as favorably reviewed by the Engineer.

C. The recommendations and instructions of the manufacturers of products used in the work are hereby made part of these Specifications, except as they may be superseded by other requirements of these Specifications.

1.04 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Shop Drawings: Submit Shop Drawings to the Engineer and receive favorable review prior to fabrication, construction or delivery to the project site in accordance with Section 01300 of these Specifications. Show sizes and arrangement of equipment, foundations, and anchor bolts required; performance characteristics; fan curves and pump curves; control diagrams; wiring diagrams; motor data sheets; methods of assembly; pipe hanging details; ductwork layouts; and connections to other work. Date and sign drawings as certified for use in construction of this project. The arrangement of mechanical equipment and appurtenant piping shown on the Drawings may be varied as necessary to fit the favorably reviewed certified manufacturer's installation drawings. However, manufacturers' drawings shall not deviate in substance from the Contract Drawings and Specifications as to location, size, type, and design of equipment. The following minimum requirements shall accompany all equipment submissions:
   1. Overall dimensions.
   2. Mounting arrangement and dimensions.
   3. Description of materials.
   4. Connection sizes and orientation.
   5. Capacity and location of lifting eyes.
   6. Motor arrangement showing location of electrical connections.
   7. Rating data - Mechanical and Electrical as applicable.
   8. Detail electrical wiring diagrams, showing component designation and rating.
   9. Seismic design certifications and anchorage descriptions as required by Section 01190.
   10. Motor data as specified in Section 11002.
   11. List of special tools and/or spare parts to be furnished, if any.

C. Each piece of equipment, for which certified witnessed or non-witnessed performance tests are required, shall be accompanied by a completed form containing at least the following information:
   1. Owner's name and location of project.
   2. Contractor's name and subcontractor if applicable.
   3. Name of item being submitted.
   4. Specification reference by section, paragraph and page.
   5. Data on item (manufacturer, general descriptive data, dimensions, size of connections, speeds, performance curves, serial number). A specific list of the test results plus a list, which shows the values that differ from Specifications.
   6. Motor data, type, voltage, frequency, phase, full load amperes, starting method, frame size, enclosure insulation type (NEMA Code letter), dimensions, service factor, serial number.
   7. Date and signature of person certifying the performance.

D. Operations and Maintenance Manuals: Prepare and submit easy to follow manuals covering installation, operation and maintenance, and troubleshooting of all equipment and machinery specified in Divisions 11, 14, and 15. Refer to Section 01300.

E. Manufacturers' Affidavits: Where called for in the Specifications, each equipment manufacturer, or their authorized representative, shall submit an affidavit conforming to the requirements of Section 01650.

1.05 RESPONSIBILITY AND CARE OF EQUIPMENT

A. The Contractor shall be responsible for the equipment included in this Contract until it has been finally inspected, tested, and accepted in accordance with the requirements of these Specifications.

B. The Contractor shall make his own provisions for properly storing and protecting all material and equipment against theft, injury, or damage from any and all causes. Damaged material and equipment shall not be used in the work.

PART 2 - PRODUCTS

2.01 DESIGN

A. General: Design all equipment for the service intended, of rugged construction, of ample strength for all stresses which may occur during fabrication, transportation, erection, and during continuous or intermittent operation. Adequately stay, brace and anchor, and install equipment in a neat and workmanlike manner. Give consideration to appearance and safety, as well as utility, in the design of details. Use cathodically compatible materials of construction.

B. Seismic: Refer to Section 01190 of the Specifications for the seismic design criteria.

C. Controls: Unless noted otherwise, the design of the electric control of any equipment system and/or equipment package shall be the responsibility of the manufacturer of the equipment system and/or equipment package. The elementary control diagrams as shown on the Electrical Drawings and the diagrams shown on the Instrumentation Drawings are illustrative of control and monitoring requirements pertaining to various equipment of this project. The manufacturers shall design their own functional electric control devices and circuitry, in consultation with the specific elementary control diagrams and other project specifications, to meet the equipment control requirements. All such systems and package controls shall be furnished by the equipment manufacturer, except that controls shown in motor control centers and process controllers, remote control devices, and their interconnecting wiring shall be provided under Divisions 16 and 17. Provide heating, ventilating, and air conditioning controls, both 24-volt and line voltage type, by a HVAC controls specialist.

2.02 MATERIALS AND STANDARD SPECIFICATIONS

A. Materials: Design, fabricate, and assemble equipment and systems with new materials and in accordance with acceptable modern engineering and shop practices. Manufacture individual parts to standard sizes and gauges so repair parts can be installed in the field.

B. Uniformity: Unless otherwise specified, equipment or material of the same type or classification used for the same purpose shall be the product of the same manufacturer and shall be the same model.

2.03 LUBRICATION

A. Provide lubricants of types recommended by equipment manufacturers, in quantities sufficient for consumption prior to completion, testing and final acceptance.

2.04 STRUCTURAL METAL FRAMING

A. Weld submerged steel surfaces which butt or bear against each other, to seal the surfaces against the penetration of the liquid. Weld all gaps between adjacent submerged steel surfaces less than 1/32-inch wide to seal the surfaces. Weld size shall be not less than the thickness of the thinnest member of the lapped or joined assembly.

2.05 EQUIPMENT BASES AND BEDPLATES

A. Mount equipment assemblies on a single heavy cast iron or welded steel bedplate unless otherwise shown or specified. Provide bases and bedplates with machined support pads, tapered dowels for alignment or mating of adjacent items, adequate openings to facilitate grouting, and openings for electrical conduits. Round or chamfer and grind smooth all corners. Continuously weld seams and contact edges between steel plates and shapes, and grind welds smooth. Do not support machinery or piping on bedplates other than that which is factory installed. Provide jacking screws in equipment bases and bedplates to aid in leveling prior to grouting. Mount all equipment bases and baseplates on reinforced concrete pads at least 3 inches high.

2.06 ANCHORS

A. Each equipment manufacturer shall furnish an anchor bolt pattern and the required anchor bolts, nuts, and washers of adequate design for securing bases and bedplates to concrete bases. Provide anchor bolts of length to allow for 1 ½ inches of grout under baseplates and adequate anchorage into structural concrete unless otherwise shown or specified.

B. Provide anchor and assembly bolts and nuts of ample size and strength for the purpose intended. All bolts shall be standard machine bolts, with cold pressed hexagon nuts. Provide suitable degauling compounds for bronze and stainless steel threaded components. Any space wholly or partially underground, or having a wall or ceiling forming part of a water channel, is classified as a moist location. Unless otherwise specified or noted on the Drawings, provide materials as follows:
   1. Bolts and nuts in submerged locations or submerged and embedded in concrete or buried in earth: Type 304 stainless steel.
   2. Bolts and nuts for supports or equipment in dry or moist locations: Galvanized steel (hot-dipped), with oversize nuts.
   3. Use other bolting materials where specifically called for in the Specifications or on the Drawings.

C. Anchor all motor-driven equipment with cast-in-place anchor bolts or drilled-in anchors set with epoxy adhesive. Do not provide expansion type anchors for motor-driven equipment.

D. Anchor all non-motor-driven equipment with cast-in-place anchor bolts or drilled-in anchors set with epoxy adhesive except that, where specifically allowed by note on the Drawings, expansion type anchors may be used.

E. Refer to Section 05090 for technical specification requirements for cast-in-place and post-installed anchors.

2.07 SAFETY GUARDS

A. Cover belt or chain drives, fan blades, couplings, nip points, exposed shafts, and other moving or rotating parts on all sides with safety guards conforming to all federal, state, and local codes and regulations pertaining; conform to the most restrictive requirement. Design guards for easy installation and removal, complete with necessary supports, accessories, and fasteners, all hot-dip galvanized. Design guards in outdoor locations to prevent entrance of rain and dripping water. Provide tachometer test opening in line with ends of shafts. Typically, guards shall be expanded metal on a structural steel frame except that outdoor guards may be of solid material. Provide hinged doors with latch for service and lubrication access.

B. Cover all pipes, manifolds, heaters, and other surfaces which have a surface temperature sufficient to burn human tissue with a thermal insulating material or otherwise guard against contact.

C. Guards to comply with CAL/OSHA 3940 through 3944.

2.08 LIFTING EYES

A. Supply all equipment weighing over 100 pounds with lifting eyes. Parts of equipment assemblies which are normally serviced separately, such as motors, to have lifting eyes of their own.

B. All bolts and eyebolts shall be coated with zebron coating.

2.09 DRIVES

A. General: Provide all drive units with an AGMA rating and service factor suitable for 24 hours per day operation under the operating load.

B. Electric Motors: Conform to the requirements of Section 11002.

C. V-Belt Drives: Equip each V-belt drive with suitable tension adjustment. Provide drives having a service factor of at least 1.6 with arc length correction at maximum torque using nameplate rating of driving motor.

2.10 NAMEPLATES

A. Manufacturer's Nameplate: Furnish each piece of equipment and its driver with a corrosion-resistant metal nameplate fastened to the item in a readily readable position. This nameplate to contain the manufacturer's name, equipment rating, capacity, size, model, serial number, and speed. All information written or printed to be in English.

B. Direction of Rotation: Furnish each piece of rotating equipment with a direction of rotation arrow.

C. Functional Identification: Label each piece of equipment using a plastic laminate label with the functional name and number of the equipment.
   1. Fasten labels to the equipment, its base, or other acceptable location:
      a. Letters: At least ½ inch high with the border trim on all sides not less than ¼ inch.
      b. Color: Green background with white letters.
      c. Fasteners: Brass or stainless steel screwed into inserts, anchor shields, or tapped holes in equipment or base.

2.11 PROTECTION AGAINST ELECTROLYSIS

A. Where dissimilar metals are used in conjunction with each other, provide suitable insulation between adjacent surfaces so as to eliminate direct contact and any resultant electrolysis. Connections of dissimilar piping materials shall utilize dielectric unions, flanges, couplings, or bushings.

2.12 SPECIAL TOOLS

A. For each type of equipment to be furnished, provide a complete set of all special tools (including grease guns or other lubricating devices) which may be necessary for the adjustment, operation, and maintenance of such equipment.

2.13 FINISHES

A. Conform to applicable requirements of Section 09960.

B. Factory Painting: On pumps, motors, drives, starters, control panels, and other similar self-contained or enclosed components, apply a factory protective paint system unless otherwise noted. Paint or otherwise protect surfaces that are inaccessible after assembly by a method which provides protection for the life of the equipment.

C. Shop Priming: Except where field sandblasting is required, apply one or more shop coats of metal primer on surfaces to be finish painted at the site, of sufficient thickness to protect surfaces until finished. Primer shall be compatible with finish coat.

D. Rust Preventive: Coat machined, polished, other ferrous surfaces, and non-ferrous surfaces which are not to be painted with rust preventive compound.

2.14 NOISE AND VIBRATION

A. Mechanical and electrical equipment, as installed in this project, shall not create sound levels that are in excess of that permitted by CAL/OSHA for 8 hours per day worker exposure unless otherwise noted for the specific piece of equipment involved. If the required sound level cannot be achieved by bare equipment in its designated environment, provide sound attenuating enclosures. Sound attenuating enclosures shall have necessary ventilation to prevent equipment overheating and shall be constructed for easy removal to permit maintenance. Devices necessary for day-to-day operation shall pierce the enclosure or otherwise be accessible without need to remove the enclosure.

B. Equipment which when operating has obvious excessive vibrations shall be repaired or replaced as directed by the Engineer. Baseline vibration measurements shall be made where specified.

2.15 FACTORY TESTS

A. Perform factory tests for each piece of equipment where specifically called for in the section specifying that equipment. Note that factory tests are inherent in many reference standards. The requirement for a factory test in a referenced standard is hereby made a part of these Specifications. Conduct factory tests at the same speeds and other conditions at which the equipment will operate in the field, except as noted.

B. Where specifically noted, performance tests may be witnessed by the Engineer or his representative. Inform the Engineer in sufficient time to allow arrangements to be

made for witness of such tests. When non-witnessed tests are performed, supply certified results.

C. Perform factory testing of pumps in accordance with the requirements and standards of the Hydraulic Institute.

D. Tests of other equipment shall conform to the requirements set forth in these Specifications.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Inspect each item of equipment for damage, defects, completeness, and correct operation before installing.

3.02 PREPARATION

A. Prior to installing equipment, ensure that the areas are clean. Maintain the areas in a broom-clean condition during installation operations. Clean, condition, and service equipment in accordance with the approved Instruction Manuals and specific recommendations of the equipment manufacturer.

3.03 INSTALLATION

A. Structural Fabrications: Conform to the AISC Code and Specification referenced in Article "Structural Steel Fabrications," and conform to Section 05100.

B. Equipment: Conform to approved Operations and Maintenance Manuals. Employ skilled craftsmen experienced in installation of the types of equipment specified. Use specialized tools and equipment, such as precision machinist levels, dial indicators, gauges, and micrometers, as applicable. Produce acceptable installations free of vibration or other defects. Align and pin to common bedplate equipment and drivers connected by flexible couplings.

C. Anchor Bolts: Deliver bolts with templates or setting drawings and verify that bolts are correctly located before structural concrete is placed.

D. Base and Bedplate Grouting: Do not place grout until initial fitting and alignment of connected piping is completed. Level and align equipment on the concrete foundations, then entirely fill the space under base or bedplates with grout. Bevel exposed grout at 45 degree angle, except round exposed grout at horizontal surfaces for drainage. Trowel or point exposed grout to a smooth, dense finish and damp cure with burlap for 3 days. When grout is fully hardened, remove jacking screws and tighten nuts on anchor bolts. Check the installation for alignment and level, and perform approved corrective work as required to conform to the tolerances given in the applicable Instruction Manual.

1. Make an allowance of at least 1½ inches for grout under the equipment bases, whether or not shown on the Drawings. Use steel shims to level and adjust the bases. Shims may be left embedded in the grout, in which case they shall be installed neatly and so as to be as inconspicuous as possible in the completed work. Unless otherwise approved, all grout shall be a favorably reviewed non-shrink, non-metallic grout.
2. Grout: Dimensionally stable, inorganic, premixed and resistant to acids, alkalies, and salt water, and unaffected by water and oil. It shall have high strength even when used as a pourable mixture, and shall bond well with steel and cured

concrete or be compatible with a suitable bonding agent which shall then be used to effect the bond. Use in strict accordance with the manufacturer's recommendations. Provide Five Star Grout as manufactured by U.S. Grout Corporation, Bonsal Construction Grout as manufactured by Bonsal Company, or equal. Submit for favorable review by the Engineer prior to use.

3. Where practicable, place the grout through the grout holes in the equipment base and work outward and under the edges of the base and across the rough top of the concrete foundation to a peripheral form so constructed as to provide a suitable chamfer around the top edge of the finished foundation.

E. Architectural Metals: Handrails, guardrails, stairs, and other architectural metals furnished as a part of equipment shall conform to the requirements of Division 5.

3.04 EQUIPMENT STARTUP AND ADJUSTMENT

A. Arrange for an authorized factory-trained representative of the company or companies supplying the various items of equipment to check the installation and adjust and test the equipment. Said representative shall be experienced and knowledgeable of the equipment being tested. Furthermore, the representative shall assist and instruct the operating staff in adjusting and operating the equipment during the initial plant operation period.

1. Provide initial lubrication for all equipment.
2. Test and demonstrate to the Engineer that all equipment operates properly and specified performance has been attained. For pumps, include measurement of suction and discharge pressure at the pump and measurement of pumping rate by volumetric means or through a suitably calibrated meter for two points on the performance curve. For adjustable-speed pumps, conduct tests at a minimum of two speeds. Furnish any test equipment or measuring devices required which are not part of the permanent installation.
3. In addition, demonstrate that the entire facility is in full operating condition prior to the acceptance of the work. Should any equipment or part thereof fail to operate as intended, immediately remove and replace it, all at the Contractor's expense. Pay for all tests involved in this Section.
4. Pressure test equipment and connections thereto as required by these Specifications.

3.05 PERFORMANCE TESTS

A. Upon completion of the work, and after all systems are set and balanced, conduct performance tests in accordance with Division 1 and other applicable sections of these Specifications. Submit test conditions, test data and results to the Engineer for review.

3.06 SOUND LEVEL TESTING

A. Measure the sound level developed by all mechanical and electrical equipment provided. Perform testing in all rooms and spaces containing such equipment during the final operation test program with all equipment operating. Use OSHA approved instrument and record the highest sound level developed when measured according to OSHA standards in each room and space. Deliver a copy of records to the Owner.

3.07 TOOLS, LOOSE PARTS, AND LUBRICANTS

A. Tools and Loose Parts Supplied: Provide an inventory of tools and loose parts required to be supplied under the project. Turn over inventory and parts to the Owner. The Owner's written acknowledgment of receipt is required for project completion. Loose parts are defined as items such as special tools, keys, safety equipment, and portable equipment. Refer to relevant technical sections of these Specifications for additional instructions.

B. Recommended Spare Parts: Furnish a complete list of recommended spare parts and supplies for each equipment furnished with current prices and a source of supply.

C. Provide a list of all recommended lubricants not listed in the Operations and Maintenance Manuals.

END OF SECTION

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SECTION 11002

ELECTRIC MOTOR DRIVES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Provide motors to drive equipment specified in other sections and Divisions, including, but not limited to, Divisions 11, 14, 15, and 16. Refer to driven equipment sections for additional requirements. Requirements of the driven equipment Specifications shall take precedence over the requirements of this Section, where conflict occurs. This Section applies to all electric motors furnished for this project, unless otherwise noted.

B. Related Sections:
   1. Section 11001: General Equipment and Mechanical Requirements
   2. Section 16010: General Electrical Requirements
   3. Section 16920: Motor Control Center

1.02 REFERENCE STANDARDS

A. National Electrical Manufacturers Association (NEMA) Standard:
   1. MG 1 Motors and Generators

B. Institute of Electrical and Electronics Engineers (IEEE) Standard:
   1. 112 Test Procedure for Polyphase Induction Motors and Generators

C. Underwriters Laboratories (UL) Publication: Recognized Component Directory

1.03 SUBMITTALS

A. For each motor, include the following data in the shop drawing submittal for the driven equipment:
   1. Machine name and specification number of driven machine
   2. Manufacturer's name.
   3. Motor model and dimension drawing, including motor weight.
   4. Manufacturer's type and frame designation.
   5. Nominal Horsepower output.
   6. Time rating.
   7. Maximum ambient temperature rating.
   8. Winding Insulation class and temperature rise class.
   9. RPM at full load.
   10. Voltage, number of phases, frequency and full load amperes.
   11. Code letter for locked rotor kVA.
   12. Service factor at 40°C ambient.
   13. NEMA design letter.
   14. Enclosure type.
   15. Bearing data including lubrication requirements, type and frequency.
   16. KW input power and power factor at 75% and 100% of rated horsepower output.

17. Guaranteed minimum full load efficiency. Also nominal efficiencies at 1/2 and 3/4 load.
18. Type of thermal protection or overtemperature protection, if included.
19. Wiring diagram for devices such as motor leak detection, temperature or zero speed switches, as applicable.
20. If utilized with a variable frequency controller, verify motor is inverter duty type. Include minimum speed at which motor may be operated for the driven machinery. Provide shaft grounding information and details.
21. Power factor at 1/2, 3/4 and full load.
22. Recommended size for power factor correction capacitors to improve power factor to 0.95 percent lagging when operated at full load.

B. Provide installation, operation and maintenance instructions, and renewal parts list as required for maintenance manuals under Section 01300.

1.04 COORDINATION

A. General: Coordinate motors with driven equipment requirements. Unless otherwise specified, equipment manufacturers or suppliers shall select and provide motors for their equipment in conformance with these Specifications. Give particular attention to coordination of requirements for:
1. Power.
2. Starting torque.
3. Speed.
4. Bearing load.
5. Ambient temperature.
6. Frequency of starting.
7. Moisture exposure.
8. Adjustable speed control, where applicable.

B. Suppliers of motors to be used with adjustable speed systems shall:
1. Provide all relevant motor data to the adjustable speed control manufacturer for analysis. Provide motors in conformance with and compatible with the adjustable speed control manufacturer's equipment and requirements.
2. Provide all relevant motor data to the pump manufacturer for vibration, reed critical frequency and other required analyses.

1.05 SPECIFIC REQUIREMENTS

A. The following motor characteristics are specified with the driven equipment in all cases:
1. Speed.
2. Horsepower or supplier responsibility to determine.
3. Horizontal or vertical arrangement.
4. Indoor or outdoor location.

B. Additional motor characteristics are specified with the driven equipment only where the required motor differs from the typical characteristics described below or where additional properties or characteristics are required that are not specified in this Section.

PART 2 - PRODUCTS

2.01 GENERAL

A. Motors shall be designed, built, and installed in the driven equipment, to provide long, trouble-free life in industrial service and shall be rated in conformance with NEMA MG1. Motors rated 100 horsepower or less and rated 600V or less shall be listed in UL Recognized Component Directory.

B. Unless otherwise specified with the driven equipment, provide motors with the following typical characteristics:
   1. NEMA Design: Electric motors shall be NEMA Design B unless otherwise indicated. In no case shall starting torque or breakdown torque be less than the value in NEMA MG 1. Motors shall be suitable for the indicated starting method.
   2. Voltage Ratings:
      a. 460 volts, three phase, 60 Hz, squirrel cage induction motors.
   3. All motors shall have a service factor of 1.15 in an ambient temperature of 40°C.
      a. Exceptions: Motors, which have special enclosures or winding configurations, may carry a Unity (1.0) Service Factor. Examples are totally enclosed, explosion proof, or submersible motors.
   4. Windings shall be copper.
   5. Provide ground lug inside the terminal box.
   6. Provide lifting eye on each motor weighing more than 50 pounds.
   7. Each motor shall be suitable for six starts per hour (5 minutes on and 5 minutes off, continuously) when powering the specific driven equipment required for this project.
   8. Motors, which have special operating characteristics such as high torque/high slip, short time intermittent ratings shall be nameplated to show how these characteristics differ from standard design.
   10. Each motor shall have an overall sound power level at no load not greater than given in NEMA MG1-Part 9.
   11. Inverter duty motors shall be provided with shaft grounding rings. Rings shall be factory installed, and shall be by Aegis, or equal. The motor warranty shall include coverage against VFD-induced bearing damage or failure.
   12. Motors, which have special operating characteristics such as multi-speed, high torque/high slip, short time intermittent ratings shall be nameplated to show how these characteristics differ from standard design.

B. Motors used with variable frequency drives shall have inverter duty complying with NEMA MG-1, Section IV, Part 31, and shall be clearly identified as “Inverter Duty.”

D. Increased circuit breaker, magnetic starter, and conductor and conduit capacities required for motors larger than the indicated sizes shall be provided as part of the Contractors work.

E. Two speed motors shall be of the two-winding type,

F. Exempt Motors: Motors for valve operators, submersible pumps, or motors which are an integral part of standard manufactured equipment, i.e., non-NEMA mounting, common shaft with driven element, or part of domestic or commercial use apparatus may be excepted from these requirements to the extent that such variation reflects a necessary condition of motor service or a requirement of the driven equipment.

2.02 NAMEPLATE

A. Provide stainless steel nameplate for each motor, attached to the motor by stainless steel screws or drive pins. Nameplates shall indicate clearly the information required by NEMA MG1, Part 10 and Part 12.

2.03 ENCLOSURE TYPE BY LOCATION

A. Unless otherwise specified with the driven equipment, provide motors with the following typical enclosures:
   1. Indoors: Horizontal motors shall be open, drip-proof; vertical motors shall be drip-proof with guard.
   2. Outdoors: Vertical motors shall be weather-protected type I. Horizontal motors shall be totally enclosed, fan cooled. All motors shall have the following features:
      a. Bearing protection.
      b. Anti-corrosion treatment of external hardware and internal metal parts.
      c. Weatherproof terminal box with gaskets between the motor, terminal box and terminal box cover.
      d. Guard screens on ventilation openings.
      e. Moderate moisture resistant insulation, specified hereinafter.
      f. Interior and exterior corrosion protection coatings.
      g. Special attention to leads into terminal box.

B. When specifically called for in the Specifications for the driven equipment or required by Code, provide the following enclosure types:
   1. Hazardous locations: Motors shall be explosion-proof and shall be UL listed for Class I, Division 1, Groups C and D locations; motors shall bear the UL label.
   2. Severe duty: Motors shall have the following features:
      a. Totally enclosed, fan cooled enclosure.
      b. Stainless steel nameplate.
      c. Cast iron housing, bearing brackets and fan guard.
      d. Cast iron conduit box with threaded conduit entrance.
      e. Corrosion resistant fan.
      f. Corrosion resistant hardware.
      g. Automatic breather/drain.
      h. Ground lug.
      i. Regreasable bearings.
      j. Provision for excluding water and dust from bearings.
      k. Class F insulation.
      l. Service factor of 1.15.
      m. Epoxy coating on all external surfaces.
   3. Submersible: Submersible motors shall comply with the following:
      a. Air filled or oil filled squirrel cage induction type.
      b. Service factor of 1.15 or better.
      c. Class F insulation, Class B temperature rise.
      d. Rated for 6 starts per hour.
      e. Listed by either UL or FM for Class 1, Division 1, Groups C and D hazardous locations.
      f. Suitable for operating in free air continuously (i.e., not submerged in sewage).
      g. Bearing B10 life 18,000 hours minimum.

h. Tungsten carbide seals.
i. Lower bearings of either the ball or roller type.
j. If required by the manufacturer to not void the motor warranty, provide a moisture detection system and a motor winding thermostat system. These systems shall be complete, including all necessary interfaces, control panels, conduits, and wires, even though these may not be shown on the Drawings.

2.04 INSULATION

A. Unless otherwise specified with the driven equipment, provide motors with Class B or F insulation, non-hygroscopic. In single phase motors 1/2 horsepower or smaller, provide Class A insulation or better.

B. Where called for in the Specifications for the driven equipment, provide the following type of insulation:
1. Moderate Moisture Resistant: Provide extra dip and bake of epoxy or polyester varnish to resist somewhat higher than normal moisture in the atmosphere.

2.05 MOTOR HORSEPOWER

A. The maximum permissible motor loading:
1. Motors with service factor 1.15 or greater: 100% of nameplate horsepower.
2. Motors with service factor less than 1.15: 90% of nameplate horsepower.

B. Probable motor horsepower ratings have been specified or shown on the Drawings. Changes from the specified horsepower may be accepted, if necessary to assure that motors do not exceed their maximum permissible loading, as defined above, under normal operation. Motor horsepowers shall not be less than those specified in driven equipment sections. If a larger horsepower rating is required by the driven equipment, provide all changes required to motor starting and control equipment and to the conduit and wiring system without any additional cost to the Owner.

2.06 EFFICIENCY

A. For motors 1 Horsepower and Larger:
1. Provide premium efficiency motors unless otherwise specified.
2. Guaranteed minimum efficiencies of premium efficiency motors shall correspond to nominal values as tabulated in NEMA MG-1, Table 12-8.

B. Efficiencies shall be determined by using the IEEE 112, Test Method B using segregated loss determination.

C. Single-phase fractional horsepower motors 1/4 HP through 3/4 HP motors shall be high-efficiency split-capacitor types having minimum efficiency ratings of not less than 64% and power factors of not less than 94.5%.

2.07 LOCKED ROTOR KVA - CODE LETTER

A. Provide motors with locked rotor kVA values less than or equal to those corresponding to the following:

Horsepower	Code Letter
≤5	M
7-1/2-10	H
≥15	G

2.08 THERMAL PROTECTION

A. Provide integral bi-metallic thermostats on the motor windings as required in Section 11303. Thermostats or other devices shall be and rated 125 Vac, 1 amp.

2.09 MOISTURE PROTECTION

A. Provide integral moisture sensing switches within submersible pumps, as required in Section 11303.

2.10 MOTOR BEARINGS

A. General: Bearings shall conform to Section 11001 - General Equipment and Mechanical Requirements, except as indicated herein.
B. Motors greater than 2 HP shall have bearings designed for 17,500 hours (belted) or 100,000 hours (coupled) L-10 life.
C. Fractional Horsepower: Motors with fractional horsepower through 2 HP shall be provided with lubricated-for-life ball bearings.
D. Horizontal Motors Over 2 HP: Motors larger than 2 HP shall be provided with relubricatable ball bearings. Lubrication shall be per manufacturer's recommendation for smooth operation and long life of the bearings.
E. Vertical Motors Over 2 HP: Vertical motors larger than 2 HP shall be provided with relubricatable ball, spherical, roller, or plate type thrust bearings. Lubrication shall be per manufacturer's recommendation for smooth operation and long life of the bearings.
F. Water Cooled Motors: If water cooling is required for the thrust bearings, cooling water lines shall be provided complete with shut-off valve, strainer, solenoid valve, flow indicator, thermometer, throttling valve, and, (where subject to freezing), insulation with heat tracing.
G. Inverter Duty Motors: Provide an insulated bearing to prevent circulating bearing currents.

2.11 FACTORY TESTS

A. Conduct factory tests on all motors in conformance with NEMA MG 1-12.55. All tests shall be made in accordance with IEEE Standard 112. Except where specific testing or witnessed shop tests are required by the specifications for driven equipment, factory test reports may be copies of routine test reports of electrically duplicate motors. Test report shall indicate test procedure and instrumentation used to measure and record data. Test report shall be certified by the motor manufacturer's test personnel and be submitted to the ENGINEER.

2.12 FACTORY TESTS

A. The CONTRACTOR shall perform the following field tests:

a. Inspect each motor installation for any deviation from rated voltage, phase, frequency, and improper installation.
b. Visually check for proper phase and ground connections. Verify that multi-voltage motors are connected for proper voltage. Verify shaft grounding devices are properly grounded.
c. Check winding and bearing temperature detectors and space heaters for functional operation.
d. Test for proper rotation prior to connection to the driven equipment.
e. Visually check that motor overload heaters are properly sized and that MCP breaker settings are correct for the motor installed.
f. Test insulation (megger test) of new and re-used motors in accordance with NEMA MG-1. Test voltage shall be 1000 VAC plus twice the rated voltage of the motor.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install motors in driven equipment in conformance with motor manufacturer's recommendations and requirements. Motor nameplate shall be visible when installed on the driven equipment.

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SECTION 11030

MODULAR SKID-MOUNTED CARBON ADSORBER ODOR CONTROL SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION

A. SCOPE

1. This section specifies requirements for a packaged 2-stage biological odor control system of unitary construction, including requirements for system construction, components, materials, functional testing, quality and use.

2. The odor control system supplier shall furnish all labor, materials, equipment and incidentals required to install a packaged biological odor control system as specified herein. The system shall be installed in a Class 1, Division 2, Group D area.

3. The odor control system shall consist of the following major components:

1. Inlet Foul Air Ductwork and Balancing Dampers (Remote-Mounted)

2. Mist/Grease Filter (Remote-Mounted)

3. FRP Exhaust Fan

4. FRP Vessel with Extended Deck

5. Inorganic Biological Media (Stage 1)

6. High H_2S Capacity Activated Carbon Media (Stage 2)

7. Air Distribution System

8. Media Irrigation System

9. Water Cabinet (mounted on a remote skid)

10. FRP Electrical Control Panel (mounted on a remote skid)

11. Nutrient Tank (mounted on a remote skid)

12. Nutrient Pump (inside the water cabinet)

13. FRP Exhaust Stack

B. SYSTEM DESCRIPTION

1. The biological odor control system shall consist of inlet foul air ductwork with dampers, grease/mist filter, exhaust fan, FRP vessel, inorganic biological media, activated carbon media, air and irrigation system, control panel,

exhaust stack, dampers, valves, piping and all other equipment and accessories for a complete system.

2. The complete odor control system shall be packaged and of unitary construction design. All components of the system shall be mounted on the vessel except for the control panel, water cabinet, and nutrient reservoir which shall be mounted on a separate skid which shall be installed at the jobsite at least 3 feet from the Class 1, Division 2, Group D hazardous area.

3. The packaged biological odor control system shall be a once-through system. The system is equipped with an exhaust fan that continuously draws the odor-laden air from the process areas into the biological odor control system for treatment. The biological odor control system shall be a two-stage system. Stage 1 shall utilize an inert, porous, mineral, expanded clay material designed to remove hydrogen sulfide (H_2S) and resist compaction and degradation from the acidic sulfates of the biological oxidation of the hydrogen sulfide. Stage 2 shall utilize a pelletized coal activated carbon media to remove any remaining hydrogen sulfide as well as other odorous organic compounds.

   The first stage shall operate with an independently controlled irrigation process to provide Stage 1 media with adequate moisture to sustain bacterial growth and to remove toxic byproducts. The irrigation process shall be controlled by a programmed timing sequence that actuates a solenoid valve located on the water supply piping. Nutrients shall trickle down over the media to enhance and sustain the biological activity. The nutrients shall be housed in a tank and shall be dosed into the system by a nutrient pump. A pre-wired control panel shall be provided to ensure proper control and operation of the system. The cleaned air is discharged to the atmosphere through the stack at the top of the unit.

4. The odor control system shall be designed for the following operating conditions:

Model Number	**I-BOx® 6000**
Quantity	1
Airflow Rate, cfm	550-850
Average Inlet H_2S Conc., ppm	10
Peak Inlet H_2S Conc., ppm	25

The odor control system shall demonstrate the following performance:

INLET	**OUTLET**
1-10 ppm H_2S	0.1 ppm H_2S
>10 ppm H_2S	1.0% of inlet

The pressure drop across the biological odor control system shall not exceed 5.0" W.C. at the maximum airflow rate specified above.

C. REFERENCE STANDARDS

1. PS 15-69: National Bureau of Standards Voluntary Product Standard "Custom Contact Molded Reinforced Polyester Chemical Resistant Process Equipment."

2. ASTM D-883: "Definition of Terms relating to Plastics."

3. ASTM D-2583: "Test for Indentation Hardness of Rigid Plastics by Means of Barcol Impressor."

4. ASTM D-2563: "Recommended Practice for Classifying Visual Defects in Glass Reinforced Plastic Laminate Parts."

5. ASTM D-4097-82: "Standard Specifications for Contact Molded Glass Fiber Reinforced Thermoset Resin Chemical Resistant Tanks."

1.02 QUALITY ASSURANCE

A. MANUFACTURER REQUIREMENTS

1. All equipment provided under this section shall be obtained from a single manufacturer, who shall:

    1. Assume full responsibility for the completeness and proper operation of the biological odor control system.

    2. Have experience; be reputable and qualified in designing and manufacturing biological odor control system equipment. The odor control system manufacturer shall show evidence of at least ten (10) identical 2-stage design installations of the type specified in wastewater plants with specified non-proprietary expanded clay biofiltration media.

    3. Supply units containing all necessary appurtenances and components for a complete and operating system conforming to this specification. The entire system shall be pre-assembled, piped, wired, and factory tested prior to shipment to facilitate installation and start-up at the jobsite. The overall vessel footprint including the fan shall not exceed 8'-6" L x 6'-0" W x 7'-0" SSH. The control panel, water cabinet and accessories, and nutrient reservoir shall be mounted on a separate skid which shall be installed at the jobsite at least 3 feet from the Class 1, Division 2, Group D hazardous area.

    4. Supply units with inorganic biological expanded clay odor control media. Provision of organic biological media shall not be acceptable. Systems using any type of structured, synthetic media shall not be acceptable. Systems using any proprietary media shall not be acceptable.

    5. The complete biological odor control system, including vessel, fan, media,

piping and accessories shall be constructed to be a single piece of unitary construction. The control panel, water cabinet, and nutrient reservoir shall be mounted on a separate skid which shall be installed at the jobsite at least 3 feet from the Class 1, Division 2, Group D hazardous area. The mist/grease filter shall be shipped loose for installation in the inlet ductwork.

2. To ensure quality and complete unit responsibility, the complete system must be assembled and tested by the manufacturer at its facility and be a standard and regularly marketed product of that manufacturer. The manufacturer must have a physical plant, technical and design staff, and fabricating personnel to complete the work specified.
3. The owner reserves the right to be present at the manufacturer's facility for visual inspection of equipment to be supplied and to witness factory functional testing.
4. The system manufacturer shall have service center and capabilities as defined in section 3.04

B. SPECIFIED MANUFACTURERS

1. Biological odor control system shall be used as manufactured and supplied by Integrity Municipal Systems LLC (IMS), Poway, CA, (858) 486-1620. The owner is aware of no other supplier that is an equal to the specified manufacturer and product.

C. WARRANTY

1. The manufacturer shall warrantee that the equipment provided shall be free of defects in material and workmanship for a period of 12 months from beneficial occupancy. The warranty period shall not extend beyond 18 months from delivery of the system to the jobsite.

D. PRODUCT SUBMITTALS

1. The following product data shall be submitted by the biological odor control system manufacturer for review and approval by the engineer prior to the fabrication of the system:
    1. Shop drawings and catalog literature showing dimensional information, details of piping and fabrication and erection of all materials and equipment furnished under this section
    2. Drawing of general arrangement and major system components
    3. Process and Instrumentation drawing
    4. Seismic anchor calculations, stamped by State of California Professional Engineer.
    5. Experience and qualifications requirements (section 1.02.A)
    6. Service center/manufacturing facility information (section 3.04)
    7. Resume of factory engineer providing services (section 3.05)
    8. Major system component information and descriptive literature for the following:
        a) Exhaust fan

b) Nutrient pump
c) Water irrigation cabinet
d) Mist/grease filter
e) Vessel fabrication
f) System controls and control panel details including power and control wiring diagrams, terminals, and numbers
g) Miscellaneous instrumentation and accessories

9. Operating weight of all equipment

E. OPERATION AND MAINTENANCE MANUALS

1. Detailed operation and maintenance (O&M) manual for the system shall be provided by the manufacturer. A total of two (2) copies of O&M manuals and one (1) electronic O&M are required.

F. MANUFACTURER SERVICES

1. The system manufacturer shall be present at the jobsite for the following time period, travel time excluded:
    1. Sixteen (16) hours for system startup, and training of Owner's staff in operation of the system.
    2. Provide one trip for 2 days for these tasks.

PART 2 - PRODUCTS

2.01 BIOLOGICAL ODOR CONTROL SYSTEM

A. The odor control gas treatment system shall be a once-through biologically active odor removal system treating the odorous air from the contaminated process areas. The system shall be designed for continuous and automatic operation as well as manual operation as required.

B. The biological odor control system shall be a two-stage system. The system shall consist of one biological treatment stage (Stage 1) followed by an activated carbon polishing stage (Stage 2) in series. The first stage shall be wetted with fresh potable or reuse make-up water. The first stage shall include a spray header to distribute liquid evenly over the media.

C. FRP vessel, inorganic biological media, activated carbon media, exhaust fan, exhaust stack, water irrigation system, air distribution system, and all other required appurtenances shall be pre-assembled as complete 2-stage biological odor control system package. The control panel, water cabinet, and nutrient reservoir will be mounted on a separate skid which shall be installed at the jobsite at least 3 feet from the Class 1, Division 2, Group D hazardous area. The inlet ductwork, dampers, and mist/grease filter shall be shipped loose for installation at the jobsite.

2.02 FRP VESSEL

A. The biological odor control system shall consist of a fiberglass reinforced plastic (FRP) vessel with extended deck. The vessel shall be of unitary construction. No

modular construction or flanged pieces are allowed for the vessel itself.

B. The system vessel shall have all components pre-mounted and piped. The system vessel shall be shipped as one piece. The system shall be included with all piping, valves and internals. The system top shall be removable for access to the top of the vessel's second stage.

C. The biological odor control system shall be manufactured with the following material of construction according to following fabrication method:

1. Vessel and accessories shall be contact molded manufactured in accordance with NBS PS15-69, ASTM 4097 for contact molding.
2. Resin used in fabrication shall be a premium vinyl ester resin such as Hetron 922 or Derakane 411 by Ashland Chemical, Vipel F010 by AOC or approved equal. The resin shall be reinforced with an inner veil of suitable synthetic organic fiber such as Nexus 111-00010. Any material of construction other than FRP with premium grade resin shall not be acceptable.
3. Reinforcement: Glass fiber reinforcement used shall be commercial grade corrosion resistant borosilicate glass.
4. Fabrication:

   General: Fabrication shall be in accordance with NBS PS 15-69, ASTM D 3299 and ASTM D-4097. All non-molded surfaces shall be coated with resin incorporating paraffin to facilitate a full cure of the surface. All cut edges, bolt holes, secondary bonds shall be sealed with a resin coat prior to the final paraffinated resin coat.

   Corrosion Liner: The inner surface of all laminates shall be resin rich and reinforced with one NEXUS 111-00010 with a minimum thickness of 10 mils. The interior corrosion layer shall consist of two layers of 1 1/2 oz. per sq. ft. chopped strand mat. The total corrosion liner thickness shall be a minimum of 100 mils.

   Structural Laminate: Structural laminates shall consist of alternating layers of 1-1/2 oz per sq. ft mat of chopped glass and 24 oz per sq. yard woven roving applied to reach a designed thickness. The exterior shall be surface coated with white gel coat containing ultra-violet light inhibitors.

D. Access Manways: The vessel shall be provided with access manways to allow access to the internals of the odor control system. As a minimum, access manways shall be provided between stages.

E. Media support and screen: The system vessel shall be provided with an HDPE and FRP support system with polypropylene screen to accommodate the biological media and carbon media beds.

F. Vessel Accessories: The system shall be provided with all piping, valves and internals. Air inlet, air outlet, spray headers, drain and all vessel fittings shown on the drawings shall be provided by the Manufacturer. A differential pressure

switch as manufactured by Dwyer will be mounted to the vessel and wired to the control panel for flow verification.

G. Hardware and Gaskets: All hardware and anchor lugs shall be 316 stainless-steel. All bolts shall be designed for the specified loads. Gaskets shall be a minimum of 1/8" thick, full face, EPDM, suitable for the intended service.

H. Neoprene Pad: A ¼" thick, 60 durometer neoprene pad must be placed underneath the scrubber vessel during installation.

2.03 ODOR CONTROL MEDIA

A. The system shall use in stage 1 an inorganic expanded clay biological media as the support substrate for selectively growing sulfur-oxidizing autotrophic bacteria. The media shall be randomly dumped in the vessel to allow a low pressure drop. The media is porous and is resistant to hydrogen sulfide (H_2S) and acidic conditions. The media shall be non-proprietary and commercially available.

B. The system shall use in stage 2 a coal based high H_2S capacity activated carbon media, with a minimum H_2S capacity of 0.30 g/cc, to adsorb residual H_2S and other odor compounds. This stage shall provide final removal of odors to specified level. No exception to this requirement is acceptable.

C. Overall media depth shall be a minimum of 48 inches.

2.04 EXHAUST FAN

A. General. Fan shall be centrifugal design manufactured of FRP with a radial blade wheel. No other material of construction is acceptable. The wheel shall be statically and dynamically balanced. The fan inlet shall be slip type and the fan outlet shall have a flanged nozzle. The fan will be provided with a double lip type shaft seal. The fan shall be mounted on the vessel's deck. No exceptions are allowed.

B. Fan shall be supplied with a TEFC motor with 1.15 service factor suitable for three-phase, 60 Hz, 480-volt service. The fan shall be direct driven. The motor shall be inverter-duty and suitable for installation in a Class 1, Division 2, Group D hazardous area.

C. Performance. The fan shall be tested and rated in accordance with AMCA and shall bear the AMCA seal.

D. The fan shall be New York Blower, Hartzell or equal.

E. The fan shall be designed for the following specifications:

Model Number	**I-BOx® 6000**
Airflow Rate, cfm	580- 850
S.P. up to System Inlet, in W.C	2.0
Total Pressure Drop, in W.C	5.0
Motor, HP	3.0

2.05 MIST/GREASE FILTER

A. A mist/grease filter module shall be provided to remove greases and mists. Module shall be of same FRP construction as the vessel and installed in the inlet ductwork by the odor control system supplier. Module shall have flanged ends and be equipped with 316SS Mesh Pad filter. The filter is to be serviced through an access door. A differential pressure gauge is provided on the system to monitor pressure drop.

2.06 FRP EXHAUST STACK

A. The scrubber system shall be provided with an exhaust stack manufactured of FRP. The exhaust stack shall be provided with a 45° elbow.

B. The exhaust stack shall be contact molded and manufactured in accordance with NBS PS15-69 and ASTM D-4097 for contact molding. The resin used in the fabrication of the exhaust stack shall be the same as that used for the main vessel such as such as Hetron 922 or Derakane 411 by Ashland Chemical, Vipel F010 by AOC or approved equal.

2.07 SYSTEM ELECTRICAL CONTROL PANEL

A. The electrical control panel shall house all required controls for the entire system. The electrical control panel shall be mounted on a remote skid.

B. The control panel enclosure shall be rated NEMA 3R and shall be made of FRP. The control panel shall be factory tested to full operation with all other components prior to shipment.

C. The control panel shall provide electrical control for the entire system with as a minimum the following switches, alarms and accessories:

1. “On-Off” switch for Exhaust Fan
2. “Exhaust Fan Running” indicator light
3. VFD for exhaust fan
4. “Hand-Off-Auto” switch for Nutrient Pump
5. “Nutrient Pump Running” indicator light
6. Push button switch with status lights for water valve

7. Timer relay for on/off control of water valve
8. Control Transformer (480V to 120V)

D. The power supply shall be 480V, 3 ph, 60 Hz.

E. Control panel shall be provided with terminal strip as required for easy wiring connections.

F. All connections from the control panel to the plant SCADA system shall be provided by the owner, with contacts a. Fan Running, b. Fan Fault and c. Nutrient Tank Low Level.

2.08 INSTRUMENTATION AND WATER CONTROLS

A. The water irrigation controls shall be mounted in a completely separate FRP water cabinet on a remote skid and shall consist of the following components:

1. Ball valves
2. Pressure reducing valve
3. Pressure gauge
4. Solenoid valve
5. Gate control valve
6. Rotameter- Variable area type with a Teflon float, EPR O-rings and PVC fittings. The rotameter shall have a direct reading scale.
7. Nutrient injection connection
8. Water fill piping for nutrient
9. Nutrient pump

B. An independent media irrigation system is incorporated into Stage 1 to provide the biological media with adequate moisture. The system shall be designed to irrigate the top of the first media bed with complete and even coverage via spray nozzles. Potable water or plant effluent water can be used provided that residual chlorine concentrations are less than 5 ppm.

2.09 PIPING

A. All make-up water and drain piping shall be SCH 80 PVC.

2.10 NUTRIENT RESERVOIR AND NUTRIENT PUMP

A. Nutrient Addition: The packaged biological odor control system uses a non-proprietary, commercially available fertilizer to provide essential nutrients to optimize the growth of sulfur-oxidizing bacteria. Nutrients supplied as a coating to the support media or proprietary nutrients shall not be allowed. The system shall be equipped with a nutrient addition system that provides a controlled dosage of nutrients that is automatically fed to the irrigation water during each irrigation cycle with the help of a nutrient pump.

B. The Nutrient reservoir shall be mounted on a remote skid along with the control panel and water cabinet. The nutrient reservoir shall be made of FRP. The nutrient reservoir shall have a float-type level switch to detect a low level. Loose nutrient tanks shall not be acceptable.

C. The Nutrient pump shall be solenoid type and shall be mounted in the water cabinet.

2.11 CONTROL PANEL, WATER CABINET, AND NUTRIENT TANK SKID

A. A skid shall provide single-point remote-mounting for the control panel, water cabinet and nutrient reservoir. The skid is to be installed at the jobsite 3 feet away from the Class 1, Division 2, Group D hazardous area.

B. The remote skid shall be contact molded and manufactured in accordance with NBS PS15-69 and ASTM D-4097 for contact molding. The resin used in the fabrication of the skid shall be the same as that used for the main vessel such as Hetron 922 or Derakane 411 by Ashland Chemical, Vipel F010 by AOC or approved equal.

2.12 INLET FOUL AIR DUCTWORK

A. The scrubber system shall be provided with FRP inlet ductwork to collect foul air and deliver it to the fan inlet. _____ (4) dampers shall be installed in the ductwork to allow for adjustment of foul air from multiple sources in accordance with the drawings.

B. The inlet foul air ductwork shall be contact molded and manufactured in accordance with NBS PS15-69 and ASTM D-4097 for contact molding. The resin used in the fabrication of the exhaust stack shall be the same as that used for the main vessel such as such as Hetron 922 or Derakane 411 by Ashland Chemical, Vipel F010 by AOC or approved equal.

PART 3 - EXECUTION

3.01 FACTORY ASSEMBLY AND TESTING

A. Each system shall be pre-assembled at the manufacturing location to the extent described in these specifications.

B. System(s) shall be tested at the location of assembly to assure they are in full operational and working order per the requirements of the specific design(s) for the project as described in this specification.

C. Engineer and/or Owner reserve the right to be present at the manufacturer's testing facility to witness the factory functional testing. Engineer and/or Owner shall provide intent to witness functional testing at the time of the design submittal review and approval, and manufacturer shall provide notice to Engineer and/or Owner regarding the scheduled time of the functional testing at least five business days in advance of the proposed functional testing. The odor control system supplier shall include in his supply all travel expenses for one trip (1) for

up to two (2) days by the owner or engineer to the manufacturer's testing facility to witness the factory functional testing (all travel accommodations need to be acceptable to the owner and engineer).

D. Factory testing shall include visual inspection of all equipment, complete assembly and functional operating testing of components including piping and equipment check, and verification of control panel wiring and operation.

3.02 DELIVERY AND INSTALLATION

A. System(s) shall be packaged and shipped so as not to incur damage to any portion of the system through handling and installation of the system itself.

B. System(s) shall be installed per the manufacturer's guidelines and recommendations. Installation shall include the re-assembly of any items separately packaged for protection during shipment. Installation is provided by the Manufacturer under these specifications.

C. Installation by the Contractor shall include:

1. Installation of dampers
2. Installation of mist/grease filter
3. Connection of inlet foul air ductwork from dampers to mist/grease filter and from mist/grease filter to system exhaust fan inlet
4. Installation of control panel, water cabinet, and nutrient tank skid
5. Wiring from control panel on remote skid to system mounted fan
6. Power to system control panel (480V, 3 ph, 60 Hz, 25 Amps)
7. Connection to existing water supply line. The nominal water requirements are at a rate of 6.0 gpm and a pressure of 30 psi. Hardness shall not exceed 200 mg/l as calcium carbonate
8. Piping connection from remote skid to system water inlet connection
9. Connection of system drain to 1-inch PVC plant drain

3.03 FIELD START-UP

A. A factory representative from manufacturer shall be present at the jobsite for initial system start-up of equipment as specified in section 1.02.F. Factory representative will provide proper system installation, will start-up the system and train owner's personnel.

3.04 SERVICE CENTER/MANUFACTURING FACILITY

A. The biological odor control system manufacturer shall have complete, ongoing service capability with factory trained personnel. The manufacturing facility shall be located in southern California within 50 miles of the jobsite. The service center/manufacturing facility shall be staffed with a minimum of five (5) full-time employees of the odor control system supplier. A manufacturer's sales representative office shall not be acceptable. No exception to this requirement is acceptable.

B. The service center/manufacturing facility shall be able to provide the following services: field H_2S measurements, airflow rate measurements, provision of

replacement parts and operational troubleshooting.

3.05 MONTHLY SERVICES [OPTIONAL]

A. The biological odor control system manufacturer shall perform monthly services at the jobsite during the warranty period. The services shall include a monthly site visit by a factory engineer for equipment inspection. Only services conducted by a factory engineer are acceptable. Factory engineer shall have intimate familiarity with design and operation of identical system through more than 5-year documented experience in the odor control industry designing, testing and servicing odor control system of the size, materials and scope specified herein. Services conducted by a manufacturer's sales representative or agent are not acceptable. No exception to this requirement is acceptable.

B. Each month, all components of the system shall be checked by the factory engineer to verify proper operation and performance. The airflow rate shall be verified and the system proper operation and performance verified (including system inlet and outlet H_2S readings). A quarterly report shall be provided for the monthly visits.

END OF SECTION

SECTION 11201

SLUICE GATES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Furnish and install complete, tested and operating, the equipment as shown on the Drawings and as specified herein.

B. Work Included in this Section:
   1. Sluice Gates with operators.
   2. Slide Gates with operators.
   3. Flap Gates.

1.02 SUBMITTALS

A. Shop Drawings: Submit shop drawings in the Product Review category for the sluice gates, slide gates, flap gates and associated operators. Submit construction details, dimensions, and construction materials. Include sufficient data to show that equipment conforms to Specification requirements. Submit shop drawings as a complete initial package.

B. Manuals: Furnish manufacturer's installation, lubrication, and maintenance manuals, bulletins, and spare parts lists.

C. Affidavits: Furnish affidavits from the manufacturer stating that the gates and operators have been properly installed and tested and are ready for full-time operation.

1.03 QUALITY ASSURANCE

A. All equipment furnished under this Section shall be of a manufacturer who has been regularly engaged in the design and manufacture of the equipment for at least 5 years. Demonstrate to the satisfaction of the Engineer that the quality is equal to equipment made by those manufacturers specifically named herein.

1.04 SEISMIC CERTIFICATION

A. Seismic anchorage certifications and descriptions are required.

PART 2 - PRODUCTS

2.01 SLUICE GATES, STAINLESS STEEL

A. General:
   1. Provide sluice gates complete with wall thimbles, stems, guides, and all appurtenances to provide complete and operational sluice gates as shown in the Sluice Gate Schedule and as specified herein.
   2. All sluice gates shall be of the same manufacturer. The complete system comprising the wall thimble, gate, stem, stem guides, and appurtenances shall be furnished by the gate manufacturer, who shall be responsible for the suitability and compatibility of components, including that the electric actuator (specified in Section 15135) is adequately sized to move the gate under the

specified operating conditions and that stem and stem guides are of adequate strength to transmit the required forces.

3. The gates as a whole and all their components shall be suitable for service in water and wastewater. The gates shall be designed to operate at all times even after long periods of inactivity.
4. All sluice gates shall be bolted to a new cast-in-place thimble. Sluice gates shall conform to AWWA Specification C561 except as modified by the requirements in this Section.

B. Sluice Gate Type: Sluice gates shall be of the full flanged back type, as shown in the Sluice Gate Schedule, for bolting to a cast-in-place stainless steel wall thimble. The gates shall be of the flush bottom type with non-rising stems as manufactured by Whipps, Fontaine, or equal.

C. Sluice Gate Construction:
1. Materials:

Part	Material	ASTM
Slide, Frame, Guides, Thimble, and Yoke	Type 304L Stainless Steel	A240
Lift Nut, Couplings	Bronze	B584
Slide Seals, Stem Guide Liner	UHMW Polyethylene	D4020
Anchor Bolts and Fasteners	Type 316 Stainless Steel	F593/F594
Stems	Type 316 Stainless Steel	A276

2. Gate frames and guides: Gate frames and guides shall be stainless steel, flanged back type, constructed of structural members or formed plate welded to form a rigid one-piece frame. Frame design shall allow for mounting directly to a wall or mounting to a wall thimble. Mounting style shall be as indicated in the Sluice Gate Schedule. The back of the frame shall be machined and drilled to attach to the wall thimble with stainless steel bolts. The guides shall extend to accommodate at least the entire height of the slide when in the fully open position. Guides shall be capable of taking the full thrust due to water pressure and pumping action associated with the installation.
3. Gate slides: The slide shall consist of stainless steel flat plate reinforced with formed stainless steel plates or stainless steel structural members to limit its deflection to 1/360 of the gate's span or 1/16-inch, whichever is smaller, under the design head conditions shown in the Sluice Gate Schedule.
4. Guides and Seals: The guides shall be made of UHMW (ultra high molecular weight) polyethylene and shall be of such length as to retain and support at least the entire height of the slide in the fully open position. Side and top seals shall be made of UHMW polyethylene of the self adjusting type. A continuous compression cord shall ensure contact between the UHMWPE guide and the gate in all positions. The sealing system shall maintain efficient sealing in any position of the slide and allow the water to flow only in the opened part of the gate. The bottom seal shall be made of resilient neoprene set into the bottom member of the frame and shall form a flush-bottom. All

seals must be mechanically fastened to the frame or slide. “J” and “P” type rubber seals are not acceptable.

5. Stems: A threaded stem shall be utilized to connect the operating mechanism to the slide. The threaded portion of the stem shall have machined cut threads of the Acme type. On rising stems, the threaded portion of the stem shall engage the operating nut in the actuator or manual operator. On non-rising stems, the threaded portion shall engage the nut on the slide. The stem shall be threaded to allow full travel of the slide unless the travel distance is otherwise shown on the Drawings. The stem shall be constructed of solid stainless steel bar for the entire length. The stem shall have a slenderness ratio (L/R) less than 200. The stem shall be designed to transmit in compression at least 2 times the rated output of the manual operator with a 40-lb (178 N) effort. Where a hydraulic, pneumatic or electric actuator is used, the stem design force shall not be less than 1.25 times the output thrust of the actuator (with pressure equal to the maximum working pressure of the hydraulic or pneumatic supply, or electric motor in the stalled condition). For stems in more than one piece, the different sections shall be joined together by solid stainless steel or bronze couplings bolted to the stem. Stems with manual operators shall be provided with adjustable stop collars to prevent over closing the slide.
6. Stem guides: Stem guides shall be provided as necessary so that the maximum L/R ratio for the unsupported part of the stem is 200 or less. Stem guide brackets shall be fabricated of stainless steel and shall be outfitted with an UHMW polyethylene bushing. Guides shall be adjustable in two directions. Locations shall be per Drawings or manufacturer's recommendations, without causing interference during gate travel.
7. Wall thimbles: Wall thimbles shall be provided when called for in the Sluice Gate Schedule. Wall thimble depth shall be equal to the thickness of the concrete wall in which the thimble is installed. Wall thimbles shall be of fabricated stainless steel construction adequate to withstand all operational and reasonable installation stresses. A water stop shall be welded around the periphery of the thimble. The fabrication process shall ensure that the wall thimble is square and plumb and the front face is sufficiently flat to provide a proper mounting surface for the gate frame. A suitable gasket or mastic shall be provided to seal between the gate frame and wall thimble. Temporary bracing to prevent distortion of the wall thimble during transportation and concrete placement shall be provided. The required number of studs, bolts, and nuts shall be provided with each wall thimble.
8. Self-contained sluice gates:
    a. Those gates so indicated in the Sluice Gate Schedule shall be the self-contained type. Self-contained gates shall be provided with a stainless steel yoke, extended guide bars and operator mounted on the yoke. The yoke shall be of sufficient section to withstand the maximum thrust developed during opening and closing of the gate under an unbalanced head of 25 feet with a maximum deflection of 1/360 of the gate span. It shall be machined on the top face to receive the proper operator. Pads on the bottom of the yoke shall be machined where they make contact with the extended guide bars.
    b. The guide bars shall be as specified above, except they shall be extended to support the yoke. They shall be of sufficient section to withstand the full thrust developed during opening and closing of the gate under the maximum unbalanced head. They shall have pads at the

top. The pads shall be machined to match the pads on the yoke. Both the pads on the yoke and on the guide bar extensions shall be drilled and bolted to take the thrust specified above.

9. Sluice gate operators: Sluice gate operators shall be as called for in the Sluice Gate Schedule. Manual operators shall be as described later in this Specification. Electric actuators shall be as specified in Section 15135.

2.02 MANUAL OPERATORS

A. Manually operated lifts shall be of the handwheel pedestal type or single speed, removable crank type as shown in the Sluice Gate Schedule, conforming to applicable provisions of AWWA Standard C560 or C561 as amended herein. After the gate has been "cracked" from its wedging devices, a maximum hand pull of 25 pounds shall be required to open the gate under the specified operating heads.

B. Provide handwheel lift units with cast iron cap, handwheel and pedestal and a cast bronze lift nut. The lift nut shall be flanged and shall have ball thrust bearings above and below it to take the thrust developed during opening and closing of the gate. Adequate grease fittings shall be provided to lubricate the bearings and other moving parts. The rim of the handwheel shall be cast smooth and be free of sharp edges. An arrow shall be cast in the rim of the handwheel with the word "open" to indicate direction of rotation to open the gate.

C. Hand cranks shall have a maximum 15-inch operating radius and shall be provided with a revolving sleeve. All gears, sprockets, and pinions shall be of steel and have cut teeth. Sufficient grease fittings shall be provided to allow lubrication of all moving parts, such as bearings, gears, etc. Ball thrust bearings shall be provided above and below the flange on the lift nut to take the normal thrust developed during opening and closing of the gate under the maximum specified operating heads. All other bearings shall be provided with bronze sleeves. An arrow shall be cast in the lift housing to indicate the direction of opening. It shall be readily visible to the operator. Lift nuts shall be of cast bronze.

D. All lifts shall be equipped with a transparent rigid butyrate stem cover with permanent marking to indicate full open, full closed, and gate level in 1-inch graduations. Lift nut shall be threaded with left hand threads for standardized valve operation.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Equipment shall be installed in strict conformance with the manufacturer's installation instructions. Installation of sluice gates and operators, flap gates and slide gates shall be in accordance with the requirements of AWWA C560 and C561 and as amended herein. The manufacturer of the sluice gates shall furnish all gates, suitably designed, so that anchorage to thimble can be performed at the designed locations.

3.02 FIELD SERVICE

A. The manufacturer of the gates shall supply a competent field service engineer to thoroughly check and inspect the slide, sluice, and flap gates after installation,

place the gates in operation and make necessary adjustments, and instruct plant personnel in proper operating and maintenance procedures.

3.03 FIELD PAINTING

A. Non-submerged ferrous metal shall be painted in accordance with Section 09960. Submerged surfaces need not be field painted but shall be touched up if required.

3.04 FIELD LEAKAGE TESTS

A. All sluice gates, slide gates, and flap gates shall be given a field leakage test under the head conditions listed in the gate schedules on the Drawings or in these specifications. A qualified representative of the manufacturer shall be present to direct any adjustments required to reduce leakage to the specified amounts.

B. Allowable Leakage:
   1. The permitted leakage for sluice gates shall not exceed 0.1 gpm per foot of seating perimeter at the specified design seating head called for in the Schedule. The leakage shall not exceed 0.2 gpm per foot of seating perimeter at the specified design unseating head called for in the Schedule for heads of 20 feet or less.
   2. The leakage for slide gates shall not exceed 1.0 gpm per foot of seating or unseating perimeter at the design heads shown in the Schedule. If "J" seals are used, this shall be reduced to 0.5 gpm.
   3. The leakage for flap gates shall not exceed 1.0 gpm per foot of seating perimeter at the design heads shown in the schedule, or 5 feet, whichever is less.

C. For individual gates, the absence of a leakage test requirement for either seating or unseating head in the Schedule or the fact that the test heads are lower than the expected operating heads shall not relieve the requirement for satisfactory functioning at operating conditions. The tests and test levels are limited by expected limitations on water levels that will be available at the time the tests must be performed.

SLUICE GATE SCHEDULE

Gate Designation	Location	Size	Back Design	Head		Operator		Thimble		Gate Weight	Bottom Type
		Diameter (inch)		Seating (feet)	Unseating (feet)	Type	Mounting	Type	Weight (lbs)	Gate & Frame Only (lbs)	
G-151	Wet Well 1	18	FB	0	23 (max)	M	SC	E	TBD	TBD	
G-251	Wet Well 2	18	FB	0	23 (max)	M	SC	E	TBD	TBD	

Legend:

Back design:
- FB - Flat Back
- FLB - Flanged Back

Type of operator:
- H - Hydraulic, see Specification Section 11203
- M - Electrical motor
- HC - Hand crank
- HW - Handwheel

Type of operator mounting:
- S - Slab or Deck
- WB - Wall Bracket
- SC - Self Contained

Type of thimble:
- E-shaped thimble
- F-shaped thimble

END OF SECTION

SECTION 11303

SUBMERSIBLE WASTEWATER PUMPS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Furnish complete, tested and operating, submersible wastewater pumps, as shown on the Drawings and as specified herein.

B. Related Sections:
   1. Section 01300: Submittals
   2. Section 08307: Access Hatches
   3. Section 11001: General Equipment and Mechanical Requirements
   4. Section 11002: Electric Motor Drives
   5. Section 15050: Piping, Valves and Accessories

1.02 SUBMITTALS

A. Shop Drawings: The Contractor shall submit shop drawings for favorable review of the Pumps and accessories. Include sufficient data to show that equipment conforms to Specification requirements as indicated herein and in Related Sections. Submit in a single complete initial package under the Product Review category. Include the following:
   1. Pump and motor product and performance data, including a prototype pump performance curve for each application and indicate minimum continuous stable flow (MCSF). Indicate impeller trim. Submit certification that pumps and motors are suitable for adjustable speed service. Submit adjustable speed performance curves covering the range from full speed to manufacturer’s recommended minimum speed. Indicate minimum continuous stable flow (MCSF) for all speeds.
   2. Typical wet well installation drawings indicating dimensions and minimum clearances.
   3. Guide rail and other accessory data.
   4. Access hatch data in accordance with Section 08307.
   5. Davit crane product and dimensional data in accordance with Section 14600.

B. Manuals: The Contractor shall furnish two sets of manufacturer's installation, lubrication, operation and maintenance manuals, bulletins, and spare parts lists.

C. Affidavits: The Contractor shall furnish affidavits from the manufacturer stating that the pumps have been properly installed and tested and each is ready for full time operation.

D. Performance Testing: Certified factory performance tests in accordance with Hydraulics Institute Standards 14.6 and witnessed by RMWD staff are required for each pump. Each pump shall not be less than Grade 1U unless noted elsewhere in this specification. Obtain favorable review from the Engineer prior to shipment of the pumps.

1.03 QUALITY ASSURANCE

A. All equipment furnished under this Section shall: 1) be of a manufacturer who has been regularly engaged in the design and manufacture of the equipment for at

least 5 years; and 2) be demonstrated to the satisfaction of the Engineer that the quality is equal to equipment made by those manufacturers specifically named herein.

PART 2 - PRODUCTS

2.01 SUBMERSIBLE WASTEWATER PUMPS

A. General: All pumps shall be heavy-duty, submersible, non-clog, centrifugal, quick disconnect wastewater pumps. The pumps shall be capable of operating in the range of capacity specified on a continuous basis with no detrimental effects to the pump or motor.

B. Pump Schedule: The pump operating characteristics shall be as follows:

Parameter	Pumps
Primary Point (gpm @ TDH)	1,007 @ 83 ft
Secondary Point at reduced speed (gpm @ TDH)	805 @ 47 ft
Maximum Capacity at full speed (gpm @ TDH)	1,450 @ 73 ft ± 2 ft
Minimum Capacity at full speed (gpm @ TDH)	850 @ 100 ft ± *2* ft
Minimum Shutoff Head	130 feet ± 10 ft
Maximum Synchronous Speed	1,770 rpm
Pump Drive Type	Variable Speed
Motor Horsepower	45 HP
Required minimum efficiency at Primary Point	65%
Solids sphere passage	3 inches
Minimum Size Discharge	4 inches
Discharge pressure gauge range (see Section 15050)	0 to 100 psig
Manufacturer and Model No.	Flygt NP 3202 or equal

C. Pump Construction:

1. General:
   a. The pumps shall be designed to permit sump-top removal of pumping units from the wet well for inspection or service without disconnecting or disturbing the discharge piping. The pump connection shall be metal to metal or with secondary O-ring seal. The design shall permit the pumps when lowered into place to be automatically connected to the discharge piping by positively locking the volute in position to prevent any axial or lateral movement. There shall be no need for personnel to enter the wet well when pump inspection or service is required.
   b. Pump assembly, including motor, pump, and cable accessories must be rated for Class 1, Division 1 hazardous environment, explosion proof, Groups C and D.

c. Lifting assemblies and discharge mating flanges shall be spark proofed, Factory Mutual or UL Standards.

2. Pump Castings: Castings shall be of cast-iron or semi-steel of uniform quality and free from blowholes, porosity, hard spots, shrinkage defects, cracks and other injurious defects. The casings shall be designed to permit replacement of wearing parts. Joints shall be properly sealed with O-rings and shall not leak under a test pressure equal to 50% greater than the pump discharge pressure or the total dynamic head, whichever is greater. Passageways shall permit smooth flow and shall be free from sharp turns and projections.
3. Impellers: Impellers shall be coated with a high chrome coating to promote corrosion resistance suitable for the service required. The impellers shall be smooth and free flowing and shall have sufficient clearance to permit objects in the sewage that enter the pump to pass into the discharge pipe. Each impeller shall be accurately fitted and keyed, splined, or threaded on the shaft, and locked in such a manner that lateral movement will be prevented and reverse rotation will not cause loosening.
4. Balance: All rotating parts of the equipment shall be in such balance, mechanically and hydraulically, as to operate throughout the required range without excessive end thrust, vibration, or noise.
5. Shafts: Shafts shall be stainless steel, shall be of sufficient size and strength to perform the work required, and shall be adequately provided with alignment bearings.
6. Bearings: Bearings subject to submersion shall have a minimum L-10 life of 50,000 hours.
7. Mechanical Seals: Each pump shall be equipped with tandem independently-mounted tungsten carbide seals. The cavity between the seals shall be filled with lubricating oil.
8. Wear rings: Provide replaceable wear rings or liners in accordance with the pump manufacturer’s standard.
9. Electrical Motors: Submersible, 60 Hertz, air filled inverter duty rated for variable-speed applications. Motor shall be capable of continuous operation over the entire range of operating liquid levels shown on the Drawings and in the Specifications. See Section 11002 for detailed motor specifications. Rated motor horsepower shall be non-overloading throughout the entire pump curve.
10. Pump and motor protection:
    a. Provide the following devices for each pump:
        1) Moisture detection probe between the mechanical seals.
        2) Thermal sensors embedded in the motor windings.
        3) Moisture detection probe in the stator cavity.
        4) Moisture detection probe in the motor cap.
    b. Relays for the protection devices shall be provided by the pump manufacturer or shall be guaranteed by the Contractor to be compatible with each pump in accordance with the pump manufacturer requirements. Install in the pump starter enclosure.
11. Shop Coating: Pump, motor, and accessories shall be factory applied and finish coated in accordance with the manufacturer's standard.

2.02 ACCESSORIES

A. Piping, Fittings, and Appurtenances: Each pump shall be furnished with quick-disconnect discharge elbow, two Schedule 40 pipe rails (or stainless steel cables), upper guide rail bracket, intermediate guide rail bracket, rail-guided lifting

assembly, and stainless steel chain of sufficient strength to raise and lower pump. All guide rail components and fasteners shall be Type 316 stainless steel or ductile iron except for non-ferrous items as required for spark proofing. Provide intermediate guide rail support brackets as recommended by the pump manufacturer. Guide cable system of stainless steel will be acceptable in lieu of pipe rails.

B. Each pump shall be provided with 3 feet of lifting chain connected to the pump. Lifting cable shall be connected to the end of the lifting chain. The lifting cable shall be of sufficient length to extract the pump from the installation. Both the lifting chain and lifting cable shall be Type 316 stainless steel. Ends of the lifting chain and one end of the lifting cable shall be provided with shackles for connecting. The other end of the lifting cable shall have a double loop for hooking on the cable holder. The double loop shall fit through the large eye of the Grip-Eye.

C. Provide a Type 316 stainless steel cable holder.

D. Furnish each submersible pump with a stainless steel Grip-Eye for use with a mechanical lifting device. Grip eye shall be appropriately sized for weight of pump to be lifted and size of lifting chain.

E. Access Frame and Cover: Provide aluminum access hatches and accessories for pump installations as shown on the Drawings in accordance with Section 08307.

F. Provide a manual davit crane with socket for mounting. The crane shall be capable of 360 degree rotation, manufactured of Type 304 stainless steel, and include 30 feet of Type 304 stainless steel wire rope. The winch shall be zinc plated. The crane shall have a load rating in excess of the weight of the pump, and shall be of sufficient height to lift the pump free from the wet well hatch opening.

G. Provide a flush valve on each submersible pump that will produce a jet of water coinciding with pump start to scour grease and re-suspend solids in the wet well. The flush valve shall attach to the pump volute, making use of pump discharge to produce a jet of water. The flush valve shall close automatically after an adjustable period of flushing. Flush valves shall have cast iron body and ball check and contain no electrical parts. Flush valves shall be attached to the pump or sump-top removable for maintenance without the need for personnel to enter the wet well itself.

H. Pressure Gauges: Provide discharge pressure gauges for each pump with features and accessories in accordance with Section 15050. Gauge range is indicated in the Pump Schedule.

I. Miscellaneous Materials:
   1. Bolts, nuts, anchors, washers, and all other types of supports necessary for the installation of the pumps, drive units, and all other accessories within the wet well shall be furnished and shall be of Type 316 stainless steel.
   2. Elastomers: Nitrile (Buna-N).
   3. Miscellaneous metal items permanently installed within the wet well: Type 316 stainless steel. Type 304 stainless steel or galvanized steel is not acceptable.
   4. Protective coatings: Discharge piping and other items within the wet well requiring protective coatings per Section 09960 shall be coated in accordance with the requirements for “submerged service.”

PART 3 - EXECUTION

3.01 INSTALLATION

A. Equipment shall be installed in strict conformance with the manufacturer's installation instructions.

3.02 FIELD SERVICE

A. The manufacturer of the pumps shall supply a competent field service engineer to thoroughly check and inspect the pumps after installation, place the pumps in operation and make necessary adjustments, and instruct owner's personnel in proper operating and maintenance procedures before and after installation. Provide a minimum of 2 man-days of field service.

3.03 FIELD PAINTING

A. Pumps and appurtenances shall be touched up as required, per Section 09960.

3.04 FIELD TESTING

A. Each pump shall be field tested to verify that they are operating properly and are able to pump the design flow rate. Field testing shall be observed by the Engineer and field staff. For further requirements on performance tests, refer to Section 11001.

END OF SECTION

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SECTION 13120

MODULAR BUILDINGS

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. SCOPE:

1. This section specifies pre-engineered and shop fabricated modular building structures, including their building foundation and structural frames, walls and roof systems, soffits, insulation, HVAC and electrical systems as required. Supplier to provide lateral resistance bracing, etc. as designed by the Structural Engineer and required by Code.

1.02 REFERENCES

A. REFERENCE STANDARDS: The publications referred to hereinafter form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only. The latest edition of referenced publications in effect at the time of the bid shall govern. In case of conflict between the requirements of this section and the listed standards, the requirements of this section shall prevail.

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI)

   a. AHRI Standard 340/360 - Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment

2. Air Movement and Control Association (AMCA)

   a. ACMA Standard 211 - Certified Ratings Program – Product Rating Manual for Fan Air Performance

   b. AMCA Standard 311 - Certified Ratings Program – Product Rating Manual for Fan Sound Performance

3. American Society for Testing Materials (ASTM)

   a. ASTM A36 - Standard Specification for Carbon Structural Steel

   b. ASTM A242 - Standard Specification for High-Strength Low-Alloy Structural Steel

   c. ASTM A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60000PSI Tensile Strength

   d. ASTM A325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength

e. ASTM D2244 - Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates

f. ASTM D4214 - Standard Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films

g. ASTM E84 Standard - Test Method for Surface Burning Characteristics of Building Materials

4. American National Standards Institute (ANSI)

   a. ANSI A117.1 - Standard for Accessible and Usable Buildings and Facilities

   b. ANSI A156.115 - Hardware Preparation in Steel Doors and Steel Frames

   c. ANSI C 73 - Dimensions of Attachment Plugs and Receptacles for Marine Ship-To-Shore Use for Small Craft

   d. ANSI Z124.2 - Plastic Shower Receptors and Shower Stalls

5. California Building Standards Commission

   a. 2019 California Building Code (California Code of Regulations, Title 24)

   b. 2019 California Energy Code (California Code of Regulations, Title 24)

   c. 2019 California Mechanical Code (California Code of Regulations, Title 24)]

6. National Electrical Manufacturer Association (NEMA)

   a. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)

   b. NEMA MG 1 - Motors and Generators

7. National Fire Protection Association (NFPA)

   a. NFPA-80 - Standard for Fire Doors and Fire Windows

   b. NFPA-105 - Standard for Smoke Door Assemblies and Other Opening Protectives

   c. NFPA-70 – National Electrical Code

8. Underwriters Laboratories (UL)

   a. UL 325 - Standard for Door, Drapery, Gate, Louver, and Window Operators and Systems

   b. UL 498 - Attachment Plugs and Receptacles

   c. UL 514A - Metallic Outlet Boxes

   d. UL 514B - Conduit, Tubing, and Cable Fittings

e. UL 1784 - Standard for Air Leakage Tests of Door Assemblies and Other Opening Protectives

1.03 SUBMITTALS

A. The following information shall be submitted for review in accordance with the SUBMITTAL PROCEDURES Section 01300:

1. A copy of this specification section, with addenda updates, with each paragraph check marked to show specification compliance or marked to show deviation.

2. Manufacturer's product data, specifications and installation instructions for building components and accessories.

3. Complete erection drawings showing foundation, anchor bolts settings, sidewall, endwall, and roof framing, transverse cross sections, covering and the trim details, and accessory installation details to clearly indicate proper assembly of building components.

4. Finishes: Provide samples to Architect of finish materials to be used at interior and exterior. Texture and colors to be selected from manufacturer’s standard line of materials.

5. Written certification prepared and signed by a professional Structural Engineer, registered to practice in the State of California, verifying that the building design meets indicated loading requirements and code of authorities having jurisdiction.

a. Signed, sealed calculations and drawings for the design for the structure.

6. Warranty: Furnish a twenty (20) year manufacturer’s roofing assembly warranty. Coverage shall be for material and installation. Also include 10-year minimum finish warranty and weather tight warranty.

1.04 OPERATION AND MAINTENANCE INSTRUCTIONS

A. Submit operation and maintenance (O&M) instructions in accordance with OPERATION AND MAINTENANCE DATA Section 01730 by submitting a copy of OPERATION AND MAINTENANCE DATA Section 01730 with each paragraph check marked to show compliance. O&M instructions shall be submitted after all submittals specified above have been returned “No Exceptions Taken” or “Make Corrections Noted.” O&M instructions shall reflect the approved materials and equipment.

1.05 QUALITY ASSURANCE

A. DESIGN CRITERIA:

1. STRUCTURAL FRAMING: Design primary and secondary structural members and exterior covering materials for applicable loads and combinations of loads in accordance with the California Building Code (CBC).

B. DESIGN LOADS:

1. Basic design loads include live load, wind load and seismic load, in addition to the dead load. Design each member to withstand stresses resulting from combinations of loads that produce the maximum allowable stresses in that member as prescribed by the CBC and indicated on Structural Drawings:

a. Floor Live Load: 40 psf

1) Storage Area Load: 125 psf at Storage Rooms and floor areas with file cabinets.

b. Roof Loads: 20 psf live load. Dead load shall include roof mounted equipment if applicable.

c. Decks, stairs, ramp and landings: 100 psf live load.

1.06 MATERIALS AND ACCESSORIES CRITERIA

A. HOLLOW METAL DOORS AND FRAMES:

1. Provide doors as indicated on Drawings. The Contractor shall comply with the requirements of SDI "Specifications for Standard Steel Doors and Frames" (SDI-100) for types and styles and design requirements for hollow metal doors and frames. The Contractor shall also comply with ANSI A156.115 for hardware preparation.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store pre-assembled buildings, appurtenances and furnishings so they will not be damaged or deformed.

PART 2 - PRODUCTS

2.01 ACCEPTABLE PRODUCTS

A. Subject to compliance with specified requirements, manufacturers offering portable mobile buildings which may be incorporated in the work include, but are not limited to, the following: Williams Scotsman, ModSpace; Huntington and Associates; or equal.

2.02 PORTABLE BUILDING FEATURES

A. The CONTRACTOR shall provide code-compliant turnkey portable building, ADA hardware as shown on the Drawings. Portable building shall be complete including foundation/anchorage and lateral resistance bracing, all finishes, electrical, controls, and air conditioning equipment and associated ductwork.

B. STRUCTURE:

1. Prefabricated portable building modules shall be factory manufactured and pre-assembled to the degree practical and field assembled to the configuration and dimensions as shown on the Drawings.

C. Provide foundation and anchorage in accordance with the requirements of the CBC.

1. Bearing pads, slabs or foundations shall be concrete, meet the requirement of division 3 specifications and shall be designed in accordance with the loading criteria herein and on Structural Drawings, as well as the applicable building codes.

D. FRAMING:

1. Floor, walls and roof of wood and/or steel framing as typical for manufacturer.

E. ROOF:

1. Roof systems, coating reflectance, and insulation shall comply with the current version of the California Energy Code.

2. Roofing to be asphalt shingles. Color and style as selected by Developer.

3. Roof shall be designed for a minimum live load of 20 psf.

4. Provide overhangs as noted on Drawings.

5. Insulation shall be R-30 minimum.

6. Gutters: PVDF coated aluminum.

F. WALLS:

1. The walls shall be framed of wood or metal per manufacturer's standard construction.

2. Insulation shall be R-19 minimum.

3. Blocking: Provide and coordinate blocking as required in walls and ceilings for mounting/securing equipment as noted on Drawings.

4. Exterior Siding:

a. Board and Batten Siding: Board width, batten size and spacing as selected by Developer. Final color as selected by Developer.

b. Trim: Material, size and finish as selected by Developer. Provide trim at openings, corners, and eaves/rakes.

c. Stucco: Texture and color as selected by Developer.

d. Provide weather barrier on exterior plywood or OSB sheathing placed under siding, thickness as required per structural engineering. Install in accordance with manufacturer's requirements.

e. Prime and seal edges prior to installation. Provide corrosion resistant metal flashing behind all siding joints. Seal joints with sealant approved by siding manufacturer.

f. Install siding and trim plumb and level with a tolerance of 1/8-inch maximum deviation from level per every 20 lineal feet of siding.

G. DOORS AND FRAMES:

1. Doors and frames shall be 16 gauge hollow metal. Exterior doors shall be insulated to R-10 minimum.

2. Size: Doors shall be 3 feet wide by 7 feet high unless noted otherwise on the Drawings.

3. Door Hardware: Provide the hardware shown on the Drawings. Provide mortise device panic hardware at all doors; storeroom function.

H. FINISHES:

1. Finishes as shown on the Drawings and as described herein.

2. Gypsum wallboard (GWB), shall be 5/8" Type "X" moisture-resistant.

3. Painting shall be as noted on Drawings. Colors as selected by Developer.

I. ELECTRICAL SYSTEM:

1. MCC and associated electrical eequipment to be furnished by others. Refer to drawings for location of equipment.

2.03 UTILITIES

A. Lighting Panelboard

1. A lighting panelboard shall be provided to provide required power to building utilities. The panelboard shall meet the ratings as shown on the Drawings and meet the specifications provided in Specification Section 16160.

B. LIGHTS:

1. Fixtures

a. Fixtures shall be of the types, wattages and voltages shown on the Drawings, comply with UL 57, and be UL classified and labeled for intended use.

b. Luminaire wire, and the current carrying capacity thereof, shall be in accordance with the NEC.

2. Light Fixture Types:

a. Type B3: Surface mount LED light located in the Electrical Room and Generator Room.

b. Type EX2: Exit light with emergency lights located in the Electrical Room and Generator Room.

c. Type EM2: Emergency light with battery backup located in the Electrical Room and Generator Room.

d. Type F1: Wall pack LED light mounted above exterior doors.

e. Provide light switches located on interior adjacent to exterior doors. Switches shall be rated 20 amperes at 120 or 277 Volts ac only.

3. Minimum room lighting levels shall be as follows:

a. Lift Station Modular Building: 30 footcandles under normal operating conditions.

4. Refer to Specifications 16500 and 16140 and associated drawings for additional lighting requirements, lighting schedule, switch requirements and quantities.

C. RECEPTACLES:

1. Receptacles shall be heavy duty, high abuse, grounding type conforming to NEMA configurations, NEMA WD1 and UL 514 Standards. GFCI receptacles shall be rated 20 ampere, 2 pole, 3 wire, 120 volt. Face shall be nylon composition meeting UL 498 test standards. Unit shall have test and reset push buttons. Reset push button shall have a visible indicator band to indicated tripped condition. Color shall be brown in industrial areas and ivory or white in office and other areas. Devices shall have nylon composition face with a nylon or melamine body. Units shall comply with Federal Specification W-C-596E and UL 498 test requirements.

2. Device plates shall be of the style and color to match the wiring devices. Plates shall conform to NEMA WD1, UL 514, and ANSI C73. Plates and boxes on finished walls shall be nonmetallic or stainless steel. Nonmetallic plats shall be smooth finish with contoured edges and shall be nylon or fiberglass. Stainless steel plates shall be 0.035 inches thick with beveled edges and shall be manufactured from NO. 302 alloy having a brushed or satin finish.

3. Refer to Specification 16140 and drawings additional requirements, quantity and location of receptacles.

D. CONDUIT

1. Conduit shall be galvanized rigid steel conduit. Galvanized Rigid Steel Conduit (GRS) shall be manufactured from mild steel, hot-dip galvanized insider and not, conforming to ANSI C80.1 and UL 6. Couplings shall be threaded type. Manufacturers shall be Allied Tube and Conduit, Wheatland Tube and approved equal.

2. Provide exposed conduit of 3/4-inch minimum trade size and encased conduit of 1-inch minimum trade size.

3. Refer to Specification Section 16110 for additional conduit, conduit support and fitting requirements.

E. LOW VOLTAGE WIRE AND CABLE

1. Conductors, include grounding conductors, shall be stranded copper. Aluminum conductor and/or solid conductor wire and cable will not be permitted. Insulation shall bear the UL label, the manufacturer's trademark, and identify the type, voltage, and conductor size. Conductors except flexible cords and cables, fixture wires, and conductors that form an integral part of equipment such as motors and controllers shall conform to the requirements of Article 310 of the National Electric Code, latest edition, for current carrying capacity. Flexible cords and cables shall conform to Article 400, and fixture wires shall conform to Article 402. Wiring shall have wire markers at each end.

2. Refer to Specification section 16120 for additional requirements.

F. HEATING VENTILATION AND AIR CONDITIONING SYSTEMS:

1. The Electrical Room shall consist of a fully automatic heating and refrigerated cooling system conforming to the most current requirements of the California Mechanical Code, California Energy Code, and local codes, as applicable.

2. HVAC system design drawings and calculations shall be submitted per paragraph 1.03 of this Section and shall identify heating and cooling loads.

3. Equipment: Ductless Split System Heat Pump

a. Unit shall be approved and listed by Intertek ETL Listed (ETL US/C). Unit shall be factory assembled, pre-charged, pre-wired, tested and ready to operate. Unit performance shall be certified in accordance with the Air Conditioning Heating and Refrigeration Institute (AHRI) Standard 210/240 for Unitary Small Air Conditioning and Unitary Small Heat Pump Equipment. Unit efficiency shall be specified by EER and HSPF meeting the minimum standards of the California Energy Code.

G. VENTILATION

1. Passive ventilation shall be provided for the Generator Area via fixed louvers and fan as per Drawings.

2.04 EXTERIOR FINISH:

A. Paint siding and trim in accordance with paragraph 2.02.

1. Paint flashing and items that are not prefinished as follows:

2. Paint: high build primer and two-coats of semi-gloss acrylic. Finish shall be fade and chemical resistant.

2.05 WEATHERPROOFING:

A. Weathertight for exterior use. All seams and joints sealed. All openings fully weather-stripped. Roof shall be manufacturer’s standard asphalt shingle roofing.

PART 3 - EXECUTION

3.01 GENERAL (NOT USED)

3.02 INSTALLATION

A. Ship portable units assembled to the degree practical. Position unit over electrical and mechanical stub-ups. Drill and secure expansion type anchor bolts. Seal around edges of crawlspace. Install air conditioner chassis and thermostat after installation of the building. The prefabricated buildings shall be installed in the locations shown and in accordance with building manufacturer's recommendations.

3.03 TESTING (NOT USED)

3.04 TRAINING (NOT USED)

END OF SECTION

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SECTION 15050

PIPING, VALVES AND ACCESSORIES

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes: Provide all piping, including fittings, valves, supports, and accessories as shown on the Drawings, described in the Specifications and as required to completely interconnect all equipment with piping for complete and operable systems, including equipment drains.

1.02 REFERENCES

A. Air-Conditioning and Refrigeration Institute (ARI)

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

C. ASTM International (ASTM)

D. American Society of Mechanical Engineers (ASME)

E. American National Standards Institute (ANSI)

F. American Water Works Association (AWWA)

G. American Welding Society (AWS)

H. Cast Iron Soil Pipe Institute (CISPI)

I. U.S. Department of Transportation (DOT)

J. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)

K. National Fire Protection Association (NFPA)

1.03 SUBMITTALS

A. Shop Drawings:
   1. Verify by excavation, inspection and measurement all installation conditions, including existing utilities and structures, for buried pipe before preparation of Shop Drawings. Submit field measurements and photos with Shop Drawings where exposed conditions are significantly different than indicated on the Drawings. See also Section 02301 Earthwork.
   2. Layouts and Schematics: Submit detailed installation drawings of all piping. Schematics may be submitted for piping 4 inches and smaller. The Drawings and schematics shall include: pipe support locations and types, fittings, valves, other appurtenances. (Product Review)
   3. Submit data to show that the following items conform to the Specification requirements:
      a. Pipe, fittings and accessories (Product Review).
      b. Fabricated pipe supports and other pipe supports (Product Review).
      c. Pipe couplings and flexible pipe pieces (Product Review).
      d. Valves and Accessories (Product Review).
   4. Submit samples of gaskets and other materials where required by the detailed specifications.

5. Submit certified test reports as required herein and by the referenced standard specifications (Product Information).
6. All items utilized on systems supplying or producing drinking water, including, but not limited to, pipe and valve linings, solvent cements, welding materials, gaskets and gasket lubricants, and additives in concrete or cement mortar shall comply with the Safe Drinking Water Act and NSF requirements for use in water systems (in accordance with Section 64591 of the California Water Works Standards). Submit proof of NSF certification for each item.
7. Samples: Solder and flux for copper pipe.
8. Gaskets for Type V-4 and 5 pipe.

B. Manuals: Furnish manufacturer's installation and operation manuals, bulletins, and spare parts lists for the following items:
1. Valves 4 inches and larger and all actuated valves.
2. Air Valves.
3. Pneumatic/motorized actuators, including positioners and I/P converters. Include the actuator manuals for the valves requiring them.

C. Affidavits: Furnish affidavits from the manufacturers for the following equipment:
1. Valves, motorized or hydraulically operated.
2. All motorized or calibrated equipment.

D. Field test reports as required in Part 3.

1.04 QUALITY ASSURANCE

A. Materials and equipment furnished under this Section shall be of manufacturers who have been regularly engaged in the design and manufacture of the materials and equipment for a period of at least 5 years. Demonstrate to the satisfaction of the Engineer that the quality is equal to the materials and equipment made by the manufacturers specifically named herein, if an alternate manufacturer is proposed.

B. Factory Quality Control: The Contractor shall test all products as noted herein and by the reference specifications.

C. Field Quality Control:
1. The Owner will:
   a. Inspect field welds and test the welds if it is deemed necessary.
   b. Perform bacteriological analysis for pipelines to be disinfected.
2. The Contractor shall:
   a. Perform leakage tests.
   b. Be responsible for the costs of additional inspection and retesting by the Owner resulting from noncompliance.

1.05 POTHOLING (CHECK ON LOCATIONS)

A. Do not prepare any shop drawings for, or make final order for, or design any pipe materials for any particular section of pipeline until all utilities in that section of pipeline have been exposed, as specified in Section 02301 and until such time as no interferences are found between said existing utilities and the proposed pipeline alignment. If interferences are found in any particular section of pipeline, do not prepare any shop drawings for, or make final order for, or design any pipe materials for that particular section of pipeline until the pipeline alignment has been modified by the Engineer to eliminate all such interferences.

1.06 CONSTRUCTION SCHEDULING/SEQUENCING

A. Construction under this Contract may involve expansion and/or modification of an existing piping system which must continue to provide service to all buildings during construction.

B. Connections and utilities changes must be programmed to provide the least possible interruptions of service. Prior to any shutdown, all materials, fittings, supports, equipment and tools shall be on the site and all necessary labor scheduled prior to starting any connection work. The Contractor shall notify the Engineer in writing at least 7 days in advance of any required shutdowns so that affected customers may be notified. In general, shutdowns shall not exceed 4 hours in duration unless specifically authorized or indicated in the suggested construction sequence. If a shutdown of more than 4 hours is required, the Contractor shall first install temporary service connections to all affected houses and other buildings. All temporary piping shall be disinfected before being put into service (water piping systems only).

C. All work under this Contract shall be conducted in a manner which will minimize shutdowns, open roadways, or traffic obstructions caused by the construction. Shutdowns causing damage to adjacent public and private property shall not be permitted, and any damage resulting shall be the sole responsibility of the Contractor.

D. Planned utility service shutdowns shall be accomplished during periods of minimum use. In some cases, this will require night or weekend work, which shall be at no additional cost to the Owner. The Contractor shall program his work so that service will be restored in the minimum possible time, and shall cooperate with the Owner in reducing shutdowns of the utility system to a minimum. No utility interruption will be permitted without the prior approval of the Engineer.

1.07 PIPING SYSTEMS

A. The various piping systems are identified by a multi-letter code on the Drawings. Unless otherwise shown on the Drawings, each system shall be constructed using the materials indicated for that system in the Pipe Schedule. Piping materials are identified by type designation in the schedule unless otherwise noted, and most valves and accessories are identified by a valve and accessory system unless otherwise noted.

1.08 APPURTENANCES

A. Furnish and install all necessary guides, inserts, anchors and assembly bolts, washers and nuts, hangers, supports, gaskets, couplings and flanges; all other appurtenant items shown on the Drawings, specified or required for the proper installation and operation of the piping; devices included in or on the piping equipment; and piping accessories.

1.09 PIPE SUPPORTS

A. General:
   1. Piping 6 Inches and Larger: Pipe supports are shown on the Drawings for piping 6 inches and larger in diameter, where the piping is shown on layout drawings. Each pipe support used is designed to resist seismic loading except where the support is of the sliding type for thermal expansion. Other supports are provided to resist axial seismic loading of pipes designed for

thermal expansion. Pipe supports that are considered seismic resistant are so noted on the pipe support detail sheets on the Drawings. The location and types of supports and braces are indicative and may be modified by the Contractor to suit field conditions, provided the modified support system conforms to the design criteria stated herein, and receives the favorable review of the Engineer. Where piping is shown schematically only, it shall be the Contractor's responsibility to support all such piping in accordance with the design criteria stated herein and using support details shown on the Drawings. Pipe supports have been designed assuming flanged joints on ductile iron pipe and steel pipe, unless otherwise indicated on the Drawings. If groove type mechanical couplings are used as an alternative, provide additional supports where required, particularly to resist rotation. Shop drawings of these additional supports shall be favorably reviewed by the Engineer prior to installation.

2. Piping Less Than 6 Inches: Pipe supports are generally not shown for piping less than 6 inches in diameter. Where supports are not shown, it shall be the Contractor's responsibility to support all such piping in accordance with the design criteria stated hereinafter and the support details shown on the Drawings. Piping 2-½ inches and larger and all piping for hazardous chemicals shall be supported with pipe supports designed to resist seismic loads. Piping smaller than 2-½ inches with non-hazardous contents may be supported with non-seismic resistant supports.
3. Where not detailed or otherwise indicated, pipe support types and spacing shall be in accordance with the Manufacturer's Standardization Society (MSS) Standard Practice No. SP-58 and No. SP-69, except as superseded by the requirements of these Specifications. Hangers and supports used as components of a fire protection system shall comply with NFPA Standard No. 13 and be listed and labeled by UL and FM.

B. Pipe Support System Design:
1. Design Loads: Pipe suspension shall be such as to prevent excessive stress or excessive variation in supporting force while system is in operation. Pipe supports shall support the sum of the weight of the pipe, fittings, appurtenances, and contents. In addition, the pipe shall be anchored to resist internal pressure forces tending to separate any unrestrained joint at pressures 1-½ times the maximum working pressure for the applicable service.
2. Seismic Loads: See Section 01190.
3. Location: All piping shall be supported in a manner that will prevent undue strain on any valve, fitting, or piece of equipment. In addition, pipe supports shall be provided at changes in direction or elevation, adjacent to flexible couplings, at all nonrigid joints, at hose bibbs, and where otherwise shown. Where piping connects to equipment, it shall be supported by a pipe support and not by the equipment.
   a. Maximum support spacing shall conform to the following table:

Pipe Size Inches	Pipe Material	Maximum Spacing Feet
1-inch and smaller	Iron Plastic	6 continuous
1-¼-inch to 2-inch	Iron Plastic	8 5

Pipe Size Inches	Pipe Material	Maximum Spacing Feet
2-½-inch to 4-inch	Iron Plastic	10 6
6-inch to 8-inch	Iron Plastic	12 8
10-inch and larger	Iron, Steel or Plastic	 15

b. Piping penetrations through concrete walls and slabs are considered to resist seismic loading, provided penetrations for pipes 3 inches in diameter and larger are complete with a wall flange.
c. Branch piping is not considered to provide resistance to seismic forces.

4. Anchors: Anchors for connecting pipe supports to concrete shall be in accordance with Section 05090.
5. Thermal Expansion Allowance:
   a. Provide one rigid pipe support for each straight run of pipe and between each pair of flexible couplings, flexible connectors, or expansion loops for pipes listed below. Provide other supports at the required spacing that allow sliding or rolling, as noted, along the pipe axis:
      1) PVC pipe larger than 1-inch in diameter (sliding inside PVC sleeve).
   b. Provide vertical support only, that is, no lateral support, within 4 feet of an angle or tee for pipes listed above.

PART 2 - PRODUCTS

2.01 GENERAL

A. Pipe and valve sizes are nominal inside diameter unless otherwise noted.

B. Construct vents of materials specified for the pipe system for which they serve.

C. All materials delivered to the job site shall be new, free from defects, and marked to identify the material, class, and other appropriate data such as thickness for piping.

D. Acceptance of materials shall be subject to strength and quality testing in addition to inspection of the completed product. Acceptance of installed piping systems shall be based on inspection and leakage tests as specified hereinafter.

E. Cutoff Flanges: Provide at all pipe or sleeve penetrations where cast into wall for pipes 4 inches and greater in nominal diameter, and at all penetrations of 3-inch and smaller nominal diameter pipe in wet or potentially wet locations as indicated on the Drawings. Cutoff flange outside diameter shall be at least a standard connection flange's outside diameter except that for pipe 30-inch-diameter and larger, nominal size, cutoff flange outside diameter may be 6 inches greater than outside pipe diameter. Cutoff flange shall be at least ¼-inch thick and shall be continuously welded (or cast) onto the pipe.

2.02 GENERAL MATERIAL REQUIREMENTS

A. Gaskets: Except where specified otherwise, gaskets shall be NBR (Nitrile or Buna-N).

B. Bolts and Tie Rods: Unless specified otherwise herein, flange bolts and nuts, coupling bolts and nuts, tie rods, and other hardware shall be as follows:
   1. Exposed: Electroplated zinc or cadmium steel.
   2. Submerged: Type 316 stainless steel, minimum tensile strength: 60,000 psi.
   3. Concrete Encased: Steel.
   4. Buried: Type 304 stainless steel, minimum tensile strength: 60,000 psi.
   5. Apply an anti-gauling compound to the threads of stainless steel bolts.

C. Flexible Sealant: Flexible sealant for pipe joints, where shown on the Drawings, shall be a two-component polysulfide, non-sag; Sikaflex 2C, Dualthane, or equal.

D. Fusion Epoxy Coating: AWWA C213; except application shall be by fluid bed only unless the greatest dimension of the article to be coated exceeds 10 feet, in which case electrostatic spray or flocking application may be used.

2.03 PIPING MATERIALS

A. Pipe and Fitting Designation: Piping materials are identified by a "Type" designation in these Specifications. The "Type" designation identifies not only the pipe itself but the associated fittings and appurtenances and the installation and test procedures described for that "Type." The designation of a particular type shall indicate a complete installation including fittings, joints, cleaning and testing. The pipe and fitting materials for each type designation shall be as specified herein and summarized in the Pipe Type Schedule.

B. Pipe Schedule: Piping systems and their corresponding piping and valve systems are listed on the Drawings.

C. Pipe Type Schedule: Pipe material, joints, and fittings shall be as summarized below. A detailed specification of each pipe type follows. (The detailed specification supersedes the schedule in case of any conflicts.)

Pipe Type		Pipe Description	Field Joints	Fittings
CUP	C-1	Copper	Solder or Flare	Wrought Copper or Bronze
DIPF	N-2	Ductile Iron Flanged Pipe	Flange or Mech. Groove Coupling	DI
PVC-1	V-1	PVC, Schedule 80	Threaded or Solvent Weld	PVC, Schedule 80
PVC-4	V-4	PVC, Pressure	B&S	DI
PVC-5	V-5	PVC, Sewer	B&S	PVC
CPVC	V-9	CPVC	Solvent Weld	CPVC

D. CUP Type C-1 Pipe:
   1. Pipe: Copper, ASTM B88.
      a. Buried: Type K (soft drawn).
      b. Exposed: Type L (hard drawn).
   2. Joints
      a. Buried: Soldered or flared.
      b. Exposed: Soldered.
   3. Solder: ASTM B32, Alloy Grade SN 94, SN 95, or SN 96. Solder and flux shall contain less than 0.2% lead.
   4. Fittings:

a. Soldered: Wrought copper, ASTM B75 for materials and ANSI B16.22 for dimensions; o r cast bronze, ASTM B62 for materials and ANSI B16.18 for dimensions.
b. Flared: AWWA C800 and ANSI B16.26.

E. DIPF Type N-2 Pipe:
1. Pipe: Flanged or grooved end ductile iron.
a. Flanged Pipe: AWWA C115 including Appendix A, minimum thickness Class 53.
b. Grooved End Pipe: AWWA C151 with grooves in accordance with AWWA C606, Table 3, for rigid joints. Provide minimum thickness classes in accordance with AWWA C606.
2. Joints: Where flanges are shown on the Drawings, provide mechanical rigid grooved couplings up to 24-inch or flanges, at the Contractor's option, except where grooved couplings are required in the Drawings. (See paragraph 1.09A.1 for special requirements for pipe supports with grooved couplings.) Provide flanges where required to connect to valves, equipment or certain pipe supports.
3. Flanges: Ductile iron, plain faced, AWWA C115. Submit certification that flanges comply with AWWA C115. Provide insulating flanges with two cathodic test stations for buried ductile iron to steel connections.
4. Mechanical Grooved Couplings: AWWA C606, minimum pressure rating of 150 psi.
5. Fittings:
a. Flanged: Ductile iron, AWWA C110 or AWWA C153.
b. Grooved End: Ductile iron, AWWA C110 for materials, dimensions and pressure ratings. Grooves shall be in accordance with AWWA C606, Table 3, for rigid joints.
c. Special Fittings: Special fittings not available in ductile iron may be fabricated of fusion epoxy lined and coated welded steel pipe with a design pressure of 450 psi. Submit design and wall thickness to the Engineer for review.
d. Buried bolts and nuts for flanged and grooved end joints shall be Type 304 stainless steel.
6. Lining:
a. Protecto 401 Ceramic Epoxy Lining, 40 mils nominal DFT, or equivalent, for pipe and fittings.
b. Fusion epoxy lining and coating, where required in the Drawings or Piping Schedule, shall be applied in accordance with paragraph 2.02.D.
7. Coating: Buried pipe shall receive asphalt coating per AWWA C115. Exposed or submerged pipe requiring protective coating per Section 09960 shall be shipped bare or shall be factory primed compatible with selected field paint system.
8. Protection for buried pipe: Polyethylene encasement, black, AWWA C105. Single-wrap pipe, double-wrap flanged fittings, mechanical joints, or other appurtenances with significantly different outside diameters from the pipe. Tape to seal seams and over laps at least 2 inches wide.
9. Bonding: Bond ductile iron to provide electrical continuity, except that insulating flanges without bonding shall be provided where shown on the Drawings.
10. Gaskets:
a. Flanged: Full face, 1/8-inch-thick NBR (Nitril or Buna-N), AWWA C115, Appendix A.

b. Mechanical Grooved Coupling: NBR (Nitril or Buna-N), AWWA C606.

11. Flange Bolts: AWWA C115, Appendix A unless stainless steel is required in paragraph 2.02.
12. Pipe Taps:
    a. Direct threaded taps are not acceptable. Pipe branch line connections shall be made using service saddles, by using reducing flanges on tees, or by tapping blind flanges on tees.
    b. Service Saddles:
        1) Materials: Ductile iron saddle with electro-galvanized straps and hardware for aboveground and bronze or 304 stainless steel for buried, and nitrile or neoprene gaskets.
        2) Type: For ductile iron pipe 4 inches and less, single strap saddles may be used. For pipe greater than 4-inch, double strap saddles shall be used.
        3) Manufacturers: Smith-Blair Model 311 or 313; equivalent by Mueller; or equal.
13. Field Closure Connections for Restrained Joints: Pipe cut in the field where necessary and when favorably reviewed by the Engineer shall be connected by one of the following methods:
    a. Series 3800 Mega-Coupling by EBAA Iron, Inc.; or equal.
    b. Mechanical Joint Sleeve with two Series 1100 Megalug Restraints by EBAA Iron, Inc.; or equal.

F. PVC-1 Type V-1 Pipe:
1. Pipe: Schedule 40 polyvinyl chloride (PVC), gray, normal impact, Type 12454 B, ASTM D1784 and ASTM D1785. Pipe shall bear the National Sanitation Foundation (NSF) label.
2. Joints: Solvent weld, except flanged or threaded permitted where required at equipment connections and where required on the Drawings. Use Military Specification T 27730A tape for threaded joints.
3. Fittings: Solvent weld, socket type, of same material as the pipe, Schedule 40, ASTM D2467.
4. Cement: Solvent weld, ASTM D2564, as recommended by the pipe manufacturer for the schedule and size to be joined.
5. Pipe Cleaner: As recommended by the pipe manufacturer for the schedule and size to be joined.

G. PVC-4 Type V-4 Pipe:
1. Pipe: Polyvinyl chloride pressure pipe, cast iron pipe outside dimensions. Pipe shall be UL listed or Factory Mutual Approved.
    a. All sizes: AWWA C900.
2. Dimension Ratio: 18 (Pressure Class 235).
3. Joints:
    a. Unrestrained Joints: Bell and spigot, gasketed; or twin gasket coupling.
    b. Restrained Joints: Bell and spigot (push-on) gasketed, or mechanical joints; both using ductile iron clamp-on restraining devices.
        1) Restraining Devices: Ductile iron with ductile iron Cor-ten rods and bolts. Pressure rating of at least 150 psi. Series 1500 or Series 2800 by EBBA Iron; equivalent by Uni-Flange; or equal for bell and spigot joints. Series 2800PV by EBBA Iron; equivalent by Unif-Flange; or equal for mechanical joints.
        2) Provide restrained joints where indicated on the Drawings.

3) Protection for Buried Restraining Devices: Double-wrap with polyethylene encasement, AWWA C105 and tape the edges of the encasement with PVC tape.

4. Gaskets: NBR (Nitrile or Buna-N).
5. Fittings: Fusion epoxy lined and coated push-on ductile iron AWWA C110 or C153. Fusion epoxy lining and coating shall be in accordance with AWWA C116.

H. PVC-5 Type V-5 Pipe:
1. Pipe and Fittings: Polyvinyl chloride sewer pipe:
a. 4-inch through 15-inch nominal size: ASTM D3034, SDR 35.
b. 18-inch through 48-inch nominal size: ASTM F679, PS46.
2. Joints: Elastomeric gasket joints, ASTM D3212.
3. Gaskets: Nitrile, ASTM F477.
4. Factory Testing:
a. Pipe Tests: Test at least three specimens for each size to be provided for the following conditions in accordance with ASTM D3034.
1) Pipe Diameters
2) Pipe Flattening
3) Impact Resistance
4) Pipe Stiffness
b. Joint Tests: Assemble two sections of pipe for each size in accordance with the manufacturer's recommendations. Test in accordance with ASTM D3212.
c. Gasket Tests for NBR Gaskets: Test three gaskets of each size for all properties noted in Section 7 of ASTM F477.

I. CPVC Type V-9 Pipe:
1. Pipe: Schedule 80 chlorinated polyvinyl chloride (CPVC), ASTM F441. Pipe shall bear the National Sanitation Foundation (NSF) label.
2. Joints: Solvent weld, except flanged permitted where required at equipment connections and where required on the Drawings.
3. Fittings: Solvent weld, socket type, of same material as the pipe, Schedule 80, ASTM F439.
4. Cement: Solvent weld, ASTM F493, IPS724 CPVC by Harrington Plastics; no equal.
5. Pipe Cleaner: As recommended by the pipe manufacturer for the schedule and size to be joined.
6. Butterfly Dampers:
a. Rating: 150 psi at 73°F.
b. Connections: Socket.
c. Materials: CPVC body, EPDM O-ring seals.
d. Manufacturers: Spears, or equal.
e. CPVC unions shall be provided on both sides of installation for removal.

2.04 PIPE COUPLINGS AND FLEXIBLE PIPE PIECES

A. General: For typical pipe joints refer to pipe material specifications. Other joint devices shall be furnished where called for on the Drawings and as specified below.

B. Dismantling Joint:

1. General: The Dismantling Joint shall be a self-contained flanged restrained joint fitting, including both flanged components and sufficient harness bars to withstand the imposed thrust complying with AWWA C219 where applicable.

The Dismantling Joint shall be furnished as a complete assembly consisting of spigot piece, flange adapter, tie bars, and gasket. The gasket seal and compression stud and nut arrangement shall be separate and independent of the tie bar restraint system.

2. Performance: No less than 5 inches of longitudinal adjustment and installed with 4 inches of inward adjustment and 1 inch of expansion.
3. Pressure Rating: 150 psi.
4. Spigot Piece and Flange Adapter: Steel.
5. Exterior Fasteners: All exterior fasteners including the bars shall be 316 stainless steel. The bar diameter shall be equal to the corresponding bolt diameter of the mating flange.
6. Flanges: AWWA C207 Class D.
7. Coating: Coated inside and out with a fusion bonded epoxy coating applied to a DFT thickness of 5 to 10 mils. The epoxy shall comply with the requirements of AWWA C550 and AWWA C213. Stainless steel fasteners and tie bars shall not be painted.
8. Gaskets:
9. Flanged gaskets shall be full faced gaskets SBR, 1/8 inch thick.
10. Wedge gaskets shall be EPDM Grade 199, Buna-S or Buna-N.
11. Manufacturer: The dismantling joint shall be Style 131 as manufactured by Dresser Industries/SVE or equivalent by Romac; or equal.

C. Flexible Couplings and Flange Coupling Adaptors:
   1. Sleeve: Cast iron or fabricated steel.
   2. Followers: Cast iron, ductile iron, or steel.
   3. Sleeve Bolts: ASTM A325, Type 3; malleable iron; or equivalent, except for buried and submerged, which shall be Type 304 stainless steel and Type 316 stainless steel, respectively.
   4. Coating: Fusion epoxy line and coat sleeve and followers.
   5. Pressure Rating: The test pressure of the applicable service or 50 psi, whichever is greater.
   6. Performance: Longitudinal movement and angular deflection capabilities shall meet AWWA C219.
   7. Flanged Coupling Adaptor Flanges: Match mating flanges. If required by connecting valve or other device, provide flanges with inside diameter equal to nominal pipe diameter.
   8. Buried Flexible Coupling Sleeve: Long barrel; Smith-Blair 442, Dresser Style 40; or equal.
   9. Manufacturers:
      a. Flexible Couplings:
         1) Connecting Pipe with Identical Outside Diameters: Smith-Blair 411 or 441; Dresser Style 38 or 138; or equal.
         2) Connecting Pipe with Slightly Different Outside Diameters: Smith-Blair 413 or R441; Dresser Style 62; or equal.
      b. Flange Coupling Adaptors: Smith-Blair 912 or 913; Dresser Style 128-W; or equal.
   10. Gaskets: SBR rubber or oil and grease resistant (Nitrile or Buna-N).
   11. Joint Restraint: Provide joint harnesses (tie rod lug or attachment plate assemblies) designed for the test pressure or 50 psi, whichever is greater, across all flexible couplings and flange coupling adaptors, except where specifically indicated otherwise on the Drawings. Anchor studs may be used on flange coupling adapters for pipe up to 12 inches in diameter.

D. Flexible Connectors:
   1. Up to 12-inch-Diameter:
      a. Type: Built-up, single arch (unless otherwise shown on Drawings) filled or wide flowing arches rubber expansion joints with full rubber flanges and retainer rings.
      b. Materials: Neoprene cover over nitrile tube, reinforced with nylon or polyester body and galvanized steel retainer rings.
      c. Pressure Rating: 190 psi.
      d. Manufacturers:
         1) Standard: Proco Series 230; Holz Type 200; Garlock Style 200HP; or equal.
         2) Concentric Reducers: Proco RC Series; Holz 200TC.
         3) Eccentric Reducers: Proco RE Series; Holz 200TE.
         4) For connections to plastic piping systems provide connectors with additional flexibility as recommended by the manufacturer. Proco Series 261R; Holz Type 320EZ; or equal.
   2. Larger than 12-inch-Diameter:
      a. Type: Built-up, single arch (unless otherwise shown on Drawings) filled arches with full rubber flanges and retaining rings.
      b. Materials: Neoprene cover over nitrile tube, reinforced with nylon or polyester body and galvanized steel retainer rings. Protect cover with Hypalon paint where exposed outdoors.
      c. Pressure Rating: 80 psi.
      d. Manufacturers:
         1) Standard: Proco Series 230; Holz Type 200, Garlock Style 200HP, or equal.
         2) Concentric Reducers: Proco RC Series; Holz 200TC.
         3) Eccentric Reducers: Proco RE Series; Holz 200 TE.
         4) For connections to plastic piping systems provide connectors with additional flexibility as recommended by the manufacturer. Proco Series 261R; Holz Type 320EZ; or equal.
   3. Restraint: Provide galvanized steel control rod-compression sleeve assemblies for all flexible spools, except where pipelines cross structural expansion joints or where specifically omitted by note in the Drawings. Number and size of control rods shall be as required for the test pressure of the pipe system or 50 psi, whichever is greater.
   4. Provide full-size intermediate metal pipe flanges where rubber spool connects with wafer style valves, lug style valves, or other pipeline items that do not have full-face metal flanges.

E. Flexible Expansion Joints:
   1. Type: Single, ball joints with integral expansion sleeves. Minimum 15 degrees deflection and 4 inches expansion. Force Balanced Design.
   2. Materials: Ductile iron conforming to AWWA C153.
   3. Pressure Rating: 350 psi minimum.
   4. Lining: Fusion epoxy.
   5. Connections: Flanges.
   6. Manufacturer: EBBA Iron Flex-Tend Force Balanced Flexible Expansion Joint; equivalent by U.S. Pipe; or equal.

2.05 CONNECTION DEVICES FOR SEWERS

A. Transition Couplings: Transition couplings shall be elastomeric plastic or synthetic rubber-resistant to sewage and grease, chemical and normal sewer gases. Couplings shall be designed to slip over the outside of the pipes being connected with a snug fit. Couplings shall be held in place and sealed with a stainless steel band clamp around each end. Couplings shall be specifically manufactured for making the transition between various types of pipe with different outside diameters. Couplings shall meet the requirements of the Uniform Plumbing Code. Fernco; Indiana Seal; or equal.

B. Transition Donuts: Transition donuts shall be elastomeric plastic resistant to sewage and grease, chemicals and normal sewer gases. They shall be designed to be inserted into the bells of sewer pipe to adapt the bell to accept the spigot of a smaller size pipe. They shall have reversed fins on the inside and outside to grip the bell and spigot. Transition donuts cast or grouted into concrete pipe or manhole sections shall have an outside diameter at least 2 inches greater than the inside diameter. Fernco; Indiana Sea; or equal.

C. Manhole Adaptors: Manhole adaptors shall be SBR rubber manhole waterstops for use with PVC sewer pipe, Fernco, or equal.

D. Flexible Manhole Connectors: ASTM C923.

E. House sewer service lateral connections between existing pipe and cast iron soil pipe replacement pipe shall be made with rubber couplings and elastomeric bushings sealed with stainless steel banks; Calder couplings as manufactured by Joints, Inc.; Fernco; or equal.

F. Other Devices: Other equivalent connection deices will be considered provided they are made of elastomers resistant to sewage and grease, chemicals, and normal sewer gases. Metallic parts shall be stainless steel.

2.06 VALVES AND ACCESSORIES

A. Valve and Accessory System Designation: Most valves and accessories to be furnished and installed are identified by a valve and accessory system designated by a letter symbol in the Pipe Schedule.

B. General Requirements for Valves:
   1. All valves of each type shall be the product of one manufacturer.
   2. All exposed valves shall be furnished with operators, handwheels, levers, or other suitable type wrench including handles as specified herein or as shown on the Drawings. Valves 4-inch and larger located more than 7 feet above the floor level shall be furnished with chain operators. Chains shall be galvanized and shall extend to within 3 feet of the floor. Provide hook so that chain may be stored clear of walkways. All buried valves shall be provided with 2-inch-square operating nut and valve boxes.
   3. All threaded stem valves shall open by turning the valve stem counter-clockwise.
   4. All exposed valves and valve operators shall have a non-bleeding shop coat, unless otherwise specified. Buried valves and operators shall be painted as specified in Section 09960.

C. General Requirements for Accessories: Pressure Gauges: Provide shutoff valves for all pressure gauges. Conform to additional requirements in this Section below.

D. Valve and Accessory Systems: See Pipe Schedule on Sheet G-2.
   1. Valve and Accessory System A: Applicable Service Condition: Clean Water and air.
      a. Globe Valves through size 3-inch:
         1) Rating: 300 psi WOG.
         2) Type: Union bonnet, handwheel operated, straight or angle pattern.
         3) Connections: Threaded.
         4) Materials: All bronze, except disc shall be Teflon.
         5) Manufacturer: Jenkins 106A; Crane 7TF; or equal.
      b. Ball Valves through size 4-inch in metal piping:
         1) Rating: 400 psi WOG.
         2) Type: Lever.
         3) Connections: Threaded.
         4) Materials: Bronze body, chrome-plated ball, Teflon seats.
         5) Manufacturers: Apollo 70-100; Watts B-6000; or equal.
      c. Swing Check Valves through size 2-inch:
         1) Rating: 300 psi WOG.
         2) Type: Swing, composition disc.
         3) Connections: Threaded.
         4) Materials: All bronze, except disc shall be Teflon.
         5) Manufacturers: Jenkins 352; Crane 141; or equal.
         6) Check valves shall include limit switch(es) as required in the Contract Drawings. Switches shall be per valve manufacturer recommendation.
      d. Pressure Gauge Assembly:
         1) Complete assembly shall include isolation valve and pulsation dampeners. Provide a support plate to the nearest flange.
         2) Pressure gauges shall have a dial size not less than 4-½ inches, polypropylene case, stainless steel movement, phosphor bronze or stainless steel bourdon tube, 0.5% accuracy (ASME B40.100 Grade 2A), friction mounted adjustable pointer, black figures on white dial, glass or acrylic window. Label face of dial to identify unit of measurement. If vibration is present: gauge case shall be liquid filled with glycerin or silicone. If vibration is not present: gauges will be a field fillable design. Process connection size shall be as shown on Drawings (1/2 NPT recommended). Complete gauge shall be Ashcroft 1279; Trerice Series 450; WIKA Type 222.34; or equal.
         3) Isolation valves shall be Type 316 stainless steel needle valves (unless ball valves are shown on the Drawings); Aschroft 7004L; Trerice 735 or 740; WIKA Type 910.11.200; or equal.
      e. Pressure Reducing Valves:
         1) For Water:
            a) Self-Contained: Watts No. U5B for low flows or 223B for flows to 170 gpm; Cashco Model D for low flows or Model 8310 DS for flows to 170 gpm.
            b) Sizes, capacities and pressures shall be as noted on the on the Drawings.
   2. Valve and Accessory System B: Applicable Service Conditions: sewage and wastewater at working pressures to 100 psig.

a. Plug valves 2-inch and larger:
    1) Rating: 175 psi through 12-inch and 150 psi 14-inch through 36-inch.
    2) Type: Resilient faced eccentric plug, lever operated 4-inch and smaller, worm geared handwheel operated 6-inch and larger, or pneumatically actuated as shown on the Drawings. Valves shall provide driptight shutoff in both directions.
    3) Connections: Flanged, 125-pound ANSI, except screwed connections may be used for 2-inch valves.
    4) Materials: Cast iron body, welded nickel seat, NBR or Buna-N coated plug, NBR or Buna-N packing or U-cup stem seal. Valves shall have interior and exterior metal surfaces other than the plug and valve seat coated with two coats of high-solids epoxy with total dry film thickness 12 mils minimum.
    5) Manufacturers: DeZurik PEC, Milliken, Clow Eccentric Plug Valve, or equal.
    6) Installation: Unless otherwise necessary for proper installation or permitted by Engineer, all eccentric plug valves shall be installed with shaft horizontal and with plug in upper half of body. Valves in sewage lines shall be installed with seat on upstream end.

b. Check Valves: General: Unless specifically called out otherwise by the Drawings or Specifications, provide swing- type check valves. Swing check valves shall be as specified above for System A.

c. Pressure Gauges:
    1) Complete installation, unless otherwise shown, shall include ¾-inch plug valve isolation at the main, a diaphragm seal made specifically for solids handling service, and gauge. Provide a support plate to the nearest flange.
    2) Plug Valve: Shall be DeZurik PEC; Val-Matic 5800 or equal. Connections shall be threaded.
    3) Gauges and Snubbers: Shall be as specified for System A.
    4) Installation: All protectors and gauge bourdon tubes shall be evacuated of air, silicone filled at the factory and factory calibrated.

d. Air Valves:
    1) Sewage Air and Vacuum Valves (SAVVs) and Sewage Combination Air Valves (SCAVs):
        a) Function: Exhausts air during pipeline filling and allows air back in when pipeline pressure drops below atmospheric pressure. Keeps sewage from air openings by incorporating deep body.
        b) Valves shall include controlled venting and shall be non-slam and/or anti-surge design.
        c) Materials: Cast or ductile iron body, stainless steel float.
        d) Pressure rating: 150 psi, 3-15 psi maximum air relief seating pressure.
        e) Manufacturer: Apco Series S-1500CS (paired with S-400 Sewage Air Release Valve) or equal.
    2) Air valves outside of the Lift Station shall be provided a locking pipe-mounted air valve enclosure, Placer Waterworks PW/SJARV-SP or equal.

a) Enclosure and air valve orientation shall be installed such that valve accessibility is maintained. Contractor shall ensure enclosure is properly supported and shall not twist or slide off pipeline.

3. Valve and Accessory System C:
   a. Applicable Service Conditions: Clean water at pressures to 150 psi and temperatures to 150°F utilizing copper piping.
   b. Gate Valves through 2 ½ inch:
      1) Rating: 200 psi WOG (Water, Oil, Gas).
      2) Type: Rising stem, screw in bonnet, solid wedge disc, handwheel operated.
      3) Connections: Threaded, solder ends for copper pipe.
      4) Materials: All bronze.
      5) Manufacturers: Crane No. 428; Nibco 111; or equal.
   c. Globe Valves through 2-½ inch:
      1) Rating: 200 psi water.
      2) Type: Renewable disc, globe or angle.
      3) Connections: Solder ends for copper pipe.
      4) Materials: All bronze.
      5) Manufacturers: Jenkins; Crane; or equal.
   d. Check Valves through 2 ½ inch:
      1) Rating: 200 psi water.
      2) Type: Regrinding swing check.
      3) Connections: Solder ends for copper pipe.
      4) Materials: Bronze with bronze or brass disc.
      5) Manufacturers: Jenkins; Crane; or equal.
   e. Ball Valves shall be as specified under Valve System A.
   f. Strainers shall be as specified under Valve and Accessory System A.

E. Miscellaneous Valves and Accessories:
   1. Link-Type Seals: Link-type seals shall be interlocking synthetic rubber links connected by stainless steel bolts and nuts to form a continuous belt. Tightening of the bolts shall expand the rubber to form a watertight seal of the annular space between a pipe and the hole or sleeve in the wall.
   2. Pipe Service Saddles for PVC Pipe other than Type V-4 pipe: Service saddles shall be provided where shown on the Drawings. Service saddles shall be the broad band strap type and be suitable for use in service up to 150 psi working pressure and 150°F. Body shall be stainless steel with ¾-inch NPT tap, except where other size is required on the Drawings.
   3. Yard Hydrants: Yard hydrants shall be furnished and installed in the locations shown on the Plans and shall be of the sizes required. They shall be Woodford model U200W frost-poof hydrants or approved equal. All hose bibbs and yard hydrants shall be paired with a freeze-proof atmospheric vacuum breaker.
   4. Flexible Rubber Hose:
      a. General: At each hose rack, provide 50 feet of flexible rubber hose of the same diameter as the hose bibb. Also provide hose at other locations where shown on the Drawings. Provide each hose with nozzle, and male and female threaded connectors. Specifically design all hose to resist deterioration due to weather, sunlight, and outdoor exposure, and to hot water or chlorine solution where applicable.
      b. Nozzles: Provide compatible nozzles on each hose associated with a hose bibb and hose rack. Nozzles shall be brass or bronze.

c. Cold Water Service: Provide rubber hose with fiber-reinforced carcass designed for 150 psi working pressure. Provide Newtype Specification No. N-135 or Corsican Specification No. S-3 by Goodall Rubber; Standard Water Hose Style B-11 by American Rubber Manufacturing; or equal.

5. Valve Boxes for Buried Valves: Adjustable, cast-iron, screw-type, installed with top set at finished grade. All valve boxes and covers shall be suitable for H20 AASHTO wheel load. Clow Figure F-2454 with Figure F-2476 extension; equivalent products by Mueller; or equal.
6. Concrete Vaults and Valve Boxes: Precast reinforced concrete, of the size and orientation shown on the Drawings. Unless otherwise shown or noted, all vaults, boxes, and their covers shall be designed for H20 AASHTO wheel loads. Steel lids shall be galvanized. Provide Christy, Brooks, or equal.
7. Valve Tags: Plastic, fiberglass, or plastic material, 2-inch square with grommeted hole. The tags shall be attached to valves with a brass jack chain. For buried installations use a nylon strap. Lettering shall be stamped or cut into the tag at least 3/16-inch high.

2.07 PIPE SUPPORTS

A. Manufacture and Design: Pipe supports shall to the maximum extent possible be standard factory fabricated units conforming to the typical supports and braces shown in the Drawings and as specified below. Where required support cannot be provided by standard factory fabricated units, and is not detailed on the Drawings, the Contractor shall provide special pipe supports. Supports shall be manufactured or special fabrications or combination as shown on the Drawings or specified. Special fabrications shall be in conformance with Section 05500. Provide ¾-inch chamfer on corners of all support elements and file or grind smooth. Supports designated to allow axial pipe movement shall have smooth and even contact surfaces.
   1. Design for Seismic Loads shall be per Section 01190.

B. Materials: All support systems shall be galvanized steel except that those that are submerged or that are located within a tank, channel, or other structure designed to hold water, below the top of surrounding walkway elevation or tank wall top, or otherwise called out on the Drawings, shall be Type 316 stainless steel. Trays for continuous support of plastic pipe or tubing shall be made of 20-gauge galvanized steel.

C. Insulation Protection Shields: Provide insulation protection shields at all pipe supports for insulated piping.

D. Provide plastic caps with rounded corners on all exposed ends of channels.

PART 3 - EXECUTION

3.01 PIPING INSTALLATION

A. General Handling and Placing:
   1. Exercise great care to prevent injury to or scoring of the pipe lining and coating, as applicable, during handling, transportation or storage. Handle fusion epoxy coated pipe and ceramic epoxy lined pipe in accordance with AWWA C213. Do not store pipe on rough ground and do not roll the pipe on

the coating. Any damaged pipe sections, specials, or fittings shall be repaired or replaced at the expense of the Contractor as satisfactory to the Engineer.

2. Carefully inspect each pipe, fitting, valve and accessory before installation to insure there is no defective workmanship or obstructions. Inspect the interior and exterior protective coatings and patch all damaged areas in the field or replace to the satisfaction of the Engineer.
3. Place or erect all piping to accurate line and grade and backfill, support, hang, or brace against movement as specified or shown on the Drawings, or as required for proper installation. Remove all dirt and foreign matter from the pipe interior prior to installation and thoroughly clean all joints before joining.
4. Use reducing fittings where any change in pipe size occurs. Do not use bushings unless specifically noted on the Drawings. Use eccentric reducing fittings wherever necessary to provide free drainage of lines.
5. Cover polyvinyl chloride (PVC) and chlorinated polyvinyl chloride (CPVC) pipe stored outside for more than two months with canvas or other opaque material. Provide for air circulation under the covering.
6. Certain installation requirements are contained in Section 02530.

B. General Buried Piping Installation:

1. Installation of gravity sewer pipe shall conform to Section 02530.
2. Trenching, bedding, and backfill for buried piping shall be as shown on the Drawings and as specified in Section 02301.
3. Where pipe grade elevations are shown on the Drawings, install the pipe with straight grades between the indicated elevations.
4. Where no pipe grade elevations are shown on the Drawings, install buried piping with at least 3 feet of cover to finished grade. Where piping crosses under buried electrical ducts, provide at least 4 feet 6 inches of cover. Provide 12 inches minimum separation between the buried pipes and ducts.
5. Provide each pipe with a firm, uniform bearing for its full length in the trench except at field joints. Do not lay pipe in water or when trench conditions or weather are unsuitable for such work.
6. Protect buried piping against thrust by use of restrained pipe joints. All exposed free pipe ends shall be securely braced. Cap or plug pipe ends that are left for future connections as shown on the Drawings and in a manner favorably reviewed by the Engineer.
7. Where piping leaves a structure or concrete encasement, provide a joint capable of angular deflection within 12 inches of the structure for pipes 12-inch and smaller or as shown on the Drawings for larger pipe sizes. Conform to details on the Drawings where such details are shown.
8. Snake buried PVC pressure pipe from side to side in the trench in long sweeps.
9. Concrete Encasements: All piping and conduits installed under slabs or footings on earth or crushed rock shall be encased in concrete not less than 6-inch thickness on all sides and extending up to the bottom of the slab or footing, unless otherwise specifically noted on the Drawings. Encasement shall extend to within 6 inches of the first pipe joint beyond the slab or footing. Provide concrete encasement whether or not the encasement is shown on the Drawings. Provide encasement under slabs on earth or crushed rock even if the structure is supported on piles, caissons, or footings. Provide continuous concrete cradles where shown.
10. Do not pull bell and spigot, gasketed joints more than 75% of the maximum deflection permitted by the pipe manufacturer.

11. Coat bolts on buried flanges or other buried appurtenances in accordance with Section 09960. Wrap the appurtenance with polyethylene encasement and tape the encasement tightly closed to the pipe.

C. General Exposed Piping Installation:
   1. Unless shown otherwise, install piping parallel to building lines, plumb and level.
   2. Install piping without springing or forcing the pipe in a manner that would set up stresses in the pipe, valves, or connected equipment.
   3. Set all pipe flanges level, plumb, and aligned. All flanged fittings shall be true and perpendicular to the axis of the pipe. All bolt holes in flanges shall straddle vertical centerline of pipes.
   4. Flexibility and Expansion: Provide flexible couplings, or flexible spools for all piping connections to motor driven equipment and where otherwise shown. The Contractor may install additional flexible couplings at favorably reviewed locations to facilitate piping installation, provided that he submits complete details describing location, pipe supports, and hydraulic thrust protection. Anchor piping subject to expansion or contraction in a manner permitting strains to be evenly distributed. Sleeves for branches through walls from adjacent mains shall be of sufficient size to allow for free side motion of covered pipe in sleeves.
   5. Install unions or flexible connections where shown on the Drawings, and at all non-motor-driven equipment to facilitate removal of the equipment.
   6. Provide valves wherever equipment drain connections are furnished and carry the discharge pipe to the nearest floor drain, drain trench or sump. Where no receptacle for drain exists, install drain piping to 1-inch above the floor. Drain piping and valve materials shall conform to the requirements of the system served.
   7. Where piping conveying liquids passes over motor control centers, electrical panels and other electrical devices, install a protective drainage tray below the piping.

D. Installation Specifics:
   1. CUP Pipe:
      a. Bends shall be made in a manner that does not crimp or flatten pipe.
      b. Dielectric unions shall be installed at connections with ferrous piping.
      c. Pipe shall have joints squarely cut clean, soldered joints shall be properly fluxed and heated before solder is placed in the joint. Joints must be driven up tight before solder is added. Compression and flared joints shall be made up in accordance with the fitting manufacturer's installation instructions. Brazing shall be in accordance with ANSI B31.1.
      d. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1-inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.
      e. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, ¾-inch ball valve, and short ¾-inch threaded nipple and cap.
      f. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using steel sleeves and mechanical sleeve seals.

g. Fire Barrier Penetrations: Where pipes pass through fire rated walls, partitions, ceilings, and floors, maintain the fire rated integrity.
h. Install branch connections to mains using tee fittings in main with take-off out the bottom of the main, except for up-feed risers, which shall have take-off out the top of the main line.
i. Install strainers on the supply side of each control valve, pressure reducing valve, pressure regulating valve, solenoid vale, inline pump, and elsewhere as indicated. Install nipple and ball valve in blowdown connection of strainers 2 inches and larger.

2. DIPF Type N-2 Pipe:
   a. Flanged Joints: Flanged joints shall be made up tight with care being taken to avoid undue strain in the flanges, fittings, and other accessories. Bolt holes shall be aligned for each flanged joint. Bolts shall be full size for bolt holes; use of undersize bolts to make up for misalignment of bolt holes or for any other purpose will not be permitted. Adjoining flange faces shall not be out of parallel to such a degree that the flanged joint cannot be made watertight without overstraining the flange. Any flanged pipe or fitting whose dimensions do not allow the making of a proper flanged joint as specified herein shall be replaced by one of the proper dimensions. Clean flanges prior to making joints. Buried flanged pipe connections shall be made with the smallest practical "bell" hole. After the joint is completed take special care to completely fill the "bell" hole under and around the pipe with compacted backfill.
   b. Mechanical Grooved Couplings: Install in accordance with the manufacturer's instructions.
3. PVC-1, PVC-4, and PVC-5 Type V-1, V-4, and V-5 Pipe:
   a. Installation of gravity sewer pipe shall conform to Section 02530.
   b. Place PVC pipe within the installation areas at least 24 hours prior to installation to permit temperature equalization.
   c. Cut pipe ends squarely, ream and deburr inside and out.
   d. Solvent Weld Joints: Clean pipe ends and sockets and join in strict conformance with the pipe manufacturer's instructions. Make joints in accordance with ASTM D2855. Handle solvent cements and primers in accordance with ASTM F402.
   e. PVC-1 Type V-1 Pipe: Threaded connections shall use a short nipple, threaded at one end, socket at the other. Provide thread sealant in accordance with the pipe manufacturer's recommendations. Take care not to overtighten the connection.
   f. PVC-1 Type V-1 Pipe: No work shall be performed until the pipe manufacturer provides onsite installation training and certifies the installers are trained per ASTM D-2855. The Owner’s inspector shall be present for the training session.
   g. PVC-4 Type V-4 Pipe: Conform to AWWA M23, Chapters 6 and 7, except as modified herein.
4. CPVC Type V-9 Pipe:
   a. No work shall be performed until the pipe manufacturer provides onsite installation training and certifies the plumbers are trained per ASTM 2855. The Owner’s inspector shall be present for the training session.
   b. Place CPVC pipe within the installation areas at least 24 hours prior to installation to permit temperature equalization.

c. Cut pipe ends squarely, ream and deburr inside and out, and bevel the ends.
d. Solvent Weld Joints: Install in accordance with ASME B31.3. Make joints in accordance with ASTM D2855. Follow all of the pipe manufacturer's recommended steps. Handle cements and primers in accordance with ASTM F402.

3.02 COUPLING INSTALLATION

A. Flexible Couplings and Flange Coupling Adaptors: Prior to installation, thoroughly clean oil, scale, rust, and dirt from the pipe to provide a clean seat for the gasket. Wipe gaskets clean before they are installed. If necessary, flexible couplings and flanged coupling adapter gaskets may be lubricated with soapy water or manufacturer's standard lubricant before installation on the pipe ends. Install in accordance with the manufacturer's recommendations. Tighten bolts progressively, drawing up bolt on opposite sides a little at a time until all bolts have a uniform tightness. Workers tightening bolts shall be equipped with torque-limiting wrenches or other favorably reviewed type. Anchor studs on restrained flanged coupling adaptors shall be installed so as to lock into holes drilled through the pipe wall in accordance with manufacturer's recommendation.

B. Tie Rods: Except where double-nutting is required, install the nuts snug. Tighten the nuts gradually and equally at opposite sides of the pipe until snug to prevent misalignment and to ensure that all rods carry equal loads. If double-nutting is required, double-nut each end of each tie rod. The space between the pairs of nuts shall be ½-inch greater than the distance between the lugs. Provide double-nutting at buried locations and where otherwise required on the Drawings.

C. Flexible Rubber Spools:
1. Install in accordance with manufacturer's instructions. Unless otherwise shown on the Drawings, install flat with one-half the maximum expansion.
2. Connect rubber spools only to full-face metal flanges.
3. Install control rod-compression sleeve assemblies with control rod nuts snug, to relieve stress on adjacent pipe, except at buried locations. Comply with manufacturer's instructions.
4. Paint buried galvanized steel retainer rings, bolts and other appurtenances in accordance with Section 09960.

3.03 INSTALLATION OF VALVES AND ACCESSORIES

A. Wrap buried valve bodies as specified for flexible couplings and flanged coupling adapters.

B. Use reducing fittings where any change in pipe size occurs between valves or accessories and the attached pipeline. Bushings shall not be used, unless specifically noted on the Drawings. Use eccentric reducing fittings wherever necessary to provide free drainage of lines.

C. Install valves and accessories such that all parts are easily accessible for maintenance and operation. Provide valve boxes for buried valves.

D. Where valve handwheels are shown on the Drawings, valve orientation shall be as shown. Where valve handwheels are not shown, orient valves to permit easy access to the handwheels or handles and to avoid interferences.

E. Install pressure gauges in a position to permit reading them from a point approximately 5 feet above floor level, except that pump pressure gauges shall be installed close to the pump elevation.

F. Rigidly support pressure switches and connect them to piping and equipment using a suitable flexible linkage that will not permit transmission of vibrations from the piping or equipment to the pressure switches.

G. Provide a union adjacent to each screwed end valve and accessory with additional unions as necessary to facilitate removal.

H. Provide a shutoff valve below each pressure gauge, protective device or air valve unless otherwise specified.

I. Connections between ferrous and non-ferrous piping, valves, accessories or pipe supports shall be made using a dielectric coupling, union, or flange.

J. Where valves or other pipeline items require metal full-face connecting flanges, provide intermediate flanges if the connecting flange is not adequate.

K. Provide a suitable chrome plated escutcheon on pipes passing through walls, floors, ceilings and partitions in finished areas.

3.04 INSTALLATION OF PIPE SUPPORTS

A. General:
   1. Install and adjust supports for each pipeline such that the pipeline is true to the indicated line and grade.
   2. Locate anchors and braces for any single support on a continuous structure; that is, not on two sides of a structural expansion joint.
   3. Tighten clamps to develop full friction along the pipeline except where loose fitting clamps are called for.

B. Electrolytic Protection: Pipe supports serving copper pipe or tubing shall be dielectrically insulated from the pipe by dielectric sleeves or plastic pipe wrap at the point of contact.

3.05 PIPE AND VALVE IDENTIFICATION

A. General: Identify all exposed piping in this project by painting, banding, system name labels, and direction arrows. The color and banding shall be as selected by the Engineer. Identify all buried and exposed valves with tags as specified below.

B. Exposed Pipe Identification: Before painting, banding and labeling, pipes shall be identified by the Contractor with temporary wired-on cardboard tags showing the proposed marking for review by the Engineer.

C. Piping: Paint all exposed pipes with the appropriate paint system as specified in Section 09960 and provide pipe markers per the schedule specified in Section 10400.

D. Valves: Provide each buried valve with a valve tag identifying the pipeline contents, and either its valve number, or the area or item served by the valve for valves without a valve number. Contents shall be as designated in the Piping Schedule.

E. Provide access panel markers for valves and control devices concealed behind access panels and above suspended ceilings. Locate markers on access doors and on ceiling T-bars.

1. Markers for Ceiling T-bar Installation: Blue, pressure-sensitive, self-adhesive, at least 3 mils thick, 3/8-inch diameter.
2. Markers for Access Doors: 1/16-inch thick, engraved plastic-laminate, with abbreviated terms and numbers corresponding to the concealed item. Provide 1/8-inch center attachment hole.

3.06 FIELD QUALITY CONTROL

A. The Owner will:
   1. Inspect field welds and test the welds if it is deemed necessary.
   2. Perform bacteriological analysis for pipeline to be disinfected.

B. Factory Quality Control: The Contractor shall test all products as required herein and by the reference specifications.

C. The Contractor shall:
   1. Perform leakage tests.
   2. Be responsible for the costs of additional inspection and retesting by the Owner resulting from non-compliance.

3.07 CLEANING

A. Cleaning of gravity sewer pipe shall conform to Section 02530.

B. Prior to testing, thoroughly clean the inside of each completed piping system of all dirt, loose scale, sand and other foreign material. Cleaning shall be by sweeping, flushing with water or blowing with compressed air, as appropriate for the size and type of pipe. Flushing shall achieve a velocity of at least 3 feet per second. The Contractor shall install temporary strainers, temporarily disconnect equipment, or take other appropriate measures to protect equipment while cleaning piping. Cleaning shall be completed after any pipeline repairs.

3.08 FIELD TESTING

A. Testing of gravity sewer pipe shall conform to Section 02530.

B. General: Perform leakage tests on all pipe installed in this project. Furnish all equipment, material, personnel and supplies to perform the tests and make all taps and other necessary temporary connections. The test pressure, allowable leakage and test medium shall be as specified and as shown in the following Paragraphs. Test pressure shall be measured at the highest point on the line, except that pressure at lowest point shall not exceed pipe manufacturer's rated test pressure, unless specifically noted otherwise. Leakage tests shall be performed on all piping at a time agreed upon and in the presence of the Engineer. All visible leaks shall be repaired, regardless of the test results. The Contractor may purchase water for construction, cleaning, testing, and disinfection of the pipelines from the District at a fire hydrants designated by the District. At any connection to the District water system, the Contractor shall provide an air-gap or reduced pressure backflow valve system to prevent backflow into the water source.

C. Buried Piping: The leakage test for buried piping shall be made after all pipes are installed and backfilled. However, the Contractor may conduct preliminary tests prior to backfill. If the Contractor elects to conduct preliminary tests, provide any necessary temporary thrust restraint.

D. Exposed Piping: All supports, anchors and blocks shall be installed prior to the leakage test. No temporary supports or blocking shall be installed for final test.

E. Encased Piping: The leakage test for encased piping shall be made after all pipe is installed and encased, and before any structures are constructed above it. However, the Contractor may conduct preliminary tests prior to encasement. If the Contractor elects to conduct preliminary tests, provide any necessary temporary thrust restraint.

F. Accessories: It shall be the responsibility of the Contractor to block off or remove equipment, valves, gauges, etc., which are not designed to withstand the full test pressure.

G. Testing Apparatus: Provide pipe taps, nozzles and connections as necessary in piping to permit testing including valves to isolate the new system, addition of test media, and draining lines and disposal of water, as is necessary. These openings shall be plugged in a manner favorably reviewed by the Engineer after use. Provide all required temporary bulkheads.

H. Correction of Defects: If leakage exceeds the allowable, the installation shall be repaired or replaced and leakage tests shall be repeated as necessary until conformance to the leakage test requirements specified herein have been fulfilled. All visible leaks shall be repaired even if the pipeline passes the allowable leakage test.

I. Reports: The Contractor shall keep records of each piping test, including:
   1. Description and identification of piping tested.
   2. Test pressure.
   3. Date of test.
   4. Witnessing by Contractor and Engineer.
   5. Test evaluation.
   6. Remarks, to include such items as:
      a. Leaks (type, location).
      b. Repairs made on leaks.
   7. Test reports shall be submitted to the Engineer.

J. Venting: Where not shown on the Drawings, the Contractor may install valved "tees" at high points on piping to permit venting of air. Valves shall be capped after testing is completed.

K. Testing Specifics:
   1. CUP Type C-1 Pipe:
      a. Duration: 4 hours.
      b. Pressure: 150 psi.
      c. Medium: Water.
      d. Allowable Leakage: None.
      e. Disinfection – Copper pipe for potable service shall be disinfected per AWWA D651-14.
   2. DIPF Type N-2 Pipe:
      a. Duration: 4 hours.
      b. Pressure: 150 psi.
      c. Medium: Water.
      d. Allowable Leakage: None.
   3. PVC-1 Type V-1 Pipe:
      a. Liquid Service:
         1) Duration: 4 hours.
         2) Pressure: 150 psi.

3) Medium: Water.
4) Allowable Leakage: None.

4. PVC-4 Type V-4 Pipe:
   a. Duration: 4 hours.
   b. Pressure: 200 psi.
   c. Medium: Water.
   d. Allowable Leakage:

$$L = \frac{NDP^{1/2}}{7400}$$

Where:

L = allowable leakage, gal. per hour.
N = number of joints being tested.
P = pressure, psi.
D = nominal pipe diameter, inches.

5. PVC-5 Type V-5 Pipe: Water exfiltration test in accordance with Section 306-1.4 of the Standard Specifications for Public Works Construction written by the Southern California Chapter, American Public Works Association, et al.
6. CPVC Type V-9 Pipe:
   a. Duration: 4 hours.
   b. Pressure: 100 psi.
   c. Medium: Water.
   d. Allowable Leakage: None.

END OF SECTION

SECTION 15135

ELECTRIC VALVE AND GATE ACTUATORS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Electric motor-operated valve and gate actuators and accessories.

1.02 REFERENCES

A. AWWA C542-16, Standard for Electric Motor Actuators for Valves and Sluice Gates.

B. UL 429, Electrically Operated Valves.

1.03 SUBMITTALS

A. Coordination with Gate Submittals: Electric actuator and gate information shall be submitted together in a complete package that fully describes both the actuator and the equipment that it is serving.

B. Shop Drawings and Product Data: Submit the following as a single complete initial submittal in accordance with Section 01300.
   1. Product data fully describing all items proposed for use to demonstrate that the equipment conforms to the Specifications.
   2. Motor data, including requirements for circuitry. Verify the circuits shown in the electrical drawings will accommodate the submitted actuator.
   3. Elementary and connection wiring diagrams clearly showing external connections to other equipment.
   4. Drawings showing the actuator and gate in its installed configuration.
   5. Layout drawing for all control panels, user interfaces, etc.
   6. Calculations supporting torque/motor horsepower calculations, including opening, closing, seating and unseating torque requirements for actuated gates. Torque calculations shall include torque required to open the seated valve or gate against its design pressure/seating head on one side and atmospheric pressure on the other.
   7. All actuators supplied for the project, regardless of gate manufacturer, shall be provided in a single submittal.

C. Factory Testing: Submit certified non-witnessed factory performance test results. Receive favorable review of test results prior to shipping the equipment.

D. Manuals: Furnish manufacturer's installation, lubrication, operation and maintenance manuals, bulletins, and spare parts lists.

E. Affidavits: Submit affidavits from the manufacturer stating that the equipment has been properly installed, adjusted, and tested, and is ready for full-time operation.

1.04 QUALITY ASSURANCE

A. Qualifications: Equipment furnished under this Section shall be supplied by a single manufacturer who has been regularly engaged in the design and manufacture of the equipment for at least 5 years. Demonstrate to the satisfaction

of the Engineer that the quality is equal to equipment made by those manufacturers named herein. The supplier of the equipment shall have local, factory-trained personnel capable of servicing both the actuator and connected equipment.

B. Regulatory Requirements: All units shall be either CSA or FM listed, and have the listing identified on the equipment nameplate.

C. Electric actuators shall be provided from the gate manufacturer as an assembled unit, with the actuator attached. Delivery of a bare-stem with field installation of the actuator is not allowed unless approved in writing by the Engineer.

D.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Immediately upon delivery to job site, place materials in area protected from weather. Use non-marring slings for loading, unloading, and handling units to prevent rope or cable damage to surfaces and protective wrappings.

1.06 WARRANTY

A. The warranty for all products and work shall comply with the requirements of the Contractor's General Warranty and Guarantee described in the General Conditions and the Supplementary Conditions.

PART 2 - PRODUCTS

2.01 MOTORIZED ACTUATORS

A. General: Motorized actuator shall consist of a motor actuator, motor starter, limit switches, and electronic controls for modulation where applicable.

B. Actuators shall be capable of either open/close service. Actuators shall include all accessories for accommodating multi-turn, quarter-turn, rising stem, or other actuation methods as required for the particular gate.

C. Housing: The actuator housing shall be cast aluminum with a ductile iron thrust base. The housing shall be rated for water-tight service in up to 6 feet of submersion for 30 minutes. Provide NEMA 4x, rated for Class 1, Division 1 enclosures for Hazardous Locations.

D. Motor: Motors shall operate on 120 VAC, 1-phase, 60 Hz power, and be rated for 60 starts per hour unless noted otherwise. Motors shall be of the high torque type, designed for continuous duty rating at a minimum of 140°F, and include Class F insulation. The motor shall be totally enclosed and non-ventilated with all leads terminating within the limit switch compartment. The gear attachment and electrical connections shall include plug-in type connectors to allow removal of the motor without disassembly of the actuator.

E. Gear Set: Gearing shall include an alloy steel worm and bronze worm gear immersed in oil lubrication. All gearing shall be bearing supported.

F. Gear Reduction Assembly: The gear reduction unit shall be selected by the valve manufacturer for reducing the rotational speed from actuator. For quarter-turn valves, operating time from fully open to fully closed shall be less than 30 seconds.

G. Controls

1. Provide integral electrical controls with indicating lights, local-remote selector, and open-stop-close selector.
2. Provide discrete and analog feedback and control for all signals as shown on the Drawings.

H. Manual Controls: Each actuator shall include a declutch lever and handwheel for manual operation. Handwheel shall provide for operation independent of motor gears.

I. Protective and Monitoring Devices:
1. Each motor shall include thermal motor overload protection. Overload protection shall be provided by thermal trip circuit breakers embedded in the motor windings.
2. A monitor relay shall de-energize the motor in the event of loss of power supply phase, control circuit supply, thermostat trip, local control selection, or local stop selection.
3. The actuator shall include a torque sensor and circuitry to de-energize the motor if no movement occurs after an open or close signal.
4. Valve or gate position shall be monitored by an optical encoding device. The encoder shall track and display valve position in either motor or handwheel operation, and in the event of power loss.

J. Termination Chamber: All electrical connections shall be made in a termination chamber that is separated from the control chamber by a double seal. The control chamber shall be completely enclosed when making electrical connections.

K. Indicators: The actuator shall include a local backlight LCD display for position, torque, setup, and diagnostic information. Lights shall also be provided for visual indication of status, including "open" and "closed" positions.

L. Actuator Sizing: The actuator size shall be determined by the actuator supplier, based on requirements supplied by the valve or gate supplier for this project. At a minimum, the actuator shall be of sufficient size to open or close the valve or gate at 200% of the maximum required opening, closing, and operating torque at the valve's or gate's design pressure or seating head.

M. Finish: All actuators shall be primed with an epoxy coating and electrostatically powder-coated at the factory.

N. Non-intrusive Settings: The actuator covers shall not be required to be removed for site commissioning. All settings and adjustments shall be made from the exterior of the control enclosure, without exposing internal components. Control selectors shall be non-intrusive, with no moving shafts penetrating the control enclosure.

O. Additional Requirements for Open-Close Actuators: Provide integral electric controls for open-close service including reversing starter, limit switches, torque switch, indicating lights and local-off-remote switch. Comply with AWWA C542-16. Controls shall include accept dray contacts for remote open/close operation and shall provide an "in Auto" dry contact for connection to PLC control system.

P. Manufacturer: Rotork, Rexa, Limitorque, or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install in strict conformance with the manufacturer's installation instructions.

3.02 FIELD SERVICE

A. Durations specified in Field Services do not include travel time to or from the project site or additional time required for retesting. If there are difficulties in operation of the equipment due to the design, fabrication, or installation, additional service shall be provided at no cost to the Owner.

B. The manufacturer of the actuators shall supply a competent field service engineer to thoroughly check and inspect the actuators after installation, certify that the actuators have been properly installed and are ready for operation, place the actuators in operation and make necessary adjustments, and instruct Owner's personnel in proper operating and maintenance procedures before and after installation in accordance with Section 01650.

C. Performance Testing: Performance test all valves, gates, and actuators. For further requirements on performance tests, refer to Sections 01650, 11001, 11201, and 15050, as well as the equipment specifications.

Gate Actuator Schedule

Gate ID	Gate Type	Open/Close or Modulating	Location	Gate Size	Cycle Time (seconds)	Design Seating/Unseating Head (feet)
G-151	Sluice	Open/Close	Wet Well 1	18” Dia	30	0/23
G-251	Sluice	Open/Close	Wet Well 2	18” Dia	30	0/23

END OF SECTION

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SECTION 15400

PLUMBING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Plumbing fixtures and accessories.
   2. Electric heat tape.
   3. Piping, valves, and accessories.

B. Related Sections:
   1. Section 11001: General Equipment and Mechanical Requirements
   2. Section 15050: Piping, Valves and Accessories
   3. Section 01190: Seismic Requirements

1.02 REFERENCE STANDARDS

A. American National Standards Institute (ANSI) Publication:

1.	Z358.1-1990	Emergency Eyewash and Shower Equipment
2.	ARI 1010-1984	Mechanically Refrigerated Drinking Water Coolers
3.	Z21.10.1	Storage Water Heaters
4.	A117.1	Specifications for Making Buildings and Facilities Accessible to and Usable by the Physically Handicapped
5.	ANSI Z358.1	Emergency Eye Wash and Shower Equipment

B. Underwriters Laboratories Inc. Standards:
   1. U.L. 174 Standards for Safety

C. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):
   1. Seismic Restraint Manual, Guidelines for Mechanical Systems.

D. All state and local building codes including plumbing, mechanical, fire, building, and electrical.

1.03 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Submit manufacturer’s information with materials, dimensions, and data to show that the products conform to the specification requirements. All products in this Section shall be included in a single initial submittal.

C. Submit operation and maintenance manuals where available from manufacturers.

1.04 QUALITY ASSURANCE

A. Codes: Comply with the rules and regulations of authorities having jurisdiction over the work specified herein, including the applicable Plumbing Code with amendments.

B. Permits and inspections shall be in accordance with General Conditions.

C. The Drawings shall be taken in a sense as diagrammatic. Size of pipes and general method of running them are shown, but it is not intended to show every offset and fitting nor every structural difficulty that may be encountered.

D. ADA compliance means that the plumbing item is accessible and usable by persons with disabilities.

1.05 SEISMIC PROTECTION

A. Provide equipment and piping with seismic protection as specified and as recommended by “Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Piping System,” latest edition by SMACNA. Provide more rigid restraint if required by Specification Section 15050.

B. Seismic Loads: See Section 01190.

PART 2 - PRODUCTS

2.01 GENERAL

A. Provide equipment and materials conforming to the standards and manufacturers' serial numbers shown, or equal.

2.02 PLUMBING FIXTURES AND ACCESSORIES

A. Floor and Trench Drains: Cast iron drains having inside caulk or push-on compression type neoprene gasket joints.
   1. FD-1 (For Industrial Areas): Zurn Z-520; Wade 1340; or equal, complete with primer connection.
   2. FD-7 (Process Drain): Zurn Z-505 with epoxy coating, Wade, or equal. Trap, primer, and vent connections are not required.
   3. TD-2 (Custom Trench Drain): Drain shall consist of a grated cover over a depression in a concrete floor. Refer to the structural drawings for specific requirements.

B. Backflow Preventer: All backflow preventers shall be approved by the Foundation for Cross Connection Control and Hydraulic Research at the University of Southern California. Provide straight configuration with shutoff valves and test cocks, unless shown otherwise on the Drawings.
   1. Pressure rating: 175 psi
   2. Temperature rating: 32 to 140 F
   3. Connections: ANSI Class 125 flanges, threaded for assemblies 2-inch and less.
   4. Type:
      a. BFP-1: Reduced pressure assembly, Febco Model 860, Watts Series 909, or equal.

2.03 PIPING, VALVES AND ACCESSORIES

A. Refer to Section 15050 – Piping, Valves and Accessories

PART 3 - EXECUTION

3.01 INSTALLATION

A. Provide unions or flanges where equipment is installed in piping. Also provide dielectric unions or couplings at points of connection of ferrous to non-ferrous metal piping.

B. Provide a shut-off stop valve in the branch of every water, air, gas or vacuum pipe service upstream of every fixture or outlet.

C. Provide identification nameplates for each item of mechanical equipment. Refer to Section 11001.

D. Furnish and install all supports, bracing and blocking required for the proper installation of the plumbing work specified herein.

E. Provide valves where equipment drain connections are furnished and carry the discharge pipe to the nearest floor drain, drain trench or sump. Where no receptacle for drain exists, install drain piping to 1 inch above the floor. Drain piping and valve materials shall conform to the requirements of the system served.

3.02 TEST AND INSPECTION

A. Test the systems and arrange for inspection by the proper authorities.

B. Water piping shall be hydraulically tested at not less than working pressure psig and demonstrated to be leak-free for the test period required by Section 15050.

C. Waste, drain and vent piping shall be tested in conformance with the Uniform Plumbing Code with local amendments.

END OF SECTION

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SECTION 15800

HEATING, VENTILATING AND AIR CONDITIONING

PART 1 - GENERAL

1.01 DESCRIPTION

A. This section includes materials, equipment, services and incidentals required to provide complete, integrate, and operating Heating, Ventilating and Air Conditioning Systems.

1.02 STANDARDS

A. Air Movement and Control Association, Inc. (AMCA)
   1. AMCA 210 – Laboratory Methods of Testing Fans for Rating Purposes
   2. AMCA 300 – Test Code for Sound Rating Air Moving Devices
   3. AMCA 301 – Method of Calculating Fan Sound ratings from Laboratory Test Data

B. California Building Code (CBC)

C. California Energy Commission (CEC)

D. California Mechanical Code (CMC)

E. National Electrical Manufacturers Association (NEMA)
   1. NEMA MG-1 – Motors and Generators

F. National Fire Protection Association (NFPA)
   1. NFPA 70 – National Electrical Code (NEC)
   2. NFPA 90A – Standard for Installation of Air Conditioning and Ventilating Systems

1.03 SUBMITTALS

A. Submit shop drawings in accordance with Standard Specification 01300.

B. Submit manufacturer’s drawings detailing equipment assemblies and dimensions, weights, required clearances, components, and location of field connections.

C. Submit manufacturer’s installation and maintenance instructions, and product certification where applicable.

D. Submit fan curves, sound power ratings, motor ratings and electrical characteristics, and motor and fan accessories.

E. Manuals: Complete operation and maintenance (O&M) manuals shall be in accordance with the requirements of Section 01300.

1.04 QUALITY CONTROL

A. Codes: Comply with all rules and regulations of authorities having jurisdiction over the work specified herein.

B. All equipment furnished under this Section shall be of a manufacturer who has been regularly engaged in the design and manufacture of the equipment for a minimum of 3 years; and be demonstrated to the satisfaction of the Engineer that

the quality is equal to equipment made by those manufacturers specifically named herein.

1.05 DELIVERY, STORAGE AND HANDLING

A. Manufacturer's instruction and warranty requirements for delivery, storage and handling of equipment shall be strictly followed.

B. Protect motors, shafts, and bearings from weather and construction dust.

PART 2 - PART 2 - PRODUCTS

2.01 GENERAL

A. Similar items of equipment specified herein shall be the end product of one manufacturer.

B. Specific information relative to the various equipment, including identification numbers, capacities, horsepower, and other information shall be as listed on the Drawings.

2.02 DUCTWORK AND ACCESSORIES

A. Ductwork shall be galvanized steel of the gauge and fabrication that conforms to SMACNA "HVAC Duct Construction Standards".
   1. Ductwork shall be of lock forming quality, ASTM A653 and ASTM A924, coating designation G90. Zinc coating in accordance with ASTM A90. Provide mill phosphatized finish for exposed surfaces of ducts exposed to view.
      a. Carbon steel sheets: ASTM A366, cold-rolled sheets, commercial quality, oiled exposed matte finish.
      b. Reinforcements shapes and plates: Unless indicated otherwise, galvanized steel where installed on galvanized sheet metal duct. Where installed on duct of other material, shapes and plates shall be of compatible materials.
      c. Tie rods: Galvanized steel, 1/4-inch minimum diameter for 36-inch length or less; 3/8-inch minimum diameter for lengths over 36 inches.
   2. Rectangular duct fabrication:
      a. General: Except as indicated otherwise, fabricate rectangular ducts of galvanized sheet steel in accordance with SMACNA "HVAC Duct Construction Standards," Tables 1-3 through 1-19, including associated details. Conform to requirements of referenced standard for metal thickness, reinforcing types and intervals, tie rod applications, and joint types and intervals.
      b. Materials: Free from visual imperfections such as roller marks, seam marks, pitting, stains, and discolorations.
      c. Size ductwork as indicated on Drawings, coordinate with structure and other installations.
      d. Duct lengths: Appropriate to reinforcement and rigidity class required for pressure classification.
      e. Static pressure classifications: Except where indicated otherwise, construct duct systems to following pressure classifications:
         1) Supply ducts: 2 inches water gauge.

f. Interior ducts shall be suitably braced and stiffened at floor and roof penetrations, as well as over their unsupported length, to maintain duct integrity and to limit vibration and noise.
g. Low pressure ductwork joints:
1) Transverse stiffeners and joints shall be appropriately spaced to maintain duct cross-section integrity in accordance with the pressure class specified and at the prevailing operating velocities.
2) After joints are crimped, they shall be further secured by bottom punching or riveting. Longitudinal seams shall be Pittsburgh locked, and shall be cross-broken outward. Intake or exhaust side ducts shall be cross-broken inward. Discharge ducts shall be cross-broken outward. All plenums and casings shall be similarly cross-broken and further reinforced with 1-inch by 1-inch by 0.125-inch angles, running diagonally between joints, riveted to the casings.
3) Girth joints shall be secured with “S” clips and drive cleats.
a) Stiffen girth joints on ducts with any dimension larger than 15 inches to prevent bulging or sagging.
b) “Ductmate” connector flanges are acceptable and, when used, all duct sealing tests as required by this specification shall hold with no variation.

3. Rectangular duct fittings: Fabricate fittings (elbows, transitions, offsets, branch connections) and other duct construction in accordance with SMACNA “HVAC Duct Construction Standard,” Figures 2-1 through 2-10.

B. Sealing Materials:
1. Sealant shall be non-hardening, water resistant, fire resistant, compatible with mating material; liquid used alone or with tape, or heavy mastic, meeting the fire hazard classification rating of 25/50 when tested in accordance with ASTM E84.
2. Duct Sealer: Miracle #D-618, United McGill “UNI-WELD,” United Sheet Metal “Duct-Sealer.”
3. Flanged joint mastics: One-part, acid-curing, silicone elastomeric joint sealants; ASTM C 920, Type S, Grade NS, Class 25, Use O.

C. Ductwork Hangers and Supports:
1. Manufacturers:
a. Acceptable manufacturers, subject to compliance with requirement.
b. B-Line Systems, Inc.; Elcen Metal Products Company; Anvil International, Inc.; PHD Manufacturing, Inc.; or equal.
2. Reference product(s): Listed with respective product specification.
3. Building attachments: Concrete inserts, powder actuated fasteners, or structural steel fasteners appropriate for building materials.
a. Clamps for attachment to steel framework: Steel C-clamp, equipped with setscrew, locknut, and retaining strap.
4. Hangers and Supports:
a. Hangers: Galvanized steel straps or bands or round steel threaded rod, sized according to Figures 5-1 to 5-7 of SMACNA Standards, suitable trapeze arrangement appropriate for the location for large or multiple ducts, fire resistant as required for applications involving fire-rated ceilings.

b. Hanger rod shall be fabricated from ASTM A36, steel, galvanized, continuously threaded, use double nuts and lock washers on threaded support rods.
c. Duct attachments: Sheet metal screws, blind rivers, or self-tapping metal screws; compatible with duct materials.
d. Trapeze and riser supports: Hot-dipped galvanized.

D. Duct Accessories:
1. Regulatory Requirements:
a. Products requiring electrical connection shall be in accordance with CCR, Title 8, and shall be listed and classified by UL as suitable for the purpose specified and indicated.
b. Non-metallic components shall meet the fire hazard classification rating of 25/50 when tested in accordance with ASTM E84.
2. Ductwork and accessories shall be installed to provide a system free from buckling, warping, breathing, and vibrating. Ductwork installation shall permit installation of other required services without piercing, crimping, or reducing duct sizes. Where space conditions permit, full radius turns shall be used at offsets.
3. Flexible duct connections:
a. Flexible connection material: Fire-retardant, waterproof, airtight, abrasion-proof, ozone-resistant, neoprene coated woven glass fabric that is not affected by temperature as low as -10°F or as high as 200°F and manufactured for pressures involved.
b. Flexible duct connections shall be Venfabrics, Inc. “Ventglas”; Duro-Dyne Corporation “Neoprene”; or equal.
c. Fabric shall conform to the requirements of NFPA 90A, maximum flame spread rating of 25, smoke developed rating of 50 for all materials, including connecting tape and sealant when tested in accordance with the requirements of ASTM E84. Minimum density shall be 30 ounces per square yard.
d. Flexible connectors shall be UL-listed.
e. Flexible connectors shall be provided with the necessary angle, straps, bolts, clips, or other fasteners to secure the flexible material to the equipment and ducts.
f. Flexible connections shall be designed to be removed and reinstalled without disassembling adjacent ductwork.
g. Flexible duct connectors shall be fabricated in accordance with SMACNA HVAC Duct Construction Standards – Metal and Flexible, and as indicated on the Drawings.

2.03 DIFFUSERS, REGISTERS, AND GRILLES

A. Air Registers and Grilles:
1. General: Except as indicated otherwise, provide manufacturer’s standard registers and grilles where shown on Drawings of type, size, shape, and capacity indicated, constructed of materials and components indicated and as required for complete installation.
2. Performance: Furnished registers and grilles shall each have, as a minimum, performance (noise criteria ratings evidenced by listing in manufacturer’s current data) as noted or scheduled on Drawings.
3. Compatibility: Border styles shall be compatible with adjacent wall and ceiling systems, specifically manufactured to fit into wall construction or

ceiling module with accurate fit and adequate support. Refer to Drawings and Specifications for types of wall and ceiling systems that will contain respective type register or grille.

B. Wall- or Duct-Mounted Return Air Grilles and Registers:
   1. Supply grilles and registers shall be double deflection with individually adjustable bars that allow 45° adjustment spread. Bars shall be on 3/4-inch centers, with horizontal face bars and vertical rear bars. Supply grilles installed in wall openings shall have an overlap margin to cover wall opening. Grilles shall have baked enamel finish, color as selected by the Architect.
   2. Provide countersunk screw holes with oval head mounting aluminum screws. Paint screwheads to match grille finish.
   3. The flange face shall have a continuous sponge rubber gasket.
   4. The frame shall be 1-inch flat steel.
   5. Supply grilles and registers shall be of steel construction equivalent to Titus Model 300RL series, Titus 250 series, or approved equal.
   6. Supply registers shall be furnished with an opposed blade volume control damper and gasket seals with the air volume adjustment made through the face of the outlet. Supply register accessories shall be painted flat black.
   7. Opposed blade volume control dampers shall be equivalent to Titus Model AG-15 or approved equal.

C. Contractor shall furnish to Owner three operating keys for each type of diffuser and register that requires them.

D. Acceptable Manufacturers: Subject to compliance with requirements:
   1. Titus.
   2. Price Companies.
   3. Carnes.

2.04 FANS

A. In-Line Centrifugal Fans:
   1. In-line centrifugal fans shall be factory-fabricated assemblies having fan, fan motor, and fan housing. Fan capacities, electrical characteristics, special features and accessories shall be as indicated in the fan schedules. Where indicated, corrosion-resistant, factory applied coatings shall be "Eisenheiss," or air-dried "Heresite," applied in strict conformance with the paint manufacturer's instructions. Fans shall bear the AMCA seal and shall be furnished with (gravity) or motorized backdraft dampers, where indicated. Belt-driven fans shall be Greenheck type BSQ; or equal.
   2. Centrifugal in-line fans: Belt-driven, as indicated on Drawings for respective applications, bear AMCA Certified Ratings Seal for sound and air performance.
   3. Housing: Square design, heavy gauge galvanized steel, equipped with square duct collars, two (2) removable access panels sized and arranged to permit easy access to all interior components, and universally adjustable mounting brackets for horizontal and vertical mounting. Provide fiberglass duct liner on interior of fan and motor housings.
   4. Fan wheel: Constructed of aluminum, centrifugal backward inclined with wheel core, matched to inlet cone, statically and dynamically balanced.
   5. Belt-driven fans: Have fan wheel mounted on ground and polished steel shaft installed in permanently sealed, lubricated pillow block ball bearings

selected for a minimum (L50) life in excess of 200,000 hours. Have motors and drives mounted out of airstream, equipped with motor cover/belt guard.
   a. Motor: Heavy-duty ball bearing type, totally enclosed fan cooled.
   b. Drive: Utilize machined cast iron pulleys, keyed and securely attached to wheel and motor shaft, adjustable type in motor, sized for a minimum of 150% of driven horsepower.
6. Disconnect switch: Provide with each unit. Provide factory wiring from motor to junction box.
7. Special construction features: Provide for particular units in corrosive environments when noted or scheduled on Drawings.
8. Isolator kits: Provide with each unit for hanging or base mounting as required, neoprene or spring type, unless specific type is indicated or required for a particular unit.
9. Suspend fans from structure above, unless respective unit is indicated on Drawings to be base mounted. Mount fans on vibration isolators and provide flexible duct connections.
10. Coordinate fan housing access panel orientation with access path.

B. See Fan Schedule on the Drawings for specific requirements.

2.05 DUCTLESS SPLIT SYSTEM VARIABLE REFRIGERANT FLOW HEAT PUMP

A. Multi-Zone Ductless Split Heat Pump System: Provide two-zone Ductless Split System Heat Pump and two indoor Fan Coil units
   1. The indoor fan coil unit shall be wall-mounted with multi-speed fan, configuration for manual or automatic heating, cooling, and fan-only operation, with integral, adjustable air distribution grille and return air openings as indicated on the Drawing. Each indoor unit shall be provided with accessory wired remote controller.
   2. The heat pump shall be designed for outdoor service. The heat pump shall be designed for independent refrigerant flow control for up to five indoor units. Heat pump shall include high- and low-pressure safety switches, low voltage startup capability, and fluid line filter drier on the condenser unit. Refrigerant charge shall be Puron R-410A.
   3. Refrigerant piping between the fan-coil unit and heat pump shall be as recommended by the manufacturer and shall be insulated per the International Energy Conservation Code.
   4. Thermostat: Provide manufacturer-supplied wireless programmable thermostat for control of ductless split system. Thermostats shall be wall-mounted and have a minimum 40 to 90°F temperature range. Thermostat shall include operator override. Unit shall provide display of space temperature.

B. Manufacturer: Daikin VRV series (outdoor) heat pump and FXHQ_MVJU series (indoor) fan/coil unit; Trane (Mitsubishi) MCY7 series (outdoor) heat pump and MMC1 series (indoor) fan/coil unit; or equal.

C. See the Air Conditioning Unit Schedule within the Contract Drawings for specific capacity and performance requirements.

PART 3 - EXECUTION

3.01 GENERAL

A. Protection: Fully protect all unfinished parts of the materials and equipment against damage from whatever cause during the progress of the work and until completion. All materials and equipment shall be covered while in storage and during construction in such manner that no finished surfaces shall be damaged or marred and all moving parts shall be kept perfectly clean and dry.

B. Installation shall be in strict accordance with the best practice of the several trades and with the respective manufacturer's instructions and recommendations. Installation shall include furnishing the required oil and grease for initial operation in accordance with the manufacturer's instructions.

3.02 DUCTWORK INSTALLATION

A. All sheet metal ductwork shall be erected in a first class and workmanlike manner and shall be in accordance with the SMACNA "HVAC Duct Construction Standards" and as specified above. No ductwork shall be fabricated or installed until it has been carefully coordinated with other trades. All transverse duct joints shall be taped airtight. Duct dimensions shown are “net” inside clear. Each air supply outlet and each air return or outside air intake shall have either an integral volume control device or shall be furnished with a volume damper.

B. The Contractor shall provide all ductwork, plenums, and auxiliary work and products necessary to make the HVAC systems complete and ready for operation. Ductwork shall comply with the following restrictions and conditions:
   1. Snap lock seams will not be permitted.
   2. Where space conditions permit, full radius turns shall be used at offsets.
   3. Visible duct deflection, loss of shape, or unwarranted noise or vibration resulting from faulty or inadequate support, reinforcing, metal gauge, fabrication, or joint spacing shall not be permitted.
   4. Sway bracing shall be provided, with a minimum of one at right angles to each duct run.
   5. Joints shall not interfere with airflow in the ducts.

3.03 DUCTWORK HANGERS AND SUPPORTS

A. Preparation
   1. Coordinate locations of inserts, anchors, and clamps with supported work and with other work and related supports.
   2. Contractor shall be responsible for correcting omissions and conflicts that are due to failure to coordinate his hanger and support work.

B. Installation of Duct Hangers and Supports:
   1. Install duct hangers and supports at proper intervals for the pressure class and conditions specified and prevailing in the system according to SMACNA Manual requirements, unless another arrangement is detailed or noted on Drawings. Supports shall be spaced to prevent visible duct deflection and loss of system integrity.
   2. Support horizontal ducts within 2 feet of each elbow and within 4 feet of each branch intersection.

3. Refer to Chapter 3, General Requirements, of the SMACNA Seismic Restraint Manual, for General Requirements for Bracing of Ducts. Supports shall be designed and installed in accordance with CBC and Section 01190.

3.04 DUCT ACCESSORIES

A. General: Provide and install duct accessories where called for, where shown Drawings, and where required according to manufacturer's installation instructions, applicable portions of details of construction in SMACNA Standards, and applicable provisions of ductwork sections and drawings.

B. Application and Installation of Flexible Connections for Ductwork:
   1. Flexible connections in ducts shall be installed in folds, and of sufficient length to accommodate the maximum deflection resulting from vibration and contraction without causing strain.
   2. Minimum length in folded position shall be 6 inches. Allow for at least 1-inch of slack.
   3. Provide flexible connections between sheet metal assemblies and equipment, and between different sheet metal assemblies, as called for in respective specifications and as shown on respective Drawings.
   4. Installation: Governed by respective application specifications and details.

C. Installation of Diffusers, Registers and Grilles:
   1. Coordinate diffuser register and grille installation interface with other work as necessary, including adjoining surfaces, ductwork, and duct accessories. Take special care in locating and sizing openings through finished surfaces to ensure complete coverage of rough openings by integral device flanges or auxiliary frames.
      a. Provide plenums for slot and strip diffusers, equipped with volume damper at branch take-off to diffuser in accessible ceilings and at plenum inlet, adjustable from face, in inaccessible ceilings.
   2. Install diffusers, registers and grilles as indicated on Drawings, in full accordance with applicable codes and regulations, recognized industry practices, and manufacturer's instructions. Install diffusers, registers and grilles tight against surface where installed.
   3. Diffusers, registers, and grilles shall be installed tight on their respective mounting surfaces, plumb and true with room dimensions and accurately centered on projections, recesses, windows, ceiling grids, light fixtures, or doors. Appropriate frames shall be provided whenever necessary to adapt to the mounting surface. Locate units in center of acoustical ceiling tiles.

3.05 TESTING AND ADJUSTING EQUIPMENT AND CONTROLS:

A. The equipment and controls of this Section shall be completely tested, adjusted, and placed in operating condition.

B. Retest equipment and controls, as necessary, during the progress of the work. No work shall be covered until it is properly tested and made tight.

C. Supply the testing apparatus and make all necessary connections for applying the tests.

D. When about to turn the apparatus over to the Owner, put all parts of the apparatus in perfect working order and thoroughly clean out all parts of the equipment.

3.06 TESTING, ADJUSTING AND BALANCING OF HEATING, VENTILATING AND AIR CONDITIONING SYSTEMS:

A. All equipment installed under this Section shall be carefully adjusted by a qualified Air Balancing Contractor to deliver and exhaust air quantities as shown on the Drawings or described herein. A final balancing report shall be submitted to the Engineer showing the air flow CFMs, fan statics and motor amperages.

B. After the systems have been completely installed, all equipment shall be carefully tested and adjusted. Adjust all dampers, registers, and air diffusers for air flow and make an accurate velometer test of air quantities delivered and removed from each opening. Any readjustments in the motors, drives, units, controls and other equipment found to be necessary in the opinion of the Engineer shall be made without additional cost and the entire system shall be placed in a satisfactory operating condition subject to the approval of the Engineer.

C. Air readings must be taken at each inlet and outlet, and fan speeds and dampers regulated until proper air volumes and diffusion are obtained at each inlet and outlet. Amperage and voltage readings shall be taken and noted, together with the nameplate amperage on the motors.

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SECTION 16010

GENERAL ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Work Included:

1. Provide all required labor, project equipment and materials, tools, construction equipment, safety equipment, transportation, and test equipment, and satisfactorily complete all electrical work shown on the Drawings, included in these Specifications, or required for a complete and fully operating facility. In addition, provide wiring for the equipment that will be provided under other Divisions of these Specifications.
2. Provide conduit, wire and field connections for all motors, motor controllers, control devices, control panels and electrical equipment furnished under other Divisions. Coordinate with the supplier of electrical equipment specified under other Divisions.
3. Provide all conduit, wiring and terminations for all field-mounted instruments furnished and mounted under other Divisions, including process instrumentation primary elements, transmitters, local indicators and control panels. This also includes lightning and surge protection equipment wiring at process instrumentation transmitters if required. Contractor shall install vendor furnished cables specified under other Divisions.
4. Provide a complete raceway system for the specialty cable systems. Install the specialty cable systems in accordance with the system manufacturer's installation instructions. Review of the raceway layout, prior to installation, with the system supplier and cable manufacturer to ensure raceway compatibility with the system and materials being furnished. Where redundant cables are furnished, install them in separate raceways.
5. Provide raceway and power wiring for all heating, ventilation and air conditioning equipment furnished under other related Divisions. Refer to HVAC drawings and related specifications for power requirements.
6. Auxiliary Devices: Provide conduit and wire for power and control for all auxiliary devices such as solenoid valves, pressure switches, and instruments that are included as part of a manufacturer's packaged system (i.e., all systems specified in Divisions 11 through 15. Contractor shall be responsible for conduit and wire to these auxiliary devices even if not specifically shown on the Drawings or specified herein.
7. Provide concrete, excavation, backfill and steel reinforcement required for encasement, installation or construction of the WORK of the various Sections of Division 16 as a part of the WORK under the respective Sections, including duct banks, manholes, handholes, equipment housekeeping pads and light pole bases.

B. Work Specified in Other Divisions:

1. Section 01190: Seismic Requirements
2. Section 11001: General Equipment and Mechanical Requirements – equipment supports and foundations
3. Section 11002: Electric Motor Drives - providing electric motors

4. Division 17: Providing instruments and other process control equipment.

C. Work to be Done by Utilities:
   1. Providing and connecting power company meters and instrument transformers.

D. Safety: Conduct operations in accordance with NFPA 70E, Standard for Electrical Safety Requirements for Employee Workspaces.

1.02 CODE COMPLIANCE AND REFERENCE STANDARDS

A. Electric equipment, materials and installation shall comply with the National Electrical Code (NEC) and with the latest edition of the following codes and standards:
   1. National Electrical Safety Code (NESC)
   2. Occupational Safety and Health Administration (OSHA)
   3. National Fire Protection Association (NFPA)
   4. National Electrical Manufacturers Association (NEMA)
   5. American National Standards Institute (ANSI)
   6. Insulated Cable Engineers Association (ICEA)
   7. Instrument Society of America (ISA)
   8. Underwriters Laboratories (UL)
   9. Factory Mutual (FM)
   10. Institute of Electrical and Electronics Engineers
   11. American Society of Testing Materials (ASTM)
   12. Local Telephone Company requirements
   13. Local Utility Company requirements
   14. California Building Code
   15. California Energy Code
   16. Title 8, Subchapter 5 of the California Administrative Code

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

C. All materials and equipment for which a UL standard exists, shall bear a UL label. No such material or equipment shall be brought onsite without a UL label affixed.

D. If the issue of priority is due to a conflict or discrepancy between the provisions of the Contract Documents and any referenced standard, or code of any technical society, organization or association, the provisions of the Contract Documents will take precedence if they are more stringent or presumptively cause a higher level of performance. If there is any conflict or discrepancy between standard specifications, or codes of any technical society, organization or association, or between Laws and Regulations, the higher performance requirement shall be binding on the Contractor, unless otherwise directed by the Owner/Engineer.

E. In accordance with the intent of the Contract Documents, the Contractor accepts the fact that compliance with the priority order specified shall not justify an increase in Contract Price or an extension in Contract Time nor limit in any way, the Contractor's responsibility to comply with all Laws and Regulations at all times.

1.03 SUBMITTALS

A. Shop Drawings shall be custom prepared for this project and submitted as listed in each of the Electrical Specification Sections. Shop drawings shall include the following:
   1. Complete materials list stating manufacturer, brand name and catalog number of each item or class of material.
   2. Shop drawings for grounding work not specifically indicated on the drawings but required under the NEC.
   3. Front, side and rear elevations along with top views with required dimensional data.
   4. Location of conduit entrances and access plates.
   5. Catalog cuts defining component data.
   6. Connection diagrams, terminal numbers, internal wiring diagrams, conductor size and cable numbers.
   7. Method of anchoring, seismic requirements and weight.
   8. Types of materials and finish.
   9. Nameplates.
   10. Temperature limitations, as applicable.
   11. Voltage requirements, phase and current, as applicable.
   12. Front and rear access requirements.
   13. Test reports.

B. O&M Manuals and other documentation, shall be submitted in accordance with these contract documents. The manuals shall be prepared specifically for this installation and shall include catalog data sheets, drawings, equipment lists, descriptions, parts lists, etc. to instruct operating and maintenance personnel unfamiliar with such equipment. All manuals and other documentation shall be submitted as listed in each of the Electrical Specification Sections and include the following:
   1. A comprehensive index.
   2. A complete "As-built" set of approved shop drawings.
   3. A complete list of the equipment supplied, including serial numbers, ranges and pertinent data.
   4. A table listing of the "as left" settings for all timing relays and alarm and trip set points.
   5. System schematic drawings "As-Built", illustrating all components, piping and electrical connections of the system supplied under this Section.
   6. Detailed service, maintenance and operation instructions for each item supplied.
   7. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures.
   8. The operating instructions shall also incorporate a functional description of the entire system, with references to the systems schematic drawings and instructions.
   9. Complete parts list with stock numbers, including spare parts.

C. Record Drawings shall be promptly furnished when the equipment installation is complete. Payment may be withheld until Record Drawings have been furnished and approved.

D. At the time of delivery of the equipment, the Contractor shall have an approved shop drawing in his possession for the Owner's Inspector and/or Owner's Engineer for verification.

E. As-Built Drawings: As the work progresses, legibly record all field changes on a set of Project Contract Drawings, hereinafter called "As-Built Drawings". The As-Built Drawings and specifications shall be kept up to date throughout the project. As-Built Drawings shall accurately show the installed condition of the following items at a minimum:
   1. One-line Diagram(s).
   2. Raceways and pullboxes.
   3. Conductor sizes and conduit fills.
   4. Panelboard Schedule(s).
   5. Control Wiring Diagram(s).
   6. Luminaire Schedule(s)
   7. Luminaire, receptacle and switch outlet locations.
   8. Underground raceway and duct bank routing including manhole/handhole locations.
   9. Plan view, sizes and locations of switchgear, switchboards, distribution transformers, motor control centers and panelboards.

1.04 TESTS

A. The Contractor shall be responsible for factory and field tests indicated in Division 16, as required by the Engineer and as required by other authorities having jurisdiction.

B. Furnish necessary testing equipment

C. Pay the costs of the tests, including replacement parts and labor due to damage resulting from damaged equipment or from testing and correction of a faulty installation.

D. Reporting
   1. Where test reporting is indicated, submit proof-of-design test reports for mass-produced equipment with the Shop Drawings.
   2. Submit factory performance test reports for custom-manufactured equipment for approval prior to shipment.
   3. Submit field test reports for review prior to Substantial Completion.

E. Remove and replace equipment or material that fails a test, or, if the Engineer approves, repair and retest for compliance.

F. Connections to equipment or materials with a factory warranty shall be as recommended by the manufacturer and shall be performed in a manner that does not void the warranty.

1.05 PERMITS AND INSPECTIONS

A. Obtain permits and pay all fees required for permits inspections.

B. The Engineer may inspect the fabricated equipment at the factory before shipment to job site. Provide the Engineer with sufficient prior notice so that an inspection can be arranged at the factory.

C. Inspection of the equipment at the factory by the Engineer will be made after the manufacturer has performed satisfactory checks, adjustments, tests and operations.

D. Favorable review of the equipment at the factory only allows the manufacturer to ship the equipment to the project site. The Contractor shall be responsible for the proper installation and satisfactory startup operation of the equipment to the satisfaction of the manufacturer and the Engineer.

1.06 COORDINATION

A. Coordinate the electrical work with the other trades, code authorities, utilities, and the Owner.

B. Where connections must be made to existing installations, properly schedule all the required work with the Owner, including the power shutdown periods. Schedule and carry out shutdowns so as to cause the least disruption to operation of the plant and privately owned facilities.

C. Submit a written sequencing request indicating the sequence and duration of activities to be performed during the plant shutdown.

D. Switching, safety tagging and other project related tasks required for shutdown or to isolate existing equipment, shall be performed by the Contractor.

E. In no case shall the Contractor begin any work in, on or adjacent to existing equipment without written authorization from the Engineer.

F. Existing Utilities
   1. Exercise extreme caution when digging trenches to not damage existing underground utilities.
   2. The cost of repairs of damages caused during construction shall be included as a part of the Work.

G. Field Verifications
   1. Visit the site before submitting a Bid to become better acquainted with the Work of this Contract.
   2. The lack of knowledge will not be accepted as justification for extra compensation to perform the Work.
   3. The cost for the above field verifications shall be included as part of the Work.

1.07 ELECTRICAL SERVICES

A. Contact the serving utility and verify compliance with requirements before construction.

B. Coordinate schedules and payments for Work by utilities.

C. Where conduits and conductors in the Work are indicated to be larger, heavier schedule, or have greater protective coating than utility requirements, provide the larger size, heavier schedule or greater protection.

D. Provide electrical service as indicated and as required by the serving utility.

E. Verify and provide service conduits, fittings, transformer pad, grounding devices and service wires not provided by the serving utility.

F. Verify with the utility the exact location of each service point and type of service, and pay charges levied by the serving utilities as part of the Work.

1.08 LOCATIONS

A. General: Use equipment, materials and wiring methods suitable for the types of locations in which they are located, as defined in Paragraph B. herein.

B. Definitions of Types of Locations:
   1. Dry Locations: All those indoor areas which do not fall within the definitions below for Wet, Damp, Hazardous, or Corrosive Locations and which are not otherwise designated on the Drawings.
   2. Wet Locations: All locations exposed to the weather, whether under a roof or not, unless otherwise designated on the Drawings.
   3. Damp Locations: All spaces wholly or partially underground, or having a wall or ceiling forming part of a channel or tank, unless otherwise designated on the Drawings.
   4. Hazardous Locations: All areas in which fire or explosion hazards may exist, normally or accidentally, due to flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flyings. These areas are shown on the Drawings, together with the Class and Division designations as defined in the NEC, determining the enclosure types and wiring methods required.
   5. Corrosive Locations: Areas where chlorine or sulfur dioxide gas under pressure, sulfuric acid, or liquid polymer are stored or processed. These areas are shown on the Drawings.

C. Unless otherwise specified herein or shown on the Drawings, electrical enclosures and associated installations shall have the following ratings:
   1. NEMA 1 gasketed or 12 for dry, non-process indoor above grade locations
   2. NEMA 3R for outdoor installations identified not to be hazardous or corrosive.
   3. NEMA 4X enclosures of Type 304 or 316 stainless steel in corrosive areas except in chlorine and HFS areas where non-metallic enclosures shall be provided.
   4. NEMA 6 or 6P enclosures for submersible, indoor or outdoor use. Enclosures for temporary submersion shall be rated NEMA 6 and prolonged submersion shall be rated 6P at limited depth.
   5. NEMA 7 enclosures (and listed for use in the area classifications shown) for "Class 1 Div. 1 Group D" and "Class 1 Div. 2 Group D" hazardous locations shown on the Drawings or as defined in NFPA 820 or other codes.
   6. NEMA 9 enclosures (and listed for use in the area classifications shown) for "Class 1 Div. 1 Group E, F and G" and "Class 1 Div. 2 Group E, F and G" hazardous locations shown on the Drawings or as defined in NFPA 820 or other codes.

D. Equipment, materials and installation in areas designated as hazardous on the Drawings shall comply with NEC Articles 500, 501, 502 and 503.

E. Equipment and materials installed in areas designated as hazardous on the Drawings shall be UL Listed for the appropriate hazardous area classification.

1.09 PHASE BALANCING

A. The Drawings do not attempt to balance the electrical loads across the phases. Circuits on motor control centers and panelboards shall be field connected to result in evenly distributed loads across all three phases.

B. Field balancing of circuits shall not alter the conductor color coding requirements defined in Section 16120.

1.10 SIZE OF EQUIPMENT

A. Investigate each space in the structure through which equipment must pass to reach its final location. Coordinate shipping splits with the manufacturer to permit safe handling and passage through restricted areas in the structure.

B. The equipment shall be kept upright at all times during storage and handling. When equipment must be tilted for passage through restricted areas, brace the equipment to ensure the tilting does not impair the functional integrity of the equipment.

PART 2 - PRODUCTS

2.01 GENERAL

A. Products that are specified by manufacturer, trade name or catalog number establish a standard of quality and do not prohibit the use of equal products of other manufacturers provided they are favorably reviewed by the Engineer prior to installation.

B. It is the intent of these Specifications and Drawings to secure high quality in all materials and equipment in order to facilitate operation and maintenance of the facility. All equipment and materials shall be new and the products of reputable suppliers having adequate experience in the manufacture of these particular items. For uniformity, only one manufacturer will be accepted for each type of product. All equipment shall be designed for the service intended and shall be of rugged construction, of ample strength for all stresses, which may occur during fabrication, transportation, erection, and continuous or intermittent operation. All equipment shall be adequately stayed, braced and anchored and shall be installed in a neat and workmanlike manner. Appearance and safety, as well as utility, shall be given consideration in the design of details.

C. All components and devices installed shall be standard items of industrial grade, unless otherwise noted, and shall be of sturdy and durable construction suitable for long, trouble-free service. Light-duty, fragile and competitive grade devices of doubtful durability shall not be used.

D. Where a NEMA enclosure type is indicated in a non-hazardous location, use that type of enclosure despite the fact that certain modifications such as cutouts for control devices may negate the NEMA rating.

E. Temperature Ratings of Equipment Terminations and lugs shall be rated for use with 75-degree C conductors. Wire sizes in the Contract Documents are based on NEC ampacity tables using the 75-degree C ratings.

2.02 MOUNTING HARDWARE

A. Miscellaneous Hardware
   1. Provide nuts, bolts and washers constructed of stainless steel.
   2. Provide threaded rods for trapeze supports constructed from continuous threaded galvanized steel, 3/8-inch diameter minimum.
   3. Struts
      a. Construct struts for mounting of conduits and equipment of stainless steel.
      b. Where contact with concrete or dissimilar metals may cause galvanic corrosion, use suitable non-metallic insulators in order to prevent such corrosion.
      c. Strut manufacturer shall be Unistrut, B-Line or approved equal.
   4. Provide plastic protective end caps for all exposed strut ends. End caps shall be manufactured by Unistrut P2860-33 or approved equal
   5. Provide stainless steel expansion anchors for attaching equipment to concrete walls, floors and ceilings. Expansion anchors shall be manufactured by Power Fasteners, Inc and be the "Power-Bolt" or "Power-Stud" series or approved equal.

2.03 LENS COLOR SCHEME

A. Indicating light lens colors shall be red for “Run”, “Open” or “On”; green for “Stop”, “Close” or “Off”; and amber for alarm.

2.04 NAMEPLATES

A. For each piece of electrical equipment, provide a manufacturer's nameplate showing his name, location, the pertinent ratings and the model designation.

B. Identify each piece of equipment and related controls with a rigid laminated engraved phenolic nameplate. Engrave nameplates with the inscriptions indicated on the Drawings and, if not so indicated, with the equipment name. Securely fasten nameplates in place using fasteners constructed of brass, cadmium plated steel or stainless steel and screwed into inserts or tapped holes as required. Where no inscription is indicated on the Drawings, furnish nameplates with an appropriate inscription furnished by the Engineer upon prior request by the Contractor.

C. Provide engraved characters of the block style, with no characters smaller than 1/8 inch top to bottom.

D. Each control device, including pushbuttons, control switches, and indicating lights, shall have an integral legend plate or nameplate indicating the device function. These shall be inscribed as indicated on the Drawings or as favorably reviewed by the Engineer.

E. At the service entrance equipment, provide a sign inscribed with 1/4 inch letters: "EMERGENCY STANDBY POWER IS SUPPLIED FROM THE GENERATOR ROOM".

2.05 PROTECTIVE MATTING

A. Provide full-length, high-voltage switchboard matting in front of indoor switchgear, service equipment and motor control centers.

B. For equipment rated at 600-volt, provide matting that is ¼-inch thick and 42" wide.

C. Protective matting shall be as manufactured by Rhino or approved equal

2.06 PAINTING

A. Equipment: Refer to each electrical equipment section of these Specifications for painting requirements of equipment enclosures. Repair any final paint finish, which has been damaged or is otherwise unsatisfactory, to the satisfaction of the Engineer.

B. Wiring System: Paint all exposed conduits, boxes and fittings to match the color of the surface to which they are affixed. Paint finishes shall include proper surface preparation, prime coat and a final finish coat, and shall conform to Section 09960.

PART 3 - EXECUTION

3.01 REQUIREMENTS

A. All electrical installations shall conform to the codes and standards outlined in this Section.

3.02 WORKMANSHIP

A. Assign a qualified representative who shall supervise the electrical construction work from beginning to completion and final acceptance.

B. Perform all labor using qualified craftsmen, who have had experience on similar projects. Provide first-class workmanship for all installations.

C. Ensure that all equipment and materials fit properly in their installations.

D. Perform any required work to correct improperly fit installations at no additional expense to the Owner.

E. Provide materials and incidental required for a complete and operable system, even if not required explicitly by the Contract Documents.

F. Typical incidentals are terminal lugs not furnished with vendor-supplied equipment, compression connectors for cables, splices, junction and terminal boxes, and control wiring required by vendor-furnished equipment to connect with other equipment indicated in the Contract Documents.

3.03 EXCAVATION AND BACKFILL

A. Provide the excavations for electrical equipment foundations and trenches for conduits as shown on the Drawings.

B. Exercise caution during all excavation work and avoid damage to existing underground pipes. Exercise extreme caution when working near existing electrical conduits and facilities. Field verify the location of all electrical facilities before proceeding with any nearby work.

C. Refer to Division 2, Earthwork, of these Specifications for all excavation and backfilling work.

3.04 CONCRETE

A. Where shown on the Drawings or specified, provide the required concrete installations for conduit encasement and equipment foundations.

B. Refer to Division 3, Concrete, of these Specifications for all concrete work.

3.05 CONDUCTOR IDENTIFICATION

A. Identify all wires and cables in conformance with the requirements of Sections 16120 and 16124. This requirement applies to all equipment provided under this contract, regardless of Division, as well as to all conductors provided or worked on during this contract.

3.06 CONCRETE HOUSEKEEPING PADS

A. Provide concrete housekeeping pads for indoor floor-standing electrical equipment.

B. Install all floor-mounted equipment on 4-inch-high reinforced concrete pads. The Contractor, suppliers, and fabricators shall take this requirement into consideration when designing, fabricating, and installing panels, motor control centers, and other enclosures so that height above the floor of the operating handles of electrical devices meets the requirements of these Specifications and applicable codes.

C. Provide concrete housekeeping curbs 3-inches above the finished floor or grade for conduit stub-ups in indoor locations that are not concealed by equipment enclosures.

3.07 CUTTING, DRILLING, AND WELDING

A. Provide any cutting, drilling, and welding that is required for the electrical construction work.

B. Structural members shall not be cut or drilled, except when favorably reviewed by the Engineer. Use a core drill wherever it is necessary to drill through concrete or masonry.

C. Provide the required welding for equipment supports. Conduits and fittings shall not be welded to structural steel.

D. Perform patch work with the same materials as the surrounding area and finish to match, as specified in Division 3 of these Specifications.

3.08 METAL PANELS

A. Mount all metal panels which are mounted on or abutting concrete walls in damp locations or any outside walls 1/4 inch from the wall, and paint the back sides of the panels with a high build epoxy primer. Film thickness shall be 10 mils minimum.

3.09 PROTECTIVE DEVICE COORDINATION

A. Provide the services of a recognized independent testing laboratory or coordination analysis consultant for the proper system coordination of the protective devices furnished on this project. Submit the name and the qualifications of the laboratory or consultant for review by the Engineer; qualifications must include professional registration of proposed personnel as electrical engineers.

B. The protective device on the line side closest to the fault or abnormal conditions shall isolate the problem portion of the system and minimize damage in that portion. The rest of the system shall be maintained in normal service. The coordination shall be in conformance with the recommendations of latest IEEE Standard 242.

C. Submit the analysis that shall include impedance and short circuit calculations, list of any assumptions made in the analysis, the recommended settings of the protective devices, and the system time/current characteristic curves. The submittal shall be made so as to allow time for review and resubmittal, if necessary, before the implementation of final settings and adjustments by the testing laboratory.

3.10 FIELD TESTS

A. Perform tests in accordance with applicable procedures as described in NETA Acceptance Testing Specifications.

B. Give 2-week notice to the Owner/Engineer prior to any test to permit witnessing the test.

C. Provide the services of a recognized independent testing laboratory and pay all costs of performing the inspections and tests as specified herein.

D. The testing laboratory shall provide all materials, equipment, labor and technical supervision to perform such tests and inspections. It is the intent of these tests to ensure that all electrical equipment is operational within industry and manufacturer's tolerances and is installed in accordance with the Contract Documents and manufacturer's instructions. The tests and inspections shall determine the suitability for energization.

E. The testing laboratory shall meet federal OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907. Membership in the International Electrical Testing Association (NETA) constitutes proof of meeting such criteria. The testing laboratory shall submit proof of these qualifications to the Engineer for review. Testing laboratory shall be Electrical Testing and Controls, Electro-Test, Power Systems, or approved equal.

F. The testing laboratory shall have a calibration program, which maintains all applicable test instrumentation within, rated accuracy. The accuracy shall be traceable to the National Bureau of Standards in an unbroken chain. Instruments shall be calibrated in accordance with the following frequency schedule:
   1. Field instruments: 6 months maximum
   2. Laboratory instruments: 12 months
   3. Leased specialty equipment: 12 months
      Date calibration labels shall be visible on all test equipment.

G. Where testing pursuant to NETA requirements is required in these specifications, submit a test report which includes the following:
   1. Name of project, name of person performing test, and date of test
   2. Description of equipment tested
   3. Description of test
   4. List of test equipment used and calibration date
   5. Test results
   6. Conclusions and recommendations

7. Appendix, including appropriate test forms
   The test report shall be bound and its contents certified. Submit the completed report directly to the Engineer no later than thirty (30) days after completion of the test unless directed otherwise. Number of reports to be submitted for review shall be the same as the number required for shop drawing submittals.

H. Safety practices shall include, but are not limited to, the following requirements:
   1. Occupational Safety and Health Act of 1970, OSHA.
   2. Accident Prevention Manual for Industrial Operations, Seventh Edition, National Safety Council, Chapter 4.
   3. Applicable state and local safety operating procedures.

I. All field tests shall be performed with apparatus de-energized except where otherwise specifically required by Section 7 of the latest Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems published by NETA. The testing laboratory shall have a designated safety representative who shall be present on the project and supervise operations with respect to safety. Circuits operating in excess of 600 volts between conductors shall have conductors shorted to ground by a hot-line grounded device approved for the purpose. In all cases, work shall not proceed until the safety representative has determined that it is safe to do so. The testing laboratory shall have available sufficient protective barriers and warning signs to conduct specified test safely.

J. Electrical equipment and materials furnished and installed by the Contractor, and the testing equipment listed below shall be tested in accordance with the "Inspection and Test Procedures" and "System Function Tests" (Section 7) of the latest Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems published by NETA. Tests shall not include any tests listed as optional in the aforementioned NETA Specifications unless specifically noted in respective equipment specifications for this project.

K. Retesting will be required for all unsatisfactory tests after the equipment or system has been repaired. Retest all related equipment and systems if required by the Engineer. Repair and retest equipment and systems, which have been satisfactorily tested but later, fail, until satisfactory performance is obtained.

L. Putting Equipment and Cables into Service: Submittal and favorable review of the specified factory and field tests shall occur before the Contractor is permitted to place the respective equipment or cable into service.

M. Miscellaneous Tests
   1. Insulation Resistance, Continuity, Rotation: Perform routine insulation resistance, continuity and rotation tests for all distribution and utilization equipment including all motors 1/2 horsepower and larger prior and in addition to tests performed by the testing laboratory specified herein. Supply a suitable and stable source of test power to the test laboratory at each test site. The testing laboratory shall specify requirements. Notify the testing laboratory when equipment becomes available for acceptance tests. Work shall be coordinated to expedite project scheduling. All testing shall be performed in the presence of the Engineer. The testing laboratory shall be responsible for implementing all final settings and adjustments on protective devices and tap changes. Any system material or workmanship that is found defective on the basis of acceptance tests shall be reported directly to the

Engineer. The testing laboratory shall maintain a written record of all tests and upon completion of project, assemble and certify a final test report.

2. Motor Current: Measure and record current in each phase for each new motor. Include measurement of the motor terminal voltages and motor currents when the motor is being operated at normal operating loads. For motors that are part of variable frequency drive systems, use true-RMS-reading instruments in making the measurements.
3. Operational Tests: Operationally test all circuits to demonstrate that the circuits and equipment have been properly installed, adjusted and are ready for full-time service. Demonstrate the proper functioning of circuits in all modes of operation, including alarm conditions, and demonstrate satisfactory interfacing with the data acquisition and alarm systems.

3.11 EQUIPMENT PROTECTION

A. Exercise care at all times after installation of equipment, motor control centers, etc., to keep out foreign matter, dust, dirt, debris, or moisture. Use protective sheet-metal covers, canvas, heat lamps, etc., as needed to ensure equipment protection.

3.12 CLEANING EQUIPMENT

A. Before final acceptance, thoroughly clean the electrical Work of cement, plaster and other materials.

B. Clean out and vacuum all construction debris from the bottom of all equipment.

C. Provide and touch-up to original condition any factory painting that has been marred or scratched during shipment or installation, using paint furnished by the equipment manufacturer.

D. Remove temporary tags, markers, stickers and the like.

E. Remove all oil and grease spots with a non-flammable cleaning solvent by carefully wiping and scraping cracks and corners.

F. Clean luminaires inside and out.

G. Dispose of cleaning debris and refuse off-site.

END OF SECTION

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SECTION 16110

ELECTRICAL RACEWAY SYSTEMS

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Furnish and install complete raceway systems as shown on the drawings and as specified herein.

B. Raceways and conductors that are listed on the conduit and cable schedules are generally not shown on the Drawings, except where they are required to pass through a restricted or designated space and the Contractor would benefit from additional information. Conduit block diagrams indicate exposed conduits as solid lines and shall be run near the ceilings or along walls of the areas through which they pass and shall be routed to avoid interferences with HVAC ducts, cranes and hoists, lighting fixtures, doors and hatches, etc. Conduit block diagrams indicate concealed or buried conduits as dashed lines and shall be run in underground duct banks, center of concrete floor slabs, in partitions, or above hung ceilings as required.

C. In the event that individual equipment loads provided are larger than indicated in the Contract Documents, revise raceways, conductors, starters, overload elements, and branch circuit protectors as necessary in order to control and protect the increased connected load in conformance to NEC requirements as part of the WORK.

1.02 REFERENCE STANDARDS

A. American National Standards Institute (ANSI) Publications:
1. C80.1 Specification for Zinc Coated Rigid Steel Conduit
2. C80.5 Specifications for Rigid Aluminum Conduit

B. Federal Specifications (FS):
1. FS W C 1094 W C 1094A Conduit and Conduit Fittings, Plastic, Rigid
2. FS WW C 540 WW C 540A Conduit, Metal, Rigid, (Electrical, Aluminum)
3. WW C 540C Conduit, Metal, Rigid & Coupling, Elbow & Nipple, Electrical Conduit, Aluminum
4. FS WW C 566 WW C 566C Flexible Metal Conduit

C. National Electrical Manufacturers Association (NEMA) Publications:
1. RN 1 Polyvinyl Chloride Externally Coated Galvanized Rigid Steel Conduit and Electrical Metallic Tubing
2. TC2 Electrical Polyvinyl Chloride (PVC) Conduit
3. TC 6 PVC and ABS Plastic Utilities Duct for Underground Installation
4. TC14 Reinforced Thermosetting Resin Conduit (RTRC) and Fittings

D. Underwriters Laboratories (UL) Standards:
1. 6 Rigid Metal Electrical Conduit
2. 6A Electrical Rigid Metal Conduit – Aluminum, Red Brass and Stainless Steel
3. 360 Liquid-Tight Flexible Metal Conduit
4. 651 Electrical Rigid Nonmetallic Conduit and Fittings

5. 651A Type EB and A Rigid PVC Conduit and HDPE Conduit
6. 2515 Aboveground Reinforced Thermosetting Resin Conduit

1.03 SUBMITTALS

A. Submit complete catalog cuts of raceways, fittings, boxes, supports, and mounting hardware, marked where applicable to show proposed materials and finishes.

B. Prepare as-built drawings of encased concealed and exposed raceways, ducts, raceways, junction boxes, pull boxes, and electrical and instrumentation equipment.

1.04 LOCATIONS

A. Refer to Section 16010 for definitions of types of locations.

PART 2 - PRODUCTS

2.01 GENERAL

A. Pull and junction boxes, fittings and other indicated enclosures that are dedicated to the raceway system shall comply with the requirements of this Section.

B. Provide exposed conduit of 3/4-inch minimum trade size and encased conduit of 1-inch minimum trade size.

C. The use of short sections of 1/2-inch flexible conduit for final termination of field control devices and instrumentation is permitted. They may not be longer than 36 inches in length, and may only transition to the smaller size junction boxes or condulets at the field device.

2.02 CONDUIT, RACEWAYS

A. Galvanized Rigid Steel Conduit (GRS) shall be manufactured from mild steel, hot-dip galvanized inside and out, conforming to ANSI C80.1 and UL 6. Couplings shall be threaded type. Manufacturers shall be Allied Tube and Conduit, Wheatland Tube or approved equal.

B. PVC coated rigid steel conduit (PGRS) shall meet the requirements of GRS above. A PVC coating shall be bonded to the outer surface with a thickness not less than 40 mils. The inside surfaces and threads of the conduit shall be provided with a 2-mil urethane coating. PGRS shall be manufactured in accordance with UL-6, ANSO C80.1 and NEMA RN1. Manufacturers shall be Robroy Industries Perma-Cote or Plasti-Bond series, Thomas & Betts Ocal Blue or approved equal.

C. Liquidtight Flexible Conduit shall be constructed of a flexible galvanized metal core with a sunlight-resistant thermoplastic outer jacket. Conduit shall be manufactured• in accordance with UL 360. Flexible conduit in hazardous areas shall be rated for the Class, Division and Group in which its installed. Manufacturers shall be Anaconda Sealtite, Electriflex Liquatite or approved equal.

D. Rigid Nonmetallic Conduit: Rigid nonmetallic conduit shall be PVC Schedule 40 (PVC 40) or PVC Schedule 80 (PVC 80) and sunlight resistant. Conduit shall be approved for underground use and for use with 90°C wires, and shall conform to NEMA TC-2 and UL 651. Manufacturers shall be Carlon, Cantex or approved equal.

2.03 CONDUIT SUPPORTS

A. For indoor, dry locations, supports for individual conduits shall be galvanized malleable iron one-hole type with conduit back spacer. All other locations shall be Type 316 stainless steel.

B. For indoor, dry locations, supports for multiple conduits shall be hot-dip galvanized Unistrut or Superstrut channels, or equal. All associated hardware shall be hot-dip galvanized. All other locations shall be Type 316 stainless steel.

C. All channels, strut, threaded rods, nuts and clamps in corrosive areas shall be of epoxy resin reinforced fiberglass material. Provide Robroy, Superstrut, or equal.

2.04 FITTINGS

A. General
   1. For use with metallic conduit, provide cast and malleable iron fittings of the threaded type with 5 full threads.
   2. Fittings
      a. Provide fittings with neoprene gaskets and non-magnetic stainless steel screws.
      b. Attach covers by means of holes tapped into the body of the fittings.
      c. Covers for fittings attached by means of clips or clamps will not be accepted.
   3. Terminations
      a. In outdoor areas, terminate conduit in rain-tight hubs as manufactured by Myers, O.Z. Gedney, Appleton or approved equal.
      b. In other than outdoor areas, provide sealed locknuts and bushings.

B. Fittings for use with rigid steel shall be hot dipped galvanized steel or galvanized cast ferrous metal; access fittings shall have gasketed cast covers and be Crouse-Hinds Condulets, Appleton Unilets, or equal. Provide threaded-type couplings and connectors; set-screw type and compression-type are not acceptable.

C. Fittings for use with PVC-coated GRS conduit shall be PVC-coated that are the products of the same manufacturer as the conduit. Both male and female threads and internal surfaces shall contain a 2-mil urethane coating.

D. Fittings for use with rigid nonmetallic conduit shall be PVC and have solvent-weld-type conduit connections. Boxes shall be manufactured of PVC or fiberglass reinforced polyester (FRP). Manufactures shall be Carlon, Crouse-Hinds, Hoffman or approved equal. If such are not available, then the Specification for PVC coated galvanized rigid steel fittings shall apply.

E. Fittings for flexible conduit shall be Appleton Type ST, O.Z. Gedney Series 4Q, or approved equal.

F. Combination expansion-deflection fittings with internal grounding shall be installed where conduit movement is expected in more than one dimension, and where conduits transition out of structures in locations where differential settlement may occur. Combination expansion/deflection fittings shall be manufactured by Crouse-Hinds Type XJGD or approved equal.

G. Expansion fittings with internal grounding shall be installed wherever exposed raceway cross building expansion joints. Expansion fittings shall be Crouse Hinds Type XLGSA or approved equal.

H. Union couplings for conduits shall be the Erickson type and shall be Appleton Type EC, O.Z. Gedney 3-piece Series 4, or approved equal. Threadless couplings shall not be used.

I. Bushings:
   1. Bushings shall be the insulated type.
   2. Bushings for rigid steel conduit shall be hot dip galvanized insulated grounding type, O.Z. Gedney Type HBLG, Appleton Type GIB, or approved equal.

J. Conduit seals in hazardous areas shall have zinc electroplate and shall be Crouse-Hinds Type EYS or EZS; Appleton Type EYS, ESU, or EY series; or approved equal.

K. Conduit seals in areas where chlorine, ammonia, sulfur dioxide and/or hydrofluosilicic areas shall be Link Seal or approved equal.

2.05 BOXES

A. Boxes specified herein are for use with raceway systems only. Boxes used for housing electrical and instrumentation equipment shall be as described elsewhere in these Specifications.

B. NEMA 1 Areas: NEMA 1 terminal boxes, junction boxes, pull boxes, etc. shall be either sheet or cast malleable iron or aluminum depending on raceway material. Boxes shall be suitable for wall mounting or have feet where self-standing. Boxes shall have continuously welded seams and welds shall be ground smooth. Box bodies shall be flanged and shall not have holes or knockouts. Box bodies shall not be less than 14 gauge metal and covers shall not be less than 12 gauge metal. All boxes shall have hinged gasketed doors with quarter turn latches or 3-point latch (single operator) system on enclosures larger than 36 inches wide or 32 inches tall. Terminal boxes shall be furnished with terminal mounting straps and brackets. Terminal blocks shall be NEMA type, not less than 20A, 600V. Boxes shall be Concept Series as manufactured by Hoffman Engineering Co. or approved equal.

C. NEMA 4X Areas: NEMA 4X terminal boxes, junction boxes, pull boxes, etc. shall be Type 304 stainless steel. Boxes shall be suitable for wall mounting or have feet where self-standing. Boxes shall have continuously welded seams and welds shall be ground smooth. Box bodies shall be flanged and shall not have holes or knockouts. Box bodies shall not be less than 14 gauge metal and covers shall not be less than 12 gauge metal. All boxes shall have hinged gasketed doors with quarter turn latches or 3-point latch (single operator) system on enclosures larger than 36 inches wide or 32 inches tall. Terminal boxes shall be furnished with terminal mounting straps and brackets. Terminal blocks shall be NEMA type, not less than 20A, 600V. Boxes shall be Concept Series as manufactured by Hoffman Engineering Co. or approved equal.

D. NEMA 7 Areas: Explosion-proof boxes shall be designed for the Class, Division and Group with which it is to be installed. Boxes shall have O-ring seals to meet NEM 4 requirements. Boxes shall be aluminum, with stainless steel hinged covers and stainless steel bolts. Boxes shall be as manufactured by Crouse Hinds Type EJB-N4, Appleton Electric, Adalet PLM or approved equal.

E. Boxes for use in chemically corrosive areas shall be of rigid PVC. Construction shall be the same as specified for NEMA 4X areas as specified above.

2.06 WIREWAYS AND AUXILIARY GUTTERS

A. General: Wireways shall consist of a prefabricated channel-shaped trough with hinged or removable covers, associated fittings, and supports. Straight sections shall not be longer than 5 feet. Separate power, control, signal and communications cables by grounded metallic dividers in wireways or run in separate wireways. Cross-sectional dimensions shall be as indicated on the Drawings. Fittings shall consist of elbows, tees, crosses, and closing plates as required.

B. Interior Locations: All components shall be constructed from sheet steel not less than 14 gauge and coated with a corrosion-resistant gray paint. Covers shall be held closed with hinges and clamps.

C. Exterior Locations: Wireway and associated fittings shall be NEMA rated for the area in which it is to be installed. Wireways shall be supplied with gasketed closing end plates and gasketed hinged covers.

D. Corrosive Locations: In corrosive locations provide enclosure type boxes for use as wireways. Enclosures and associated fittings shall meet NEMA 4X classifications and shall be manufactured from reinforced injection molded fiberglass or formed and welded stainless steel and shall have gasketed closing plates and hinged and gasketed covers with spring loaded latches.

E. Ground the steel and aluminum wireway bodies. Provide steel dividers with steel wireways or aluminum dividers with aluminum wireways, and ground by means of an individual grounding conductor.

F. Terminate conduits in all wet and damp locations with rain-tight hubs as manufactured by O.Z. Gedney, Myers or approved equal. In finished areas, provide sealed locknuts and bushings.

2.07 CONDUIT SEALANTS

A. Moisture Barrier Types: Sealant shall be a non-toxic, non-shrink, non-hardening, putty type hand applied material providing an effective barrier under submerged conditions.

B. Fire Retardant Types: Fire stop material shall be a reusable, non-toxic, asbestos-free, expanding, putty type material with a 3 hour rating in accordance with UL 1479. Provide products indicated by the manufacturer to be suitable for the type and size of penetration.

PART 3 - EXECUTION

3.01 CONDUIT, RACEWAY AND FITTING INSTALLATION

A. No wire shall be pulled until the raceway system is complete in all details; in the case of concealed work, until all rough plastering or masonry has been completed; in the case of exposed work, until the raceway system has been completed in every detail.

B. From pull point to pull point, the sum of the angles of all of the bends and offsets shall not exceed 270 degrees.

C. Coat threads with a conductive lubricant before assembly.

D. Provide joints that are tight, thoroughly grounded, secure and free of obstructions by use of a mandrel. Adequately ream the conduit in order to prevent damage to the wires and cables inside. Use strap wrenches and vises to install the conduit in order to prevent wrench marks on the conduit. Any conduit with wrench marks shall be replaced.

E. The ends of all conduits shall be tightly plugged to exclude dust and moisture during construction. Duxseal, or 3M seal spray shall be used in all applications. Plugging with tape is prohibited, even for short periods of time.

F. For power, control and signal circuits, provide conduit per Conduit Use Tables below, unless specifically indicated otherwise on the Drawings:
   1. Exception: For raceways leaving a building above grade and then going below grade, provide PVC-coated GRS from a point 3 feet above grade to a point 5 feet from the building wall.

G. Unless boxes have cast, threaded hubs, provide insulated type metallic grounding bushings for metallic conduits at all boxes. Bond together all conduits to provide continuity of the equipment grounding system. Size bonding conductor per NEC.

H. Provide flexible conduit in lengths of not more than 36 inches at connections to motors, valves and any equipment subject to vibration or relative movement. All flexible conduits, regardless of length or manufacturer rating, shall have a dedicated ground bonding conductor pulled through, whether it is included in the conduit fill schedules or not.

I. Conduits embedded in concrete floors on grade shall be installed between grids of reinforcing steel, or shall be encased below the floors, provided the concrete is thickened in a manner satisfactory to the Engineer. Installation of conduit below the bottom of this slab is not acceptable; embedding or encasing is required.

J. Damage to PVC coating of coated conduits or fittings shall be repaired with factory-approved PVC patching material to the original factory condition.

K. Underground Raceways: Slope all underground raceways to provide drainage; for example, slope conduit from equipment located inside a building to the handhole located outside the building. For additional requirements see Section 16402.

L. Conduit Supports: Properly support all conduits as required by the NEC. Run all conduits exposed except where the Drawings indicate that they are to be embedded in the floor slab, walls, or ceiling, or to be installed underground.
   1. Exposed Conduits:
      a. Support exposed conduits within 1 foot of any outlet and at intervals not exceeding NEC requirements; wherever possible, group conduits together and support on common supports. Support exposed conduits fastened to the surface of the concrete structure by one-hole clamps, or with channels. Use conduit spacers with one-hole clamps. Coordinate conduit locations with piping, equipment, fixtures, and with structural and architectural elements. Conduits attached to walls or columns shall be as unobtrusive as possible and shall avoid windows. Run all exposed conduits parallel to building lines. No diagonal runs will be accepted. Bends in parallel runs shall be concentric and shall be run straight and true.
      b. Group together exposed conduits in horizontal runs located away from walls and support on trapeze hangers. Arrange such conduits uniformly and neatly. Trapeze hangers shall consist of channels of adequate size,

suspended by means of minimum 3/8” diameter rods or other suitable means from the ceiling or from pipe hangers. Install such runs so as not to interfere with the operation of valves or any other equipment, and keep at least 6 inches clear of any pipe which may operate at more than 100°F. Treat cut surfaces or damaged ends with corrosion-resistant coatings such as "Devcon Z", prepared by Subox Coatings; "Galvanox Type I", prepared by Pedley-Knowles; or approved equal. Application shall follow manufacturer's recommendation.

M. All penetrations through walls into or out of corrosive locations, as defined in Section 16010 shall be made gas-tight. In concrete walls, pour concrete after the conduit is in place, if possible. If not, core drill concrete or CMU walls, install conduit and caulk around it with non-shrink grout. Install conduit seal in each conduit near the penetration.

N. All conduit penetrations through interior walls and floors shall be sealed with fire retardant type conduit sealant.

O. Conduit Identification: In each handhole, pullbox, cabinet, motor control center or other equipment enclosure, identify each conduit using the conduit number shown on the Drawings by means of a stamped brass tag affixed with stainless steel wire; where affixing a tag is not feasible, identify conduits by affixing a brass tag with epoxy or other approved method of stenciling to the wall or structure adjacent to the conduit terminus.

P. Conduit Seals:
   1. Moisture Seals: Provide in accordance with NEC Paragraph 300.5(g).
   2. Gas Seals: Provide in accordance with NEC Paragraph 501.5.

Q. Rigid PVC conduit shall be stored on a flat surface and shielded from the sun.

CONDUIT USE TABLE 1

	Inside Buildings						
	Exposed			**Concealed**			
Circuit Type	Standard	Corrosive	Hazardous	Above Suspended Ceilings	In Stud Walls	Embedded In Concrete	Slab On Grade
Power & 120 Vac Control	GRS	PVC Coated GRS	PVC Coated GRS	PVC-80 or GRS	GRS	PVC-40 or PVC-80	PVC-40 or PVC-80
Signal	GRS	PVC Coated GRS	PVC Coated GRS	GRS	GRS	GRS	GRS

CONDUIT USE TABLE 2

	Outside Buildings			**Transition**
Circuit Type	Exposed	Buried In Soil	Duct Bank Encased In Concrete	Within 5 Feet of Building
Power & 120 Vac Control	PVC Coated GRS	PVC Coated GRS	PVC-40	PVC Coated GRS
Signal	PVC Coated GRS	PVC Coated GRS	GRS	PVC Coated GRS

* Provide ground wire sized per NEC requirements for all circuits.

** Aluminum and/or Fiberglass may be used in corrosive locations where environmental conditions warrant its use.

Notes:
1. Generally, the Conduit Use Tables apply.
2. Signal circuits are those subject to RF interference or induced current. MSPs, TSPs, telephone cable, coaxial cable, and manufacturer's cables specially designed for low level signals are all presumed to be part of signal circuits.
3. Provide fiberglass conduit where indicated on the Drawings.

3.02 WIREWAY INSTALLATION

A. Straight sections and fittings shall be solidly bolted together to be mechanically rigid and electrically continuous. Dead ends shall be closed. Unused conduit openings shall be plugged.

B. Wireways shall be supported every 5 feet.

C. Wireways and auxiliary gutters shall not contain wiring or control devices and shall not extend over 30 feet in length.

END OF SECTION

SECTION 16120

LOW VOLTAGE WIRE AND CABLE

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Furnish labor, materials, equipment and incidentals necessary to install wire and cable specified under this Section. Electrical work shall be in accordance with Specification 16010 – General Electrical Requirements.

B. Work shall include building wire, cable, wiring connections and terminations and modular wiring systems.

1.02 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM):
   1. B3-74 Specification for Soft or Annealed Copper Wire
   2. B8-77 Specification for Concentric Lay Stranded Copper Conductors, Hard, Medium-Hard, or Soft
   3. B173-71 Specification for Rope Lay Stranded Copper Conductors Having Concentric Stranded Members

B. Insulated Cable Engineers Association (ICEA):
   1. S-66-524 Cross-Linked Thermosetting Polyethylene Insulated Wire and Cable

C. International Electrical Testing Association (NETA);
   1. ATS Acceptance Testing Specifications

D. National Electrical Manufacturers Association
   1. WC-3 Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
   2. WC-5 Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

E. Underwriters Laboratories (UL) Standards:
   1. 62 Flexible Cords and Fixture Wire
   2. 510 Insulating Tape
   3. 1063 Stranded Conductors for Machine Tool Wire

1.03 SUBMITTALS

A. Submit the following material or equipment data:
   1. Each type of cable and wire t be used.
   2. Cable and wire splices
   3. Wire markers

1.04 DELIVERY, STORAGE AND HANDLING

A. The Contractor shall protect all cable and wire from being damaged at all times.

B. Cable ends shall be protected from water entry in accordance with the manufacturer's recommended procedures. Cable ends shall not be left open in manholes or other locations subject to submergence. If the cable ends become

submerged prior to splicing or termination, the cables shall be replaced in their entirety.

C. Cables shall be pulled into raceways in accordance with the manufacturer's requirements. Under no circumstances shall cable pulling tensions exceed the manufacturer's written instructions.

D. Pulling tensions on raceway cables shall be within the limits recommended by the cable manufacturer. Wire pulling lubricant, where needed, shall be UL approved.

PART 2 - PRODUCTS

2.01 CONDUCTORS

A. General: Conductors, include grounding conductors, shall be stranded copper. Aluminum conductor and/or solid conductor wire and cable will not be permitted. Insulation shall bear the UL label, the manufacturer's trademark, and identify the type, voltage, and conductor size. Conductors except flexible cords and cables, fixture wires, and conductors that form an integral part of equipment such as motors and controllers shall conform to the requirements of Article 310 of the National Electric Code, latest edition, for current carrying capacity. Flexible cords and cables shall conform to Article 400, and fixture wires shall conform to Article 402. Wiring shall have wire markers at each end.

B. Power and Control Conductors, 600 Volts and Below:
   1. Solid copper wires shall be 600 volt Type XHHW, sizes #12 and #10 AWG for use with lighting and receptacle circuits only.
   2. Stranded copper wire for power circuits shall be 600 volt Type XHHW or RHW, Class B stranding, sizes #12 AWG and larger.
   3. Stranded copper wire for control circuits shall be 600 volt Type XHHW or RHW, Class B stranding, size #14 AWG.
   4. Control wires inside panels and cabinets shall be machine tool grade type MTW, UL approved, rated for 90 degrees C at dry locations.
   5. Fixture wire shall be 600 volt, silicone rubber insulated, 200°C, UL Type SF 2, with stranded copper conductors.
   6. Cords shall be 600 volt, 2 conductor plus ground, Type SO, hard service, of adequate length and with grounding type plug attached, rated in amperes as shown on the Drawings.
   7. Conductors for feeders as defined in Article 100 of the NEC shall be sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch circuits to the farthest connected load does not exceed 5 percent.
   8. Conductors for branch circuits as defined in Article 100 of the NEC shall be sized to prevent voltage drop exceeding 3 percent at the farthest connected load or combinations of such loads and where the maximum total voltage drop on both feeders and branch circuits to the farthest connected load does not exceed 5 percent.

C. VFD Power Cables
   1. VFD power cable shall be three (3) conductor, stranded copper, PVC jacketed, shielded type, tray cable (TC) rated 600 volts with three (3)

symmetrical ground conductors. The individual conductors shall be UL listed as Type XHHW-2 or RWH-2 rated for 90 degrees C at wet and dry locations, with XLPE insulation.

2. VFD Cables shall be as manufactured by Belden, Alpha, General Cable, or equal.

2.02 SPLICES AND TERMINATIONS OF CONDUCTORS

A. Splices:

1. Wire and Cable Splicing Materials and Applications:
   a. For Lighting Systems and Power Outlets: Wire nuts shall be twist-on type insulated connectors utilizing an outer insulating cover and a means for connecting and holding the conductors firmly. They shall be UL listed and suitable for connecting two to four solid copper conductors of #14 or #12 AWG size or two or three #10 AWG solid copper conductors.
   b. All Equipment: Crimp type connectors shall be insulated type with nylon jacket, suitable for the size and material of the wires and the number of wires to be spliced and for use with either solid or stranded conductors. They shall be UL listed.
   c. Division 16 Equipment and Power Conductors: Bolted pressure connectors shall be suitable for the size and material of the conductors to be spliced. They shall be UL listed and of the split bolt or bolted split sleeve type in which the bolt or set screw does not bear directly on the conductor.
   d. All Equipment: Epoxy splice kits shall include epoxy resin, hardener, and mold, and shall be suitable for use in wet locations and hazardous locations.
2. Terminal Cabinets: Provide terminal cabinets per Section 17510 *(40 67 00)*. Termination system shall include insulated, crimp-type connectors. Coordinate the lug and boards for correct fit. All terminations shall include marker sleeves.

B. Terminations:

1. Low Voltage Terminations:
   a. Crimp type terminals shall be UL listed, self-insulating sleeve type, with ring or rectangular type tongue, suitable for the size and material of the wire to be terminated, and for use with either solid or stranded conductors.
   b. Terminal lugs shall be UL listed and of the split bolt or bolted split sleeve type in which the bolt or set screw does not bear directly on the conductor. Tongues shall have NEMA standard drilling.
   c. Crimp with manufacturer recommended ratchet-type tool with calibrated dies. Hand crimping tools are not acceptable.

C. Tape used for splices and terminations shall be compatible with the insulation and jacket of the cable and shall be of plastic material. Tape shall conform with UL 510. Varnished cambric, rubber and thermoplastic tape shall be used for all split-bolt terminations.

D. Wire markers shall be heat shrink type (Raychem; T&B; or equal). Wire identification numbers shall be permanently imprinted on the markers. In locations which are not practical for heat shrink type labels, such as conduit bodies and small pull boxes, machine-printed, adhesive backed wire markers shall be used.

Markers shall be custom-printed with the full identification string. Individual character markers and clip-on wire markers are not acceptable.

PART 3 - EXECUTION

3.01 CONDUCTOR INSTALLATION

A. The Contractor shall provide, terminate and test all power, control, and instrumentation conductors.

B. The Contractor shall, as a minimum, provide the number of control wires listed in the conduit schedule or on the Contract Drawings. Excess wires shall be treated as spares for future use.

C. Conductors shall not be pulled into any raceway until raceway has been cleared of moisture and debris.

D. Wire in panels, cabinets, and wireways shall be neatly grouped using nylon tie straps, and shall be neatly fanned out to terminals.

E. Single conductor cable in cable trays shall be No. 1/0 or larger and shall be of a type listed and marked for use in cable trays. Tray cable smaller than 1/0 shall be multi-conductor, with outer jacket.

F. Provide the following types and sizes of conductors for the uses indicated for 600 volts or less:
   1. Solid Copper, Sizes #12 and #10 AWG: As shown on the Drawings for circuits for receptacles, switches and light fixtures with screw-type terminals.
   2. Stranded Copper, Size #14 AWG and Larger, Individual Conductors or CC: As shown on the Drawings for the control of motors or other equipment. Size #14 shall not be used for power supplies to any equipment.
   3. Stranded Copper, Sizes #12 AWG and Larger: As shown on the drawings for motors and other power circuits.
   4. Stranded Copper, #6 AWG and Larger.
   5. Fixture Wire: For connections to all fixtures in which the temperature may exceed the rating of branch circuit conductors.

G. Color Coding: All wire shall be coded with specific colors infused in the conductor insulation at the time of manufacture. If a conductor is specified in a gauge not available with integrally colored insulation, it shall be marked by the Contractor at the time of installation using colored electrical coding tape or an approved marking paint. Where tape or paint is used as the conductor identification system, it shall clearly distinguish the conductor over its entire exposed length in all junction boxes, manholes, conduit bodies, or other accessible intermediate locations, and at every termination. All wiring shall conform to the following wiring color code:

SYSTEM	CONDUCTOR	COLOR
120/240 Volt AC, 1-Phase, 3 Wire	Neutral Line 1 Line 2	White Black Red
120/208 Volt AC, 3-Phase, 4 Wire;	Neutral Phase A Phase B Phase C	White Black Red Blue

SYSTEM	CONDUCTOR	COLOR
277/480 Volt AC, 3-Phase 4 Wire	Neutral Phase A Phase B Phase C	Grey Brown Orange Yellow
All Systems	Earth, System, or Equipment Ground	Green Insulation, Green w/ Yellow Tracer, or Bare Conductor
120 Volt AC Control Power Circuits (In field or in Control Cabinets)	Neutral Line 1 Line 2	White Black Red
120 Volt AC UPS-derived Control Power (secondary side)	Neutral Line	White w/ Red Tracer Red w/ White Tracer
24 VAC Control Power Circuits (In field or in Cabinets)	Neutral Line	White or Grey, with Yellow Tracer Brown
12 or 24 Volt DC Control Wiring (PLC Discrete I/O, etc.)	DC Negative DC Positive DC Switched (DI/DO)	Yellow Orange Blue
120 Volt AC Control Wiring inside or outside cabinets to/from PLC Discrete I/O	Common or Neutral 120 VAC discrete inputs 120 VAC relay or discrete outputs	White or Grey, w/ Blue Tracer Blue Red
Instrumentation Twisted-shielded Cabling (PLC Analog I/O @ 4-20mA, or 1-5 Volt DC, etc.) Process Signals to/from Transmitters, Analyzers, etc.	Negative Polarity Positive Polarity (1st Conductor) Positive Polarity (2nd Conductor) Shield Drain Wire	Black White (or clear) Red Bare Conductor, or covered w/ heat-shrink tubing of a unique color
Instrumentation wiring in cabinets (PLC Analog I/O from field terminations of shielded cables).	PLC Analog Input Connections PLC Analog Output Connections	Grey Brown

H. Exercise care in pulling wires and cables into conduit or wireways so as to avoid kinking, putting undue stress on the cables or otherwise abrading them. No grease will be permitted in pulling cables. Only soapstone, talc, or UL listed pulling compound will be permitted. The raceway construction shall be complete and protected from the weather before cable is pulled into it. Swab conduits before installing cables and exercise care in pulling, to avoid damage to conductors.

I. Cable bending radius shall be per applicable code. Install feeder cables in one continuous length unless splices are favorably reviewed.

J. Provide an equipment grounding conductor, whether or not it is shown on the Drawings, in any flexible conduit or any raceway in which all or any portion of a run consists of non-metallic duct or conduit. For flexible conduit, an external bonding jumper is an acceptable alternative.

K. In panels, bundle incoming wire and cables, No. 6 AWG and smaller, lace at intervals not greater than 6 inches, neatly spread into trees and connect to their respective terminals. Allow sufficient slack in cables for alterations in terminal connections. Perform lacing with plastic cable ties or linen lacing twine. Where plastic panel wiring duct is provided for cable runs, lacing is not necessary when the cable is properly installed in the duct.

L. For cables crossing hinges, utilize extra flexible stranded wire, make up into groups not exceeding 12, and arrange so that they will be protected from chafing and excess flexing when the hinged member is moved.

3.02 CONDUCTOR SPLICES AND TERMINATIONS

A. Splices: Install all conductors without splices unless necessary for installation, as determined by the Engineer. Splices, when permitted, and terminations shall be in accordance with the splice or termination kit manufacturer's instructions. Splice or terminate wire and cable as follows:
   1. Watertight Splices: Splices in concrete pullboxes, for any type of cable or wire, shall be watertight and rated for continuous submergence. Make splices in low voltage cables using epoxy resin splicing kits rated for application up to 600 volts.

B. Terminations:
   1. Terminate stranded #14 wire using crimp type terminals where not terminated in a box lug type terminal. Terminals must be coordinated with type of terminal board where provided.
   2. Excess control wire shall be long enough to terminate at any terminal block in the enclosure, be properly taped, be identified with origin and be neatly coiled.

3.03 CONDUCTOR IDENTIFICATION

A. Except for interior lighting and receptacle circuits, identify each wire or cable at each termination and in each pullbox, junction box, handhole, and manhole using numbered and lettered wire markers. All electrically common conductors shall have the same number. Each electrically different conductor shall be uniquely numbered. Identify panelboard circuits using the panelboard identification and circuit number. Identify motor control circuits using the equipment identification number assigned to the control unit by the motor control center manufacturer and the motor control unit terminal number. Identify other circuits as shown in the circuit schedule or as favorably reviewed by the Engineer.

B. Conductors between terminals of different numbers shall have both terminal numbers shown at each conductor end. The terminal number closest to the end of the wire shall be the same as the terminal number.

3.04 FIELD TESTS

A. Refer to Specification 16950 – Electrical Tests for all cable testing requirements.

END OF SECTION

SECTION 16124

SIGNAL CABLE

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.

B. Related Work Described Elsewhere:
   1. Division 17: Instrumentation and Controls

1.02 REFERENCE STANDARDS

A. American National Standards Institute (ANSI)/Telecommunications Industry Association (TIA):
   1. 568-C.2 Balanced Twisted-Pair Telecommunications Cabling and Components Standards

B. American Society for Testing and Materials (ASTM):
   1. B8-11 Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

C. Institute of Electrical and Electronic Engineers (IEEE):
   1. 1143 Shielding Practice for Low Voltage Cables, Guide on

D. Insulated Cable Engineers Association (ICEA)
   1. S-73-532 Standard for Control, Thermocouple, Extension, and Instrumentation Cable

E. National Fire Protection Association (NFPA):
   1. 262 Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces

F. Underwriters Laboratories Incorporated (UL):
   1. 13 Standard for Power-Limited Circuit Cables
   2. 83 Thermoplastic-Insulated Wires and Cables
   3. 444 Communications Cables
   4. 1666 Standard for Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts

1.03 SUBMITTALS

A. Submit material or equipment data in accordance with the Product Information category of the General Conditions and the submittal requirements of Section 16010.

PART 2 - PRODUCTS

2.01 INSTRUMENTATION CABLE

A. Provide UL listed, twisted pair instrumentation Tray Cable (TC) conforming to ICEA S-73-532, and suitable for transmission of 4-20mA analog, low voltage signals.

B. The cable shall be two-conductor (2/C), three-conductor (3/C), four-conductor (4/C), or more as indicated on the Drawings.

C. Each conductor in the cable shall be #16 AWG 7x24 stranded bare copper, or as indicated on the Drawings.

D. Conductor insulation: Polyvinyl Chloride/Nylon

E. Shield: Aluminum Foil, 100 percent coverage

F. Drain wire: #18 AWG, stranded, tinned copper

G. Jacket material: Polyvinyl Chloride, minimum thickness 0.047 inches.

H. Insulation shall be rated at 600 volts.

I. Temperature rating: UL dry, 90 degrees C; UL web, 75 degrees C

J. Instrumentation cable installed in underground conduits shall be rated as suitable for the application.

K. Instrumentation cable shall be Belden 3090A, 3091A, or approved equal.

2.02 ANTENNA FEEDER CABLE

A. Antenna feeder cable shall be coaxial type suitable for use with the radio system.

B. Use only coaxial cable recommended for specific applications such as radio antenna systems as required by the radio manufacturer or system supplier. Due to wide differences in electrical ratings and physical characteristics between cable types, any deviations from manufacturers recommended types, cable is not acceptable.

PART 3 - EXECUTION

3.01 CABLE INSTALLATION

A. Signal cable shall be installed by personnel who have a minimum of 3 years' experience in terminating and splicing shielded twisted pair cables and coaxial cables.

B. Adequate care shall be exercised by the installers to prevent cable damage or sheath distortion. Bending radius shall not be less than 10 times the cable outside diameter.

C. Raceways shall be swabbed before installation of cable to remove moisture and debris.

D. Cables shall be continuous from initiation to termination without splices except where specifically indicated.

E. Cable shielding shall be grounded at one end only of the cable. Bonding shall be to a single ground point only. Bonding from cable to cable in multiple run installations shall not be permitted.

F. Heat shrinkable sleeving shall be installed on all cables to insulate shielding at the ungrounded cable terminations.

G. Signal cable shall not be run in the same raceway with power and control wiring except where specifically indicated.

H. Where installed in control consoles containing power circuits, cables shall be routed a minimum of 2 inches distant. Color coding shall be strictly observed throughout the installation.

I. Cable in panels, cabinets, and wireways shall be neatly grouped using nylon tie straps, and shall be fanned out to terminals.

J. For telephone cables, provide station cable to outlets. Use backbone cable for connection between telephone patch panels. Allow at least 25% spare capacity between patch panels.

K. Manufacturer's cable pulling tension shall not be exceeded.

L. Pulling lubricant shall be UL approved.

3.02 CONDUCTOR SPLICES AND TERMINATIONS

A. Splices: Install all conductors without splices unless necessary for installation, as determined by the Engineer. Splices, where approved, and terminations shall be in accordance with the splice or termination kit manufacturer's instructions.

B. Terminations:
   1. Crimp-type terminals shall be UL listed, self-insulating, sleeve type with ring or rectangular tongue, suitable for size and material of the wire to be terminated and for use with either stranded or solid wire. Spade type lugs are acceptable with telephone cable systems only.
   2. Crimp with manufacturer's recommended ratchet-type tool with calibrated dyes. Hand crimping tools are not acceptable.
   3. Coaxial cable and connectors shall be terminated in accordance with the manufacturer's instructions.

3.03 CONDUCTOR IDENTIFICATION

A. Identify each wire or cable at each termination, in each pullbox, and in each handhole using numbered and lettered wire markers. All electrically common conductors shall have the same number. Each electrically different conductor shall be uniquely numbered. Identify panelboard circuits using the panelboard identification and circuit number. Identify motor control circuits using the equipment identification number assigned to the control unit by the motor control center manufacturer and the motor control unit terminal number. Identify other circuits as shown in the circuit schedule or as favorably reviewed by the Engineer. Conductor numbering shall be coordinated with the Interconnection Diagrams specified in Division 17.

B. Conductors between terminals of different numbers shall have both terminal numbers shown at each conductor end. The terminal number closest to the end of the wire shall be the same as the terminal number.

3.04 FIELD TESTS

A. Perform testing in accordance with Section 16950 – Electrical Tests.

END OF SECTION

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SECTION 16140

WIRING DEVICES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.

B. Work Included:
1. Installation, connection and furnishing all single, duplex, GFI and special purpose receptacles complete with wall plates and/or covers as shown on the Drawings.
2. Installation, connection and furnishing of all single pole, three-way, pilot light and momentary position toggle switches complete with wall plates and or handle operators as shown on the Drawings.

1.02 REFERENCE STANDARDS

A. American National Standards Institute (ANSI) Publication:
1. C73 Plugs and Receptacles
2. C73a Plugs and Receptacles
3. 568 Communication Cables

B. Federal Specifications (FS):
1. W-C-596 D & E General Specifications for Cable Outlet Electrical Connector
2. W-S-896 D & E General Specifications for Flush Mounted Toggle and Lock Switches

C. National Electrical Manufacturers Association (NEMA) Publications:
1. WD 1 General Color Requirements for Wiring Devices
2. WD 6 Wiring Devices - Dimensional Specifications

D. Underwriters Laboratories (UL) Standards:
1. 20 General-Use Snap Switches
2. 498 Standard for Attachment Plugs and Receptacles
3. 514 Electrical Outlet Boxes
4. 943 Ground-Fault Circuit-Interrupters

1.03 SUBMITTALS

A. Submit material or equipment data in accordance with the Product Information category of the General Requirements and the submittal requirements of Section 16010.

B. Submit complete catalog cuts of switches, receptacles, enclosures, covers and appurtenances, marked to clearly identify the proposed materials.

C. Submit documentation showing that the proposed materials comply with the requirements of the NEC and UL.

1.04 LOCATIONS

A. Refer to Section 16010, General Electrical Requirements, for definitions of types of locations.

PART 2 - PRODUCTS

2.01 RECEPTACLES

A. General: Receptacles shall be heavy duty, high abuse, grounding type conforming to NEMA configurations, NEMA WD1 and UL 514 Standards.

B. Single and Duplex Receptacles:
   1. Receptacles shall be of back and side wire design utilizing screw type terminals. Receptacles shall be rated 20 ampere, two-pole, 3-wire, 120-volt, NEMA 5-20 configuration, self-grounding. Color shall be brown in industrial areas and ivory or white in office and laboratory areas. Power contacts shall be a T-type design and shall be brass. Ground contacts shall be brass.
   2. Devices shall have a nylon composition face with a nylon or melamine body. Units shall comply with Federal Specification W-C-596E and meet UL 498 test requirements. Receptacles shall be Hubbell HBL Series; Daniel Woodhead; or equal.

C. GFI Receptacles:
   1. Device shall be rated 20 ampere, 2 pole, 3 wire, 120 volt, conforming to NEMA WD-1 configuration. Face shall be nylon composition meeting UL 498 test standards. Unit shall have test and reset push buttons. Reset push button shall have a visible indicator band to indicated tripped condition.
   2. GFCI component shall meet UL 498 Class A standards with a tripping time of 1/40 second at 5 milliamperes current unbalance. Operating range shall extend from 31°F to 158°F. Unit shall have transient voltage protection and shall be ceramic encapsulated for protection against moisture.
   3. Provide Hubbell 5362SG, Daniel Woodhead, or equal.

2.02 SWITCHES

A. Line Voltage Types: Switches shall be rated 20 amperes at 120 or 277 Volts ac only. Units shall be flush mounted, self-grounding, quiet operating toggle devices. Handle color shall be brown in industrial areas and white or ivory in office and laboratory areas. Units shall conform to Federal Specifications W-S-896 D and E, UL 20, and NEMA WD1 standards. Hubbell PRO Series; Daniel Woodhead; or equal.

2.03 PLATES

A. General: Plates shall be of the style and color to match the wiring devices, and of the required number of gangs. Plates shall conform with NEMA WD1, UL 514, and ANSI C73. Plates on finished walls shall be non-metallic or stainless steel. Plates on unfinished walls and on fittings shall be of zinc plated steel or cast metal having rounded corners and beveled edges.

B. Non-Metallic: Plates shall be smooth finish with contoured edges and shall be nylon or fiberglass.

C. Stainless Steel: Plates shall be 0.035 inches thick with beveled edges and shall be manufactured from No. 302 alloy having a brushed or satin finish.

D. Galvanized: Plates shall be galvanized sheet steel raised 1/2 inch, with rounded corners.

E. Cast Metal: Plates shall be cast or malleable iron covers with gaskets so as to be moisture resistant or weatherproof.

F. Damp or Wet and Corrosive Locations: Plates shall be provided with a hinged non-metallic cover/enclosure marked with “Suitable for Wet Locations when in use” and “UL Listed.” Provide a gasket between the enclosure and the mounting surface, and between the hinged cover and mounting plate/base. The cover shall be TayMac Specification Grade; or equal.

PART 3 - EXECUTION

3.01 INSTALLATION OF WIRING DEVICES

A. Rigidly attach wiring devices in accordance with the NEC and as indicated, avoiding interference with other equipment.

B. Dry Locations: The device shall be installed in flush mounted boxes with washers as required to bring the device mounting strap level with the surface of the finished wall.

C. Damp or Wet Exterior Locations: Install only wiring devices approved for outdoor service in these locations.

D. Mounting Heights: Locations of wall outlets shall be measured from the finished floor to the center of the outlet box. Boxes shall be adjusted so that the front edge of the box shall not be further back from the finished wall plane than 1/4 inch. Boxes shall be adjusted so that they do not project beyond the finished wall Boxes located in CMU walls are to be located bottom or top at the mortar line closest to the dimension listed. Height above finished floor shall be as follows:

	Inches From Floor
Telephone Outlets - Office Areas	12
Telephone Outlets - Industrial Areas	12
Duplex Receptacles - Office Areas	12
Receptacles - Industrial Areas	46
Toggle Switches	46

E. Damp or Wet Interior Locations: Install only wiring devices approved for outdoor service. Adjust boxes so that front edge will be 1/4 inch beyond the rear edge of the finished wall. Use metal tubing sleeves to bring device mounting straps flush with the front edge of the finished wall.

F. Receptacles:
1. Receptacles shall be grounded by a grounding conductor, not by a yoke or screw contact.
2. Receptacles shall be oriented so that the grounding slot is located at the top of the outlet.
3. Receptacles shall be installed with connections pigtailed (spliced) to the branch circuit wiring so that removal of the receptacle will not lose neutral

continuity and branch circuit power will not be lost to other receptacles on the same circuit.

3.02 INSTALLATION OF WALL PLATES

A. General: Plates shall match the style of the device and shall be plumb within 1/16-inch of the vertical or horizontal.

B. Interior Dry Locations: Install plates so that all four edges are in continuous contact with the finished wall surfaces. Plaster filling will not be permitted. Do not use oversize plates or sectional plates.

C. Exterior and/or Wet Locations: Install plates with gaskets on wiring devices in such a manner as to provide a raintight weatherproof installation. Cover type shall match box type.

3.03 GROUNDING

A. Devices including switches and receptacles, shall be grounded in accordance with NEC, Article 250 and Specification 16450.

B. Switches and associated metal plates shall be grounded through the switch mounting yoke, outlet box, and raceway system.

C. Flush Receptacles
   1. Flush receptacles and their metal plates shall be grounded through positive ground connections to the outlet box and grounding system.
   2. Maintain the ground to each receptacle by a spring-loaded grounding contact to the mounting screw, or by a grounding jumper, each making a positive connection to the outlet box and grounding system at all times.

D. Receptacles served from an uninterruptible power supply shall be provided with an isolated grounding conductor from the serving power panelboard

3.04 TESTS

A. See Specification 16950 for Testing Requirements.

END OF SECTION

SECTION 16160

PANELBOARDS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Provide panelboards complete and operable, in accordance with the Contract Documents.

B. Single Manufacturer: Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer's services.

1.02 REFERENCE STANDARDS

A. American National Standards Institute (ANSI):
   1. Z55.1 Gray Finishes for Industrial Apparatus and Equipment

B. National Electrical Manufacturers Association (NEMA):
   1. PB1 Panelboards
   2. 250 Enclosures for Electrical Equipment (1,000 Volts Maximum)

C. Federal Specifications (FS):
   1. W-P-115 Panel, Power Distribution
   2. W-C-375 Circuit Breakers, Molded Case, Branch Circuit, and Service

D. Underwriters Laboratories (UL):
   1. 50 Enclosures for Electrical Equipment, Non-Environmental Considerations
   2. 67 Standard for Panelboards
   3. 869A Reference Standard for Service Equipment
   4. 1699 Standard for Arc-Fault Circuit-Interrupters

E. National Fire Protection Association (NFPA):
   1. 70 National Electrical Code (NEC)

1.03 SUBMITTALS

A. Submit material or equipment data in accordance with the Product Review category of the General Conditions and the submittal requirements of Section 16010.

B. Shop Drawings: For each panelboard, submit manufacturer's name and data as required:
   1. Bill of materials.
   2. Panelboard enclosure type.
   3. Main bus and terminal connection sizes.
   4. Main bus configuration
   5. Bus materials
   6. Location of line connections.
   7. Scaled and dimensioned cabinet drawings showing conduit entrance and exit locations.
   8. Gutter space.
   9. Gauge of boxes and fronts

10. Finish data.
11. Voltage rating.
12. Continuous current rating.
13. Short circuit rating.
14. Breaker types, trip ratings, and interrupting ratings.
15. Mounting method.
16. Circuit breaker layout drawing with dimensions and nameplate designations matching the Drawings.

C. Submit catalog cuts for panelboard, circuit breakers, protective devices, metering, and any other included accessories.

D. Submit time current curves for each circuit breaker type included.

E. Submit seismic design certifications and anchorage descriptions as required by Section 01190.

F. Submit field acceptance test results.

1.04 LOCATIONS

A. Refer to Section 16010 for definitions of types of locations.

PART 2 - PRODUCTS

2.01 GENERAL

A. Panelboards shall be factory assembled, dead-front units conforming to NEMA PB 1, UL 50, and UL 67. All panelboards shall be UL labeled.

B. Unless otherwise indicated, provide enclosure types to match the ratings required for the location in which the panelboard is installed, in accordance with Section 16010.

C. Provide service entrance rated panelboards where used as a service entrance. Service entrance rated panelboards shall conform to UL 869A and be labeled as such.

D. Each panelboard shall have a manufacturer's nameplate showing the voltage, bus rating, phase, frequency and number of wires.

E. Panelboards, circuit breakers, and all major components installed within shall be the product of a single manufacturer.

F. The number and arrangement of circuits, spares and blank spaces for future circuit breakers shall be as shown on the Drawings.

G. Circuit breaker ampere trip ratings shall be as required by the equipment.

H. Ratings:
1. Voltage: As shown on the Drawings
2. Continuous current: As shown on the Drawings
3. Main circuit breaker: As shown on the Drawings
4. Short circuit:
   a. Panelboards rated 240 VAC or less, and not used as a service entrance, shall have short circuit ratings not less than 10,000 amperes RMS symmetrical or as indicated by the Short Circuit Study prepared under Specification 16961, whichever is greater.

b. Service entrance panelboards rated 240 VAC or less shall have short circuit ratings not less than 22,000 amperes RMS symmetrical or as indicated by the Short Circuit Study, whichever is greater.
c. Panelboards shall be labeled with a UL short circuit rating. Series ratings are not acceptable.

2.02 PANELBOARDS

A. Panelboards shall meet the requirements of Federal Specification W-P-115 for Type I, Class 1 panelboards with circuit breakers.

B. Construction:
1. Busbars shall be tinned copper.
2. All circuit breakers shall be bolt-on type, with 1, 2 or 3 poles, as shown on the Drawings. Breakers shall be quick-make, quick-break, inverse time trip characteristics, to trip free on overload or short circuit. Each breaker shall have a single operating handle which indicates the trip condition of the breaker by its position. Circuit breakers shall meet the requirements of Federal Specification W-C-375.
3. Where GFCI circuit breakers are shown on the Drawings or required by NEC, a unit shall be provided that contains a conventional thermal-magnetic trip and a ground-fault sensor, rated to trip the circuit breaker in approximately 0.025 second for a 5-milliampere ground fault, UL Class A sensitivity. The ground-fault sensor shall have the same rating as the circuit breaker and shall have a push-to-test button.
4. Where AFCI circuit breakers are shown on the Drawings or required by NEC, a unit shall be provided that contains a conventional thermal-magnetic trip and an arc-fault sensor, in accordance with UL 1699. The arc-fault sensor shall have the same rating as the circuit breaker and shall have a push-to-test button.
5. Panelboards shall have hinged doors with combination catch and latch and common keying for locks. The front panels shall be arranged such that when the plates are removed, the gutters, terminals and wiring will be exposed and accessible. The doors shall have inner doors within the plates to have only the breaker operating mechanism exposed when they are opened. Live conductors and terminals shall be concealed behind the plates.
6. Unless dictated otherwise by the enclosure type, panelboards shall be constructed of hot dipped zinc galvanized steel with stainless steel screws. Enclosures shall have a factory-applied finish in ANSI 61 grey, in accordance with ANSI Z55.1.

C. Provide surge protective devices (SPDs) as shown on the Drawings and in accordance with Section 16280.

D. Manufacturers:
1. 240V and below: Eaton Pow-R-Line 1a/2a, Schneider Electric NQ/NF, or approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Panelboards shall be installed as indicated on the Drawings and in accordance with the manufacturer's instructions.

B. Panelboards shall be mounted with the top of the box 6 feet 6 inches above the floor. Panelboards shall be plumb within 1/8 inch. The highest breaker operating handle shall not be higher than 72 inches above the floor.

C. Provide neutral-ground bonding at service entrances as shown on the Drawings and as required by the NEC.

D. Provide grounding where shown on the drawings and as required by the NEC. Grounding shall be in accordance with Section 16450.

3.02 IDENTIFICATION

A. Provide a nameplate for each panelboard as required by Section 16010.

B. Provide a typewritten and printed circuit schedule in each panelboard. Handwritten schedules will not be accepted. Circuit schedule shall be placed within a clear pocket affixed to the inside of the hinged panelboard door.

3.03 FIELD ACCEPTANCE TESTS

A. Test per Specification 16950.

END OF SECTION

SECTION 16180

PROTECTIVE DEVICES AND SWITCHES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.

B. Work Included: Provide all necessary labor, tools and material to install circuit protective devices as shown on the Drawings and as described in these Specifications.

1.02 REFERENCE STANDARDS

A. American National Standards Institute (ANSI) Publication:
   1. Z55.1 Gray Finishes for Industrial Apparatus and Equipment

B. National Electrical Manufacturers Association (NEMA) Publications:
   1. ICS 3 Industrial Systems
   2. ICS 6 Enclosures for Industrial Controls and Systems
   3. 250 Type 1 Enclosures for Electrical Equipment (1,000 Volts Maximum)

C. Federal Specifications (FS):
   1. W C 375 Circuit Breakers, Molded Case, Branch Circuit and Series Service, Series Trip
   2. W F 1726 Class H Cartridge Fuses

D. Underwriters Laboratories (UL) Standards:
   1. 50 Electrical Cabinets and Boxes
   2. 198C Fuses, High-Interrupting-Capacity-Current Limiting Types
   3. 489 Molded Case Circuit Breakers and Enclosures
   4. 698 Industrial Control Equipment for Use in Hazardous (Classified) Locations
   5. 894 Switches for Use in Hazardous (Classified) Locations

E. National Fire Protection Association (NFPA) Publication:
   1. 70 National Electric Code

1.03 SUBMITTALS

A. Submit material or equipment data in accordance with the Product Review category of the General Conditions and the submittal requirements of Section 16010.

1.04 LOCATIONS

A. Refer to Section 16010 for definitions of types of locations.

PART 2 - PRODUCTS

2.01 DISCONNECT SWITCHES

A. Disconnect switches shall be heavy duty safety switches with the voltage ratings, current ratings, and number of poles as indicated by the Drawings. The switches shall be 600 volt type and horsepower rated. Auxiliary contacts shall be provided as indicated on the Drawings. Switches shall be Square D Type HD; Westinghouse HUN Series; or equal.

B. Enclosures shall be as follows:
   1. Dry Locations: NEMA Type 1.
   2. Corrosive Locations: NEMA Type 4X.
   3. Hazardous Locations (gases): NEMA Type 7.
   4. Hazardous Locations (dusts): NEMA Type 9.
   5. Wet Locations: NEMA Type 4.

C. Nameplates: Provide an engraved plastic nameplate for each disconnect switch identifying the motorized equipment it controls.

2.02 CONTROL STATIONS

A. Control station shall be of copper-free aluminum finish for use with control devices. Unit shall include a lockout on "STOP" button, neoprene covers for front operated pushbuttons, and a lockout on selector switch covers (locks two- or three-position handle in any position). Receptacle housing shall be copper-free aluminum. Insulation shall be diallyl phthalate (DAP) and contacts shall be brass. Rocker handles, push buttons and guards shall be Type 6/6 nylon. Shaft and shaft bushings shall be stainless steel. Control stations shall be Crouse-Hinds, Series DSD; Westinghouse Type PB 1; or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install units plumb within 1/8 inch of vertical, and in accordance with manufacturer's instructions. Make sure that fuse ratings are as shown on the Drawings, and that breaker trip settings are per the Engineer's instructions.

3.02 FIELD TESTS

A. Insulation Resistance Tests: Perform insulation resistance tests on circuits to be energized with a line-to-neutral voltage of 120 volts or more. Make these tests after all equipment has been connected, except that equipment which may be damaged by the test voltage shall not be connected. Test the insulation with a 500 Vdc insulation resistance tester with a scale reading 100 megohms. The insulation resistance shall be 20 megohms or more. Submit results for review.

B. Continuity Tests: Perform circuit continuity tests from a low powered dc test source to operate a buzzer or bell. Tests shall be made prior to energizing the protected circuit.

C. Operating Tests: Demonstrate that the protected circuit can be manually controlled by the installed equipment.

SECTION 16205

STANDBY DIESEL ENGINE-GENERATOR SETS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provisions: Applicable provisions of Sections 11001 and 16010 become a part of this Section as if repeated herein.

B. Work Included: Furnish all labor, materials, equipment, services and incidentals required to provide a complete and operable standby diesel engine-generator system. Materials and equipment shall be new and of best quality, as specified and shown on the Drawings. The work shall include, but not be limited to:
   1. Standby diesel engine-generator set (hereinafter called engine-generator) complete with all appurtenances. Unit shall be complete with all standard accessories for the manufacturers and models listed in Paragraph 2.01.E in addition to those additional and special features described.
   2. Fuel system including sub-base (“belly”) tank assembly, fuel piping from tank to engine, and engine-mounted fuel pump.
   3. Automatic starting and shutdown controls, starting batteries, battery rack, charger, and generator controls.
   4. Exhaust system complete with flexible connectors, silencer, exhaust piping, and insulation and supports for silencer and exhaust pipe.

C. Related Work Specified in Other Sections:
   1. Section 09900: Painting
   2. Division 3: Concrete Work
   3. Section 16250: Automatic and Non-Automatic Transfer Switches

1.02 QUALITY ASSURANCE

A. Comply with all rules and regulations of authorities having jurisdiction over work specified herein.

B. Permits and inspection shall be in accordance with Division 1 of this Specification.

C. The Drawings are diagrammatic. Size of equipment and pipes and general method of routing are shown, but it is not intended to show every offset and fitting nor every structural difficulty that may be encountered.

1.03 REFERENCE STANDARDS

A. ASTM International (ASTM) Publication:
   1. A123 Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

B. Federal Specification (FS):
   1. FF-H-106C Hardware, Builders Locks and Door Trim

C. National Electrical Manufacturers Association (NEMA) Publications:
   1. ICS-1 General Standards for Industrial Controls and Systems

2. ICS-2 Standards for Industrial Control Devices, Controllers and Assemblies
3. 250 Enclosures for Electrical Equipment (1,000 Volts Maximum)
4. MG 1 Motors and Generators

D. National Fire Protection Association (NFPA) Publications:
1. 30 Flammable and Combustible Liquid Code
2. 37 Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
3. 70 National Electrical Code
4. 110 Standard for Emergency and Standby Power Systems

E. Underwriters Laboratory (UL) Standard:
1. 508 Electric Industrial Control Equipment

F. All state and local building codes, including building, mechanical, fire and electrical.

1.04 SUBMITTALS

A. Submit material or equipment data in accordance with the submittal requirements of Sections 01300 and 16010.

B. Shop Drawings: Submit shop drawings and include the following information. Check the shop drawings submittal to verify that all details and data required below are included. If the submittal is not complete, it cannot be favorably reviewed and will be returned for completion.
1. Plan layout drawings for the engine-generator with location dimensions for all connections including: electrical, fuel, and exhaust with base dimensions and weights.
2. Composite assembly drawing of engine-generator showing location of all auxiliary equipment, dimensions and weight.
3. Front, rear, and both side elevations of the complete engine-generator unit assembly, including fuel tank.
4. Specification sheets with performance data and engineering details adequate to determine compliance with specifications of:
a. Engine (including engine cranking amperes at 20°F)
b. Radiator and water pump
c. Alternator and voltage regulator
d. Base assembly, housing, and vibration isolation mounts
e. Control panel with all components
f. Jacket water heater
g. Sub-base fuel tank assembly
h. Engine-mounted fuel pump
i. Governor
j. Battery system
k. Exhaust silencer, piping and accessories
l. Roof thimble (for exhaust pipe)
m. Battery charger
n. Alarms
5. Electrical interconnection diagram including: alternator, voltage regulator, control panel, circuit breaker, batteries, jacket heater, switches, and accessories.
6. Complete identification of all components and materials by manufacturer, model number, rating and material.

7. Complete engine and alternator voltage dip and load data. Provide calculations to show compliance with specified performance requirements specifically prepared for this project. Generalized catalogs are not sufficient to meet this requirement. The voltage dip characteristics shall also be confirmed in the filed. Failure of this field test shall constitute evidence that the equipment has not met the voltage dip criterion. The equipment shall be replaced or modified until the installed equipment operates successfully as specified herein. (See Paragraph 3.03 Testing and Run-In.) Under no circumstances will equipment with a voltage dip greater than specified be acceptable.
8. Wiring diagrams for alternator excitation and regulation circuits, alarm circuits, and instrument circuits.
9. Elementary control diagram and separate wiring diagram for automatic engine starting and protective shutdown controls. These diagrams shall show a wire number for every control circuit wire. Include a comprehensive description of operation.
10. Complete surface preparation and finish data for the engine, alternator, cabinet, panels, frame, housing, and other surfaces.
11. Detailed description of factory testing program, testing equipment, reporting procedure, and criteria for test passing or failing.
12. Detailed description of field testing program including: description of tests, testing equipment, reporting procedure, and criteria for test passing or failing. (This may be a separate submittal made at a later time, but not later than 30 days before the actual tests.)
13. Seismic Anchorage Design, including layout and calculations, signed and sealed by a Professional Engineer, registered in the State of Colorado.

C. Factory Test Report: After fabrication and testing but before shipping from the factory, submit results of the factory test for review. Do not ship any generator units until the factory test results have received favorable review.

D. Field Test Report: Submit field test report for review within fifteen days of the time of completion of the field test.

E. Manual: Provide in conformance with Sections 01300 and 16010.

PART 2 - PRODUCTS

2.01 ENGINE-GENERATOR SET

A. General:
1. The engine-generator shall be an EPA Tier 4 (Final), factory-fabricated and assembled package of new and current equipment, and shall consist of engine, alternator, controls, and other accessories as specified and as may be required for a complete and operable assembly, capable of automatic startup and shutdown. Elevation of installation is 200 feet with ambient temperatures between 30 and 100 °F.
2. Install the engine-generator permanently on a welded steel base for anchoring to a concrete base.
3. The engine-generator shall have only one source of supply and responsibility.
4. The assembly and complete installation shall comply with the all applicable requirements for the State of California and the South Coast Air Quality Management District.

B. Engine:
   1. Type: The engine shall be for operation on No. 2 diesel fuel, shall be water-cooled, and shall include a mounted radiator with duct flange, pusher-type fan. The engine brake horsepower rating shall be adequately sized for motors shown in Paragraph 2.01.C, including starting loads, as well as lighting and control loads.
   2. Control Panel: Provide an engine-generator controller meeting NFPA 110, Level 1 requirements. The control panel shall be wired, tested, and shock-mounted on the engine-generator by the manufacturer. The Control panel shall incorporate the following features:
      a. Engine Start System: Provide a complete automatic engine start-stop control which shall start engine on closing remote contact and initiate engine cool down and shutdown on opening contact. The engine controls shall also include a three-position selector switch with the following positions: RUN/STOP/AUTOMATIC; the STOP position shall shut the engine down immediately, bypassing the cool down cycle.
      b. Safety Shutdowns: Provide a cranking limiter to open the starting circuit in approximately 45 to 60 seconds if the engine fails to start in that time. Provide sensing elements to shut the engine down immediately when conditions reach a level deemed harmful to the unit. Provide an individual signal light and alarm terminals for each condition. Provide one set of Form C output contacts for connection to the telemetry system as a composite “Generator Shutdown” alarm. Safety shutdowns shall include:
         1) Low lubricating oil pressure
         2) High water temperature
         3) Overspeed
         4) Overcrank
         5) Low coolant level
         6) Low fuel level
         7) Any additional conditions standard with the manufacturer.
      c. Alarm Outputs: Provide one set of Form C output contacts for connections to the telemetry system as a "Composite Generator Warning" Alarm. The contacts shall be actuated for any one or more of the shutdown conditions or for overcurrent trip of the generator main breaker; provide alarm signal light for such overcurrent trip. The contacts shall remain activated during the entire period of the abnormal condition, and reset shall be automatic.
      d. Provide one set of Form C output contacts to indicate that the engine is running.
      e. Fuel System Control: Provide auxiliary contacts for monitoring the fuel supply system as shown on the Drawings. Provide engine shutdown in the event of no fuel in the fuel tank.
      f. The contacts shall be wired to a terminal strip inside a closed, gasketed box.
   3. Batteries: Provide starting batteries mounted in attached battery racks with non-conducting floor. Guarantee the batteries for one year or more and provide a new battery for any battery found defective within the guarantee period. Mount batteries above the concrete floor level. Batteries shall be the lead acid type. Engine shall be at the temperature maintained by the jacket heater for a 20˚F ambient.

4. Battery Charger: Provide a charger of the two-rate type, with current and voltage ratings to suit the batteries. Include a dc ammeter, fused ac input and dc output, and charge rate selector switch. The charger shall operate on 120 Vac. Charger output shall be current limited to 140% of rated current.
5. Jacket Water Heater: Provide single-phase jacket water heater(s) with one thermostat. Size heater to maintain 100˚F in 20˚F ambient. Heaters having a total wattage of 1,200 or less shall be 120 volts; larger shall be 208 volts.
6. Provide an exhaust silencer of the critical silencing type capable of not less than 30 dB-A attenuation, sized by the engine manufacturer to provide silencing without harmful back-pressure. Furnish with 24-inch-long steel flexible exhaust connection sections. Install silencer as shown on the Drawings. Thermally insulate silencer and exhaust piping using 1-1/2-inch thickness molded calcium silicate covered with a 0.010-inch thickness weatherproof stainless steel jacket having moisture barrier and held in place by stainless steel bands.
7. Engine Exhaust: Provide Schedule 40, black steel pipe conforming to ASTM A120, with condensate drains at low points. Insulate pipe with material as specified in Section 16205, Paragraph 2.01.C.5.
8. Fuel Supply System: Provide a fuel supply system capable of delivering the required amount of fuel to the engine even when the fuel level is down within 1-inch of the tank bottom. Exposed fuel oil piping shall be Schedule 40 black steel with 150-pound welded steel fittings. For buried pipes, see Section 15050 for fuel oil piping requirements under Type "O" pipe.
    a. Provide all required conduits, supply, return, fill and vent fuel lines, and other accessories as required by the engine manufacturer's design.
9. Initial Fills:
    a. Provide crankcase oil.
    b. Provide initial fill of engine coolant as recommended by the manufacturer to protect engine cooling system to a minimum temperature of 20˚F, and as required to inhibit corrosion in the cooling system.
    c. Fuel Oil: Supply the fuel oil for testing of operation.

C. Alternator:
1. The alternator shall be four-pole and of revolving field design with temperature-compensated solid state voltage regulator and high speed brushless rotating rectifier exciter system with permanent magnet. The stator shall be directly connected to the engine flywheel housing and rotor shall be driven through semi-flexible driving flanges to ensure permanent alignments. The insulation system shall be Class H with 125 degree temperature rise. The three-phase, broad range generator shall be 12-lead, reconnectable, and shall meet the requirements of NEMA Standard MG-1.
2. Alternator Performance:
    a. Frequency regulation shall be isochronous ±1.0% from no-load to rated load.
    b. Steady-state voltage regulation shall be within ±2% of rated voltage, from no-load to full rated load. Rheostats shall provide a minimum of ±5% voltage adjustment from rated value. Voltage regulator shall be of the silicon controlled rectifier type.
    c. The instantaneous voltage dip at any point in the loading sequence shall not exceed 15% of rated voltage.

3. Control Panel: The alternator control panel shall be wired, tested, and shock mounted on the generating set by the manufacturer. It shall have NFPA 110 Level 1 compliance.
4. Alternator Main Power Circuit Breaker: Provide a main power circuit breaker as shown on the Drawings. The circuit breaker shall be molded case, 3-pole, 480 VAC, 100% rated, capable of interrupting the maximum fault current the alternator is capable of producing. Breaker shall be quick-make, quick-break type, with wiping contacts and arc chutes for each pole. Breaker shall have shunt-trip device, electrically activated for tripping/closing from the generator control panel. Provide battery and charger for shunt trip circuit.
5. Main conductors: Provide necessary sets of line lugs capable of accepting conductor sizes and count as shown on the Drawings.
6. Provide exerciser and all appurtenances for periodic automatic running of the engine-generator set.

D. Vibration Isolation System for Engine-Generator Unit:
1. Isolation system shall be a combination reinforced concrete inertia pad supported on earthquake-restrained spring vibration isolators.
2. Vibration isolation shall be greater than 95%.
3. Vibration isolation system shall be Korfund Dynamics Corporation Series L Isolators supporting a Type RCPF base frame, Mason Industries Type KSL Base supported on SSLFH Mounts with adjustable vertical limit stops, or equal.

E. Engine-Generator and Accessories Manufacturers, Model Numbers and Sizing Data:
1. Engine Manufacturer:
a. Kohler
2. Minimum standby rating: 180KW (at 0.8 power factor)
3. Maximum engine speed: 1,800

2.02 ENGINE EXHAUST SYSTEM

A. Exhaust Silencer:
1. Provide an exhaust silencer of the critical silencing type capable of not less than 25 dBA attenuation, sized by the engine manufacturer to provide silencing without harmful backpressure. Furnish with minimum 18-inch-long steel flexible exhaust connection sections and rain cap.

B. Exhaust Piping: Provide Schedule 40, Standard ASTM A53, Grade B steel pipe with condensate drains at low points.

C. Insulation: Thermally insulate exhaust silencer, piping, and accessories. Insulation for engine exhaust piping and accessories shall be as follows:
1. Insulation shall be a 2-inch thick blanket-type system rated for 900ºF continuous service. Insulation shall include a Type 304 stainless steel inner liner asbestos-free fiberglass mat insulation. Insulation exterior shall be fiberglass impregnated cloth. Thermal Energy Products “Exhaust Wrap”; or equal.
2. Provide insulation over flexible connections. Fabricate insulation section as necessary to allow the full rated travel of the expansion joint.

D. Paint silencer, rain cap, and exterior exhaust pipe in accordance with Section 09960.

2.03 SUBBASE FUEL TANK

A. Subbase Fuel Tank Assembly: The fuel system will consist of subbase-mounted fuel tank, double-wall (rupture basin) and shall include the following:
   1. Provide UL 142 listed, double-walled steel, subbase fuel tank mounted underneath the generator, sized for 24 hours of operation at full load.
   2. Fuel level sight gauge.
   3. Flexible fuel lines for feed and return. Fuel returns from engine by gravity. Provide check valves in return and intake lines if recommended by engine supplier.
   4. The fill line shall be extended through the enclosure and provided with lockable cap. Include overfill prevention valve, overfill alarm and spill containment pan on the fill system.
      a. Containment pan shall have a minimum 5-gallon capacity, and shall have drain tube that drains any spillage back into the tank. Cover shall have a lockable hasp.
      b. Overfill prevention valve shall automatically stop fuel flow and 90% capacity and drain fuel from the highest point to allow fill nozzle to be removed without spilling.
      c. Fuel tank overfill protection alarm: Provide a sensor with an audible/visible alarm that indicates when fuel level is at approximately 90% capacity.
   5. Leak and level detection system to monitor any leak from the tank and low and high fuel levels.
   6. 2-inch normal vent, 4-inch primary and 4-inch emergency vent, all with piping extended to 12 feet above-grade in accordance with the Fire Code.
   7. Drain pet cock valve.
   8. Fuel strainer.
   9. Custom tank dimensions shall be no greater than 140”L x 51.25”W x 23”H.

PART 3 - EXECUTION

3.01 ENGINE-GENERATED INSTALLATION

A. General: Mount and anchor the engine-generator set and the sub-base fuel tank assemblies to a concrete base pad. Mount the engine-generator set on concrete inertia base using seismically-restrained spring isolators. Design the engine-generator set and the sub-base fuel tank assembly anchorage and support systems to resist seismic earthquake forces in accordance with Section 01190. In the shop drawing submittals, include calculations to demonstrate the adequacy of the anchorage and support systems.

B. Foundations, Installation and Grouting: Furnish the necessary materials and construct suitable concrete foundations.

C. Skilled mechanics shall install all such equipment in accordance with the instructions of the manufacturer.

D. In setting equipment, make an allowance of at least 1-inch for grout under the equipment bases. Shims used to level and adjust the bases shall be steel. Shims may be left embedded in the grout, in which case they shall be installed neatly and so as to be as inconspicuous as possible in the completed work. Unless otherwise approved, all grout shall be an approved non-shrink, non-metallic grout.

E. Fuel and Lubricants: During testing and prior to acceptance, furnish all fuel and lubricants necessary for the proper operation of this equipment.

F. Tools: For each type of equipment to be furnished by the Contractor, provide a complete set of all special tools (including grease guns or other lubricating devices) which may be necessary for the routine adjustment, operation and maintenance of such equipment.

G. Exhaust pipe shall have approved metal shield and thimble to provide clearance between exhaust and combustible roof materials in accordance with the Mechanical Code. Install condensation drains at low point in exhaust piping and rain cap at the outlet of the exhaust pipe.

3.02 WIRING

A. Wiring, including ground, control circuits, and accessories, between alternator and alternator control panel, starter, and automatic transfer switch shall be in accordance with manufacturer's recommendations and NEC, unless shown otherwise. Battery cables shall be adequate to supply full voltage to the starter. Battery charger and jacket water heater shall be wired on separate circuit breakers and circuits.

B. Route conduits to reach their destination in a neat and orderly manner.

C. All engine-generator wiring embedded in concrete, below grade, or floor level, shall be in rigid conduits.

D. Conduits terminating on the engine-generator shall be protected from vibration by a section of flexible conduit.

E. Grounding: Generator shall be grounded directly to the service entrance ground, in accordance with NEC.

F. In the vicinity of terminations, lace all power conductors to resist short circuit forces.

3.03 TESTING AND RUN-IN

A. General: Tests are to determine proper operation and capacity of the equipment and to demonstrate compliance with the Drawings and Specifications. All equipment that fails any test will be rejected, and complete re-testing will be required after the Contractor makes corrections or modifications to equipment which has previously failed any test. All field tests shall be witnessed by the Engineer.

B. Factory Tests: Factory test the engine-generator to assure compliance with the Drawings, Specifications, NEMA MG-1, and the manufacturer's quality control provisions. Provide three copies of all factory test reports.

C. Field Tests:
   1. General: Fully field test the engine-generator to demonstrate that all components are in compliance with the Specifications and are ready for service.
   2. Installation of the engine-generator shall be complete and the unit shall be serviced, tested, adjusted, and ready for use before the field tests are scheduled.

3. Provide written notice to the Engineer of the scheduled dates for the field test at least ten (10) working days prior to the field test date. The notice shall include a written test schedule listing the tests, the test procedure, the criteria for a satisfactory test, ratings of load bank to be used, and description of special measurement equipment to be employed.
4. Provide load bank to simulate the initial load, 100% load and motor starting loads specified in Paragraph 2.01.E or coordinate testing using actual plant loads for part of the 100% load.
5. Make repairs and adjustments as required to achieve satisfactory performance of the engine-generator unit. If repairs or adjustments are made during the tests, additional testing shall be performed as required by the Engineer, at no additional cost.
6. Make written records of the tests, and within ten (10) days after completion of the field test, submit three (3) copies of the test records to the Engineer. The test record shall indicate the test criteria and arrangement, the time of the test, the results, and pertinent data such as voltage, frequency, kilowatts, power factor, load current, oil pressure, water temperature, and ambient temperature. Pertinent data shall be recorded for each test, and at least every thirty (30) minutes when the test requires more than thirty (30) minutes.

D. Alarm, Control, and Equipment Tests:
1. Demonstrate each alarm and safety shutdown provision as being caused by the abnormal condition unless an alternative test condition has been favorably reviewed by the Engineer prior to the scheduling of the tests.
2. Operate each control circuit and device to demonstrate its proper operation.
3. Demonstrate the battery charger and jacket water heater operation successfully.

E. Operational Tests:
1. Simulate a power failure in order to demonstrate the proper operation of the transfer switch and engine-generator.
2. Demonstrate motor starting capability by applying the specified initial load and then the equivalent of starting and running the specified motor loads. Voltage dip shall be measured and recorded to demonstrate conformity to the Specifications.
3. Show that phase rotation of the engine-generator and the utility power are compatible at the site.

F. Endurance Tests:
1. Operate the engine-generator for ½-hour at one-half its kW rating.
2. Operate the engine-generator for six (6) hours continuously at 100% of its kW and kVA ratings.
3. Measure the temperature rise of the windings of the alternator using the resistance method.

G. Provide load banks, fuel, test equipment, labor, materials, and all other equipment and services required for all tests.

3.04 OWNER ORIENTATION

A. Provide instruction of Owner's representatives as specified in Section 11001.

END OF SECTION

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SECTION 16250

AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.

B. Work Included. Provide transfer switch complete with controls and accessories, as shown on the Drawings at each location shown on the Drawings.

C. Related Work Specified in Other Sections:
   1. Section 16205: Standby Diesel Engine-Generator Set

1.02 REFERENCE STANDARDS

A. American National Standards Institute (ANSI) Publication:
   1. Z55.1 Gray Finishes for Industrial Apparatus and Equipment

B. National Electrical Manufacturers Association (NEMA) Publication:
   1. ICS 1 General Standards for Industrial Controls and Systems
   2. ICS 6 Standards for Industrial Control Devices, Controllers and Assemblies
   3. CS 6 Enclosures for Industrial Controls and Systems

C. Underwriters Laboratories (UL) Publication:
   1. 1008 Automatic Transfer Switches (revised 1986)

D. International Electrical Testing Association (NETA):
   1. TS Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems

1.03 SUBMITTALS

A. Submit material or equipment data in accordance with the Product Review category of the General Conditions and the submittal requirements of Section 16010.

B. Submit shop drawings which include:
   1. Dimensioned drawings
   2. Elementary diagrams
   3. Wiring diagrams
   4. Nameplate list
   5. Evidence that the equipment will be provided with all specified accessories, options, features, and characteristics.
   6. Certifications that the equipment is designed and manufactured in conformance with applicable codes and standards.
   7. Regarding the seismic anchorage requirements of GC1 71:
      a. certification of compliance or written notice of noncompliance, and
      b. a sketch or description of the anchorage system.

C. Manual. Provide manufacturer's installation and maintenance instruction manuals in conformance with Section 16010.

PART 2 - PRODUCTS

2.01 AUTOMATIC TRANSFER SWITCH

A. General. The automatic transfer switch shall transfer from the normal service to a standby engine generator in the event of power failure. The switch shall transfer the system back to normal power after normal power has been restored. The switch shall include all controls and accessories. The switch shall be UL labeled, shall meet the requirements of UL Standard 1008 and shall be suitable for total system transfer including motor and lighting loads.

B. Construction:

1. The automatic transfer switch shall be of the mechanically held double throw type, actuated by two electrical operators momentarily energized and connected to the transfer mechanism by a simple over-center linkage. All main power contacts and auxiliary contacts shall be mechanically attached to a common shaft, shall be double-break silver alloy with wiping action, and shall be protected by arcing contacts. Arcing contacts shall close before and open after the main contacts and shall be readily replaceable. Contact design and arrangement shall permit repeated making and breaking of full-load current, in a combination of motor and other loads, without damage to the main contacts. Provide a main transfer mechanism utilizing rugged metal parts throughout. Molded circuit breaker type designs are not acceptable.
2. The switch transfer shall be produced in such a way that a time delay of at least 0.4 seconds exists between the opening of the closed contacts and the closing of the open contacts. The transfer switch shall be capable of transferring in either direction with 70% of rated voltage applied at the switch terminals.
3. All switch and relay contacts, coils, springs, and control elements shall be serviceable or removable from the front of the mounted switch and accessory assembly without the removal of either assembly from its compartment and without disconnection of drive linkages, power conductors, or control conductors.
4. The enclosure shall be NEMA 1 construction with hinged doors on the front for access to the interior controls. Secure doors by a locking type latch. Provide two keys for the lock.
5. Cable connections shall be accessible from the front without removing internal components.
6. Safety Requirements.
    a. Arrange the electrical supply to each control panel to be disconnected by a single switch or circuit breaker, except for necessary foreign circuits. Cover any live parts within the control panel fed from foreign control or signal circuits or arrange for them to be disconnected by one of the following methods:
        1) Enclosed relays which are automatically de-energized when the main disconnecting switch is opened; or
        2) Door-operated enclosed disconnect switches; or
        3) Clearly identified enclosed manually operated disconnect switches, which may be located inside the control panel door, provided the operating handles are isolated or barriered from all open live parts.

b. Arrange the controls so that manipulation of control switches, adjustments to timing relays, or replacement of fuses can be done without exposure to live parts.

7. The transfer switch shall have the following features:
   a. Continuous rating of 480 volts, 3 phase, with 3 poles and full neutral bus. Current rating shall be as shown on the Drawings.
   b. Adequate line and load lugs for terminating the power conductors shown on the Drawings.
   c. A terminal strip with terminals for terminating all external control circuits. Number all terminals using the wire number for the wire terminated.
   d. Cable wiring with cable ties, secured in place and guarded where subject to mechanical injury.
   e. Permanent identification of each wire at each point of connection using numbered wiring sleeves. Provide electrically common wires with the same number. Uniquely number electrically different wires.

C. Controls. Include the following controls and accessories:
   1. Three-Phase Relay Protection. Three adjustable close differential relays, connected phase-to-phase, all set to drop out at 80% and to pick up at 90% of nominal voltage.
   2. Test Switch. A test control switch which shall cause the automatic transfer switch to start the engine, transfer, retransfer, and the like, simulating a power outage. Mount this switch on the door of the transfer switch compartment.
   3. Override Switch. An override control switch (1) to prevent the automatic transfer switch from transferring from the "normal" to the "standby" position and (2) to prevent the engine-generator from being signaled to start. This control switch shall be mounted on the door of the transfer switch compartment.
   4. Indicating Lights. One each to indicate the switch is supplying "normal" or "standby" power. Provide neon type lamps with series resistors as required, in oil-tight units with clear lenses. Label each light with plastic nameplates engraved "NORMAL" and "STANDBY", respectively. Mount lights on the door of the transfer switch compartment.
   5. Engine Starting Delay. A timer which, following loss or deterioration of "normal" power, will delay closure of engine starting contact for an adjustable period up to 2 minutes, to eliminate starts during brief or momentary outages of "normal" power. Set delay at 5 seconds.
   6. Transfer Relay. A relay to prevent the transfer to standby until the standby power voltage and frequency are 90% of rated values.
   7. Retransfer Delay. A timer to provide an adjustable delay from 2 up to 25 minutes (minimum range) before retransfer to "normal" power. If "standby" power fails before preset delay period elapses, and if "normal" power is within set limits of voltage, override the delay and retransfer immediately.
   8. Nameplates. An engraved plastic nameplate for every lamp, switch, and other control device or indicator. Identify all switch and control positions. Nameplate wording shall be subject to review by the Engineer.
   9. Unloaded Generator Operation. A timer which, following retransfer to "normal" power, will maintain engine in unloaded operation for a fixed period of 5 minutes before signaling it to shut down.

10. Auxiliary Contacts. Two sets of Form C contacts which change state after the engine starting delay. One of these sets is for starting the engine, the other is spare.
11. Transfer Delay. A timer to provide an adjustable delay of 1 to 5 seconds in the closing of the open contacts after the closed contacts have opened. Provide this delay for both transfer and retransfer switch operations.

D. UL Label. The transfer switch shall have a UL label on the unit when it arrives at the site. Absence of the UL label shall be sufficient cause for the unit to be rejected. Provide all of the specified features, options, and accessories. If the manufacturer's standard UL unit does not have the specified features, options, or accessories, then provide alternative features, options, or accessories to accomplish the same purpose in a manner similar to that specified, while still providing a unit with a UL label.

E. Current Ratings. The transfer switch shall have continuous ampere rating as shown on the Drawings and a short circuit withstand rating for 3 cycles at 480 volts as follows:

Continuous Ampere Rating	Withstand RMS Amperes, Symmetrical
100-150	16,000
225-800	40,000
1,000-1,600	50,000

F. Finish. Shall be manufacturer's standard not less than 3 mils thick. Color shall be light gray ANSI 61 per Z55.1.

G. Factory Tests. Assemble, wire and test the automatic transfer switch at the factory. Conduct tests to assure that every component functions properly. Submit prototype test reports on bus bracing for the Engineer's review.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Securely anchor the transfer switch both to the wall and floor; for switches not suitable for floor mounting, provide a structural metal base which is hot dip galvanized after fabrication. The door shall open freely and close tightly. Repair any defect or damage to the switch, enclosure or paint, to the satisfaction of the Engineer.

B. Lace all power conductors to resist short circuit forces.

3.02 TESTING

A. Field Tests. Perform the tests for automatic transfer switches as outlined in Section 8.22.4 of NETA ATS 1987. Submit reports for review by the Engineer.

END OF SECTION

SECTION 16280

SURGE PROTECTIVE DEVICES

1.01 SECTION INCLUDES

A. This Section describes the materials and installation requirements for surge protective devices (SPD). These devices are used to protect AC electrical circuits from the effect of lightning induced currents, substation switching transients and internally generated transients resulting from inductive and or capacitive load switching.

1.02 REFERENCES

A. Underwriters Laboratories (UL):
   1. 67 – Standards for Panelboards
   2. 845 – Standard for Safety Motor Control Centers
   3. 857 – Standard for Safety Busway
   4. 891 – Standard for Safety Switchboards
   5. 1558 – Standard for Safety Metal Enclosed Low Voltage Switchgear
   6. 1449 Fourth Edition 2016 - Surge Protective Devices (SPD)
   7. 1283 - Electromagnetic Interference Filters

B. American National Standards Institute (ANSI) / Institute of Electrical and Electronics Engineers (IEEE):
   1. C62.41.1-2002 - IEEE Guide on the Surge Environment in Low Voltage (1000 V and Less) AC Power Circuits
   2. C62.41.2-2002 - IEEE Recommended Practice on Characterization of Surge Voltages in Low Voltage AC Power Circuits
   3. C62.45-2002 - IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits

C. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC) Article 285

1.03 SUBMITTALS

A. Submit surge protective device catalog cut sheets, dimensional data, and shop drawings with the applicable equipment in which the device is installed or to which it is connected.

PART 2 - PRODUCTS

2.01 GENERAL

A. SPD shall be Listed in accordance with UL 1449 Fourth Edition 2016 and UL 1283, Electromagnetic Interference Filters.

B. SPD shall be Component Recognized in accordance with UL 1449 Fourth Edition, at the standard's highest short circuit current rating (SCCR) of 200 kA.

C. SPD shall be tested with the ANSI/IEEE Category C High exposure waveform (20kV-1.2/50 s, 10kA-8/20 s).

D. SPD shall provide suppression for all modes of protection: L-N, L-G, and N-G in WYE systems.

E. The manufacturer of the SPD shall be the same as the manufacturer of the service entrance and distribution equipment in which the devices are installed and shipped or coordinated with the manufacturer of the panel in which it is installed so as to maintain the proper UL listing.

2.02 SPD RATINGS

A. Minimum surge current rating shall be 250 kA per phase (100 kA per mode) for service entrance and 120 kA per phase (50 kA per mode) for distribution applications.

B. UL 1449 voltage protection rating (VPR) must not exceed the following:

VOLTAGE	L-N	L-G	N-G
240/120	700V	700V	700V
208Y/120	700V	700V	700V
480Y/277	1200V	1200V	1200V

C. Pulse life test: Capable of protecting against and surviving 5000 ANSI/IEEE Category C High transients without failure or degradation of clamping voltage by more than 10%.

D. SPD shall be designed to withstand a maximum continuous operating voltage (MCOV) of not less than 115% of nominal RMS voltage.

E. SPD shall be constructed using multiple surge current diversion thermally protected metal oxide varistors (TPMOV). The surge current circuit shall be designed and constructed in a manner that ensures surge current sharing.

F. Visible indication of proper SPD connection and operation shall be provided. The indicator lights shall indicate which phase as well as which module is fully operable. The status of each SPD module shall be monitored on the front cover of the enclosure as well as on the module.

G. SPD shall be equipped with an audible alarm which shall activate when any one of the surge current modules has reached an end-of-life condition. An alarm on/off switch shall be provided to silence the alarm. The switches and alarm shall be located on the front cover of the enclosure.

H. SPD shall be equipped with dry contacts (normally open or normally closed) to allow connection to a remote monitor or other system for the following conditions:
   1. End-of-life condition for the complete SPD or module.
   2. SPD has operated to protect the equipment from a surge.

I. Terminals shall be provided for necessary power and ground connections.

2.03 MANUFACTURERS

A. Eaton SPD, Square D, Surgelogic IMA Series, ASCO Power Technologies (APT), or approved equal.

PART 3 - EXECUTION

3.01 NOT USED

END OF SECTION

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SECTION 16402

UNDERGROUND ELECTRICAL WORK

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.

1.02 APPLICABLE STANDARDS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.
   1. Federal Specifications (Fed. Spec.):
      a. RR-F-621C Frames, Covers, Gratings, Steps, Sump and Catch Basin, Manhole
      b. RR-G-661D Grating, Metal, Bar Type (Floor, except for Naval Vessels)
   2. American Concrete Institute (ACI) Publication:
      a. 318 Building Code Requirements for Reinforced Concrete
   3. American Society of Testing and Materials (ASTM) Publications:
      a. A36 Structural Steel
      b. A153 Specifications for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
      c. A615 Deformed and Plain Billet - Steel Bars for Concrete Reinforcement
      d. C33 Concrete Aggregates
      e. C139 Concrete Masonry Units for Construction of Catch Basins and Manholes, Specification for
      f. C150 Portland Cement
      g. C478 Precast Reinforced Concrete Manhole Sections, Specification for
      h. C857 Recommended Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
      i. C858 Standard Specification for Underground Precast Concrete Utility Structures
   4. American Association of State Highway and Transportation Officials (AASHTO) Publication:
      a. HB-13 Standard Specifications for Highway Bridges
   5. American National Standard Institute (ANSI) Publication:
      a. C2 National Electrical Safety Code
   6. National Fire Protection Association (NFPA) Publication:
      a. 70 National Electrical Code (NEC)
   7. 7. State of California Public Utilities Commission (Cal. PUC) Publication:
      a. G.O.128 Construction of Underground Electric Supply and Communication System, Rule for

1.03 SUBMITTALS

A. Submit material or equipment data in accordance with the Product Review category of the General Conditions and the submittal requirements of Section 16010.

B. Manufacturer's Data and Shop Drawings:

1. Manhole and Handhole - Include a table of dimensions which shows proposed size of each manhole and handhole.
2. Manhole Frame and Cover
3. Handhole Frame and Cover
4. Sealing Material for Precast Manhole and Handhole Joints

C. Certificates
1. Test Reports: Submit for approval 30 days before the materials are used, copies of laboratory test reports for the following:
a. Arc-proofing test for cable fireproofing materials

PART 2 - PRODUCTS

2.01 GENERAL

A. Materials and equipment shall conform to the respective specifications and standards and to the specifications herein. Electrical ratings shall be as indicated.

B. Conduit: Provide per Section 16110.

C. Wire and Cable: Provide per Section 16120 and Section 16124.

2.02 HANDHOLES

A. Provide handholes of reinforced precast concrete, or injection molded composite plastic material. Handholes shall include a base, a body, extensions, and a cover. Handholes with a perimeter of 10 feet or more (e.g., 3 feet by 2 feet) shall have both pulling irons and cable racks. All hardware shall be stainless steel, or hot-dip galvanized after fabrication; cable racking hardware, however, shall be non-metallic and corrosion resistant as manufactured by Pacific Utilities Supply or equal. If no handhole size is shown on the Drawings, size units per NEC or provide 12 inches by 24 inches by 18 inches deep, whichever is larger. Structure shall be fabricated in accordance with ACI 318.

B. Manholes shall be rated for HS 20-44 as given in AASHTO HB-13.

PART 3 - EXECUTION

3.01 TRENCHING, BACKFILL, AND COMPACTION

A. See Section 02221.

3.02 WIRE AND CABLE INSTALLATION

A. See Section 16120 and Section 16124.

3.03 UNDERGROUND RACEWAYS WITH CONCRETE ENCASEMENT

A. All underground raceways shall be encased in concrete unless otherwise specifically shown otherwise on the Drawings.
1. Concrete encasement shall be minimum of 3 inches around outer walls of raceways and minimum of 2 inches between raceways. Conduits shall be PVC Type EB.
2. Concrete shall be portland cement type with 4 sacks cement per cubic yard of concrete, maximum coarse aggregate size of 3/8-inches and shall have

minimum strength of 2,000 psi after 28 days. Amount of water shall not exceed slump required for placement. Five pounds red lead oxide shall be added per cubic yard of concrete for medium voltage raceway encasement only.

3. Underground raceways shall slope toward manholes, pullboxes, etc., at minimum rate of 3 inches per 100 feet unless indicated otherwise on Drawings. Raceway entrances in manholes, handholes, etc., shall be by means of bell ends and shall be sealed against entry of silt, debris, rodents, etc., into raceways.
4. Top of concrete encasement shall be minimum of 24 inches below grade.
5. Minimum radius of all horizontal bends in underground duct banks shall be 25 feet. Bends shall be formed of factory made sweeps or continuous assembly of bend segments or curved segments, except that polyvinyl chloride conduits may be field formed. Minimum radius of all vertical bends in underground raceways shall be ten times nominal size of conduit. Vertical bends shall be made of rigid steel or permanently coated aluminum conduit.
6. Underground raceways within roadways shall be run parallel or perpendicular to road centerline.
7. Pull wires left in underground raceways shall be 1/8-inch nylon rope or 3/16-inch polypropylene.
8. Terminate conduits in end-bells where duct lines enter manholes and handholes. Provide structural support for concrete encased duct banks at the point where they terminate. Separators shall be of precast concrete, high impact polystyrene, steel, or any combination of these. Stagger the joints of the conduits by rows and layers so as to provide a duct line having the maximum strength. During construction, protect partially completed duct lines from the entrance of debris such as mud, sand and dirt by means of suitable conduit plugs. As each section of a duct line is completed, draw a brush through having the diameter of the duct, and having stiff bristles until the conduit is clear of all particles of earth, sand, and gravel; then immediately install conduit plugs.

B. See Section 16110 for additional requirements.

3.04 UNDERGROUND RACEWAYS WITHOUT CONCRETE ENCASEMENT

A. Provide raceways without concrete encasement only if specifically shown on the Drawings, otherwise, provide concrete encasement as above.

B. Provide sand backfill three inches all around the raceway.

C. Construct raceways per the applicable provisions above for underground raceways with concrete encasement.

D. See Section 16110 for additional requirements.

3.05 HANDHOLES

A. Provide handholes complete with all accessories, as indicated. Provide additional handholes as needed so that the spacing between handholes does not exceed 300 feet. Identify each casting by having the manufacturer's name and address cast into an interior face or permanently attached thereto. Stencil manhole number in the neck with 3-inch-high yellow letters.

B. Handhole, or Concrete Pullbox Grounding: Ground rods installed in electrical distribution system handholes, or concrete pullboxes shall be properly connected

to the cable shielding, metallic sheath, and armor at each cable joint or splice by means of No. 4 AWG or equivalent braided tinned copper wire. Connections to metallic cable sheaths shall be by means of tinned terminals soldered to ground wires and to cable sheaths. Care shall be taken in soldering not to damage metallic cable sheaths or shields. Ground rods shall be protected with a double wrapping of pressure-sensitive plastic tape for a distance of 2 inches above and 6 inches below concrete penetrations. Ground wires shall be protected with a double wrapping of pressure-sensitive plastic tape for a distance of 2 inches above and 6 inches below concrete penetrations. Ground wires shall be neatly and firmly attached to manhole and handhole walls and the amount of exposed bare wire shall be held to a minimum.

C. Installation of Cable in Handholes: Do not install cables utilizing the shortest route, but route along those walls providing the longest route and the maximum spare cable lengths. Form all cables to closely parallel walls, not to interfere with duct entrances, and support on brackets and cable insulators at a maximum of 18 inches. In existing manholes, handholes and vaults where new ducts are to be terminated or where new cables are to be installed, provide cable supports and grounding as required for a neat and workmanlike installation with all cables properly arranged and supported. Support cable splices in underground structures by racks, leaving top space open for future cables, except as otherwise indicated for existing installations. Provide one spare three-insulator rack arm for each cable rack in each underground structure. Provide additional cable racks in each existing underground structure through which new cable is run.

D. Fireproofing (Arc Proofing) of Cables in Handholes and Vaults: All wire and cables which will carry current at 2,200 volts or more in manholes, handholes, and vaults shall be fireproofed.

1. Arc-proofing Test for Cable Fireproofing Materials: Test one sample assembly consisting of a 3-inch diameter lead tube with a 1/4-inch wall thickness, fireproofed as specified. Make tests at three different points. At each point the testing shall consist of an arc magnetically blown against the test assembly until melting occurs at the point of arc contact. The arc shall be struck between two 7/8-inch electrodes located one inch from the sample assembly. Electrodes must be electrodes located one inch from the sample assembly. Electrodes must be squared off after each test run. Arc current shall be between 195 and 210 amperes at 40 vdc. For each test the fireproofing shall prevent damage to the lead for at least 25 seconds at any point and an average time of no less than 30 seconds for the test. In lieu of the above test, the Contractor may submit copies of the report of such a test previously made for the manufacturer, with certification that the material supplied for this project is the same as that used in the test. Test elements and requirements shall be essentially as specified in the test above.
2. Fireproofing Tape: Strips of fireproofing tape approximately 1/16-inch thick by 3 inches wide shall be wrapped tightly around each cable spirally in half-lapped wrapping, or in two butt-joined wrappings with the second wrapping covering the joints in the first. The tape shall be applied with the coated side toward the cable and shall extend one inch into the ducts. To prevent unraveling, the fireproofing tape shall be random wrapped the entire length of the fireproofing with pressure sensitive glass cloth tape. The fireproofing tape shall consist of a flexible, conformable fabric having one side coated with flame retardant, flexible, polymeric coating and/or a chlorinated elastomer not less than 0.050-inch thick and shall weigh not less than 2.5 pounds per

square yard. The tape shall be noncorrosive to cable sheath, shall be self-extinguishing, and shall not support combustion. The tape shall not deteriorate when subjected to oil, water, gases, salt water, sewage and fungus.

END OF SECTION

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SECTION 16405

SWITCHBOARDS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.

1.02 APPLICABLE STANDARDS

A. American National Standard Institute (ANSI) Publications:
   1. C57.13 Requirements for Instrument Transformers

B. International Electrical Testing Association (NETA) Publications:
   1. ATS Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems

C. National Electrical Manufacturers Association (NEMA) Publication:
   1. PB2 Deadfront Distribution Switchboards

D. National Fire Protection Association (NFPA) Publication:
   1. 70 National Electrical Code (NEC)

E. Underwriters Laboratories (UL) Publication:
   1. 891 Deadfront Electrical Switchboards

1.03 SUBMITTALS

A. Submit material or equipment data in accordance with the Product Review category of the General Conditions and the submittal requirements of Section 16010.

B. Shop Drawings: Submit shop drawings which shall include: complete layout of equipment and devices; front and end elevations and floor plan to scale with major dimensions; structural details and overall weights; complete nameplate data and ratings of all devices; material, sizes, locations, and short circuit bracing rating of all buses; nameplate schedules; and circuit breaker time-current curves.

C. Regarding the seismic anchorage requirements of GC1 71, submit
   1. Certification of compliance or written notice of noncompliance, and
   2. A sketch or description of the anchorage system.

D. Factory Test Report: Include the results of the applicable production tests as required in NEMA PB2.

E. Manuals: Provide in conformance with Section 16010.

PART 2 - PRODUCTS

2.01 SWITCHBOARD

A. Standards: Design, build and test the switchboard in accordance with applicable portions of NEMA PB2 and UL 891, and comply with the NFPA 70.

B. Switchboard shall be rated 480 volts, 600amperes, 3 phase, 60 Hz (as shown on the Drawings).

C. Structure: The switchboard shall be a NEMA 1 completely self-supporting structure of the required number of vertical sections bolted together to form one metal-enclosed switchboard approximately 90 inches high. Sides, top and rear covers shall be code gauge steel, bolted to the switchboard structure. The frame structure members shall be die-formed 12 gauge steel bolted together and reinforced at external corners with rugged gussets both internal and external to the structure members. The switchboard frame shall be suitable for use as floor sills. Structure shall be for indoor use. Switchboard shall be constructed so that when installed on the concrete pad (see Part 3) the unit complies with the NFPA 70 6' 6" rule. Access shall be from the front.

D. Devices: The switchboard shall include all the devices shown on the Drawings. Devices with operating handles or control knobs or switches shall have the handles, knobs or switches externally accessible without opening any inner doors or covers.

E. Buses:
   1. Main buses shall be either copper or tin-plated aluminum, supported with high impact non-tracking insulation material, and braced to withstand mechanical forces exerted during short circuit conditions of 50,000 RMS symmetrical amperes. The continuous current density of the buses shall not exceed 1,000 amperes per square inch of cross section for copper or 750 amperes per square inch for aluminum. Continuous current ratings shall be as shown on the Drawings. Bus arrangement shall be A B C (left-to-right, top-to-bottom, front-to-rear) throughout.
   2. Bus bar shall be bare sections.
   3. Ground bus shall be copper, not less than 1/4 square-inch in cross section. Secure to the vertical section.
   4. Neutral bus shall be copper and not less than 50% of the rating of the main bus. Bus shall be insulated from the structure. Provide removable link between neutral and ground bus.

F. Wiring: Factory install all wiring within the switchboard and neatly cable and secure to supporting surfaces. Provide terminal lugs for all external wiring. Small wire shall be Type SIS.

G. Provision for Future: Arrange horizontal main buses for convenient future extension as shown on the Drawings. Provide vertical buses to the spaces shown on the Drawings for future devices, arranged to accept future mounting bolts and bus connecting straps.

H. Ambient Temperature: Base device ratings on operation in an ambient temperature not exceeding 40°C.

I. Connections: Cable connectors and device lugs shall be compression type and suitable for use with copper or aluminum cables.

J. Hardware: All hardware used on conductors shall have high tensile strength and suitable protective finish.

K. Handling Means: Provide the switchboard with adequate lifting means and make switchboard capable of being rolled or moved into position and bolted directly to the floor without the use of floor sills.

L. Finish: Chemically clean and treat all steel surfaces, providing a bond between paint and metal surfaces to help prevent the entrance of moisture and the formation of rust under the paint film. Finish the switchboard exterior with ANSI 61 light gray paint, not less than 2 mils thick.

M. Provide group mounted main and feeder circuit breakers.

N. Main Circuit Breaker: Molded case type, 3 pole, manually operated, 600 Vac with a symmetrical RMS interrupting rating of 30,000 amperes at 480 volts, and with solid state trip unit. Frame and trip ratings shall be as shown on the Drawings. Square D ME, NE, or PE Series; Westinghouse LC, MC, NC, or PC Series; or equal.

O. Feeder Circuit Breakers: Current limiting type manually operated, 600 Vac, 100,000 RMS symmetrical amperes of the ratings indicated on the Drawings. Units shall be equipped with solid state overload sensing circuitry having the following features:
   1. Fault clearing in 1/4 cycle.
   2. Current limiting without the use of fuse elements.
   3. Integral current sensors.
   4. Overcurrent pickup adjustable from 0.7 to 1.0 of breaker sensor plug rating.
   5. Rating plug interlocked with flux transfer trip.
   6. Adjustable fault Ampere settings from 5.0 times sensor rating with zero delay to 10.0 times sensor rating with 10 cycles short delay.
   7. Flux transfer shunt trip mechanism with manual trip pushbutton feature. Westinghouse Type FCL, LCL; Square D IF, IK, IL; or equal.

P. Current Transformers: Provide three current transformers in accordance with ANSI C57.11, 600 volt, 10 kV BIL, with ANSI metering accuracy class of 0.3 at burden B 0.1 and continuous thermal rating factor of 2.0.

Q. Instruments: Ammeter and voltmeter shall be semi-flush switchboard type, be not less than 4 1/4 inches square, have a 250 degree scale, and be accurate to within 1% of full scale. Ammeter shall be transformer-rated with a scale of 0 to [ ] amps. Voltmeter shall be direct reading with a scale of 0 to [ ] volts. Provide current limiting fuses for voltmeter.

R. Instrument Switches: Voltmeter and ammeter switches shall each have 3 phase and one OFF positions. Each shall be panel mounting type with clearly marked escutcheon plate and knurled handle. Ammeter switch shall not open the current transformer circuits.

S. Utility Metering Sections: Provide pull section for underground service entrance with sealable cover, barrier, and cable terminating facilities, bus or cables from pull section landing lugs to service section, provisions for mounting utility current transformers, and sockets for utility meters, all as shown on the drawings and as required by SDG&E.

T. Switchboards shall be listed and labeled as service entrance equipment if the switchboard is used as service entrance.

U. Ground Connections: Provide binding post type lugs for attachment of ground cables to sheet steel enclosures. Lugs shall be of the binding post type, shall accommodate a range of stranded copper cable from #2 AWG to #2/0 AWG, shall have a 1/2 to 13 NC stud size and shall be attached to enclosures using a threaded or tapped boss welded to the sheet steel. These lugs shall be Burndy

Type KC, Anderson Type KS, or equal. Provide bolted pressure connectors for all other ground connections. Provide one lug for each outgoing circuit.

V. Nameplates: Nameplates shall be provided for each control component. The nameplate shall be phenolic, black background with white lettering. All nameplates shall be fastened by stainless steel screws.

X. Switchboard shall be Westinghouse Powerline Series, Square D I Line Series, or equal.

PART 3 - EXECUTION

3.01 CONDUIT AND WIRE INSTALLATION

A. Install conduit and wire in conformance with Section 16110 and 16120.

3.02 SWITCHBOARD INSTALLATION

A. Mount the switchboard and anchor to a concrete pad. Install level and plumb. Doors shall open and close freely and all manually operated device handles and controls shall operate properly. Repair any damage to the enclosure, components or finish to the satisfaction of the Engineer. Clean switchgear inside and out and all nameplates.

B. Lace conductors to resist short circuit forces. Follow manufacturer's recommendations.

3.03 GROUNDING INSTALLATION

A. Ground in accordance with Section 16450.

3.04 FIELD TESTING

A. Test switchboard and circuit breakers in accordance with NETA Publication ATS Sections 8.1, 8.6, 8.10, and 8.11.

END OF SECTION

SECTION 16450

ELECTRICAL GROUNDING

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.

B. Work Included: Furnish all labor, material, equipment, tools and services necessary for the installation, connection and testing of all grounding as specified herein and as shown on the Drawings.

1.02 REFERENCE STANDARD

A. American Society for Testing and Materials (ASTM) Publication:
1. B228 Copper Clad Steel Conductors Specification
2. D178 Specifications for Rubber Insulating Matting

B. National Fire Protection Association (NFPA):
1. 70 National Electrical Code (NEC)

C. Underwriters Laboratories (UL) Standards:
1. 467 UL Standard for Safety Grounding and Bonding Equipment

D. International Electrical Testing Association (NETA) Publication:
1. ATS Acceptance Testing Specifications for Electrical Equipment for Power Systems

E. Institute of Electrical and Electronics Engineers:
1. 142 Grounding of Industrial and Commercial Power Systems (Green Book)

1.03 SUBMITTALS

A. Submit material or equipment data in accordance with the Product Information category of the General Conditions and the submittal requirements of Section 16010.

PART 2 - PRODUCTS

2.01 GENERAL

A. The grounding systems shall consist of the ground rods, grounding conductors, ground bus, ground fittings and clamps, and bonding conductors to water piping, structural steel and UFER grounding as shown on the Drawings. One system shown provides service and separately derived system grounds. A second system is an electronic ground system to provide for the discharge of static electricity.

2.02 SYSTEM COMPONENTS

A. Ground Rods: Ground rods shall be cone pointed copper clad Grade 40 HS steel rods conforming to UL 467. The welded copper encased steel rod shall have a conductivity of not less than 27% of pure copper. Rods shall be not less than 3/4-

inch in diameter and 10 feet long, unless otherwise indicated. Rods longer than 10 feet shall be made up of 10-foot units joined together with threaded couplings. The manufacturer's trademark shall be stamped near the top.

B. Ground Conductors: Buried conductors shall be medium-hard drawn bare copper; other conductors shall be soft drawn copper. Sizes over No. 6 AWG shall be stranded. Coat all ground connections except the exothermic welds with electrical joint compound, non-petroleum type, UL listed for copper and aluminum applications.

C. Ground Connections: Connection to ground rods and buried connections shall be by exothermic weld. Lugs for attachment of cables to steel enclosures shall be of the binding post type with a 1/2-13NC stud. Each post shall accommodate cables from #4 AWG to #4/0 AWG.

D. Ground Rod Boxes: Boxes shall be a 9-inch-diameter precast concrete unit with hot-dip galvanized traffic covers. Units shall be 12-inches deep. Covers shall be embossed with the wording "Ground Rod."

E. Ground Bus: Ground bus shall be a high conductivity copper alloy strap measuring 1/4-inch thick copper conforming to ASTM B187-C11000 and of minimum 4” x12” length or as shown on the Drawings. Bus shall be predrilled and tapped to accept 8-32 brass machine screws on 1-inch centers. Bar shall be equipped with fiberglass-reinforced molded polyester UL-compliant standoff insulators rated for 600V. Ground bus shall be mounted with 1/8” thick stainless steel brackets and 3/8” stainless steel bolts.

F. Ground Plates: Ground plates shall be of the irreversible compression type suitable for embedment in cast concrete. Ground plates shall be made of high-strength, high-conductivity cast copper alloy body with a pure wrought copper compression element. Grounding plate shall be 4 hole and suitable for termination with size #2-250kcmil copper conductors. Ground Plates shall be Hubbell/Burndy Type YGF or approved equal.

G. Exothermic Welds: Exothermic welded connections shall be Erico CADWELD, Hubbell BURNDYWeld, or approved equal.

H. Insulating Tape: Insulating tape for copper conductors passing through concrete slabs shall be UL Listed, premium grade, 10-mil thick, pressure-sensitive vinyl insulating tape. Tape shall have elastic backing with strong adhesive strength. Tape shall be 3M/Scotch Vinyl Insulation Tape 22, or approved equal.

I. Ground Enhancement Material (GEM): GEM must be permanent and maintenance free (no recharging with salts or chemicals which may be corrosive), maintain its earth resistance with time and not depend on water to maintain its conductivity. GEM in its set form shall have a resistivity of not more than 20 ohm-cm. GEM shall be suitable for installation in dry form or slurry form, set up firmly and not dissolve or decompose or otherwise pollute the soil or local water table. GEM shall be manufactured by Erico Products or approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Ground all equipment for which a ground connection is required per NEC whether or not the ground connection is specifically shown on the Drawings.

B. Provide a ground wire in every conduit carrying a circuit of over 50 volts to ground.

C. Sizes shall be as indicated on the Conduit/Cable Schedule and in accordance with NEC Article 250.

D. Provide a grounding-type bushing for secondary feeder conduits that originate from the secondary section of each MCC section, switchboard, or panelboard.

E. Individually bond the raceway to the ground bus in the secondary section.

F. Provide a separate grounding conductor in each individual raceway for parallel feeders. Connect the parallel ground conductors together at each end of the parallel run, as required by the NEC.

G. Interconnect the secondary switchgear MCC or panelboard neutral bus to the ground bus in the secondary switchgear compartment only at the service entrance point. For wye connected, 3 phase, separately derived systems with 3 wire distribution, connect the transformer neutral to the grounding electrode system at the transformer. Connections shall be in accordance with the NEC.

H. Provide a ground ring with minimum burial depth of 36 inches or as indicated on the Drawings, whichever is greater.

I. Embed a grounding conductor in every duct bank as indicated. The ground conductor shall be terminated at the ground grid at each end of the duct bank. Where no ground grid is installed, terminate at a suitable grounding electrode conductor near the end of the duct bank in accordance with the NEC.

J. Provide a ground rod box for each ground rod so as to permit ready access for the connection and/or removal of any pressure connectors to facilitate testing.

K. Install ground enhancement material around each ground rod per GEM manufacturer's installation instructions. GEM shall extend 6 inches in all directions around the ground rod surface. GEM shall extend from 8 inches below top of ground rod to bottom of ground rod.

L. Bond metallic water piping at its entrance into each building. Ground separately derived electrical system neutrals to the metallic water piping in addition to the system driven ground, per NEC requirements.

M. Make embedded or buried ground connections, taps and splices with exothermic welds irreversible, compression connectors. Do not conceal or cover ground connections until the Engineer or an authorized representative has established that every grounding connection conforms to the requirements of the Contract Documents and has given the Contractor written confirmation.

N. Effectively bond structural steel for buildings to the grounding system using exothermic welds.

O. Where bare copper ground conductor is installed through a new concrete slab, wrap the conductor with insulating tape before pouring concrete. Apply tape in half-lapped layers with sufficient tension to produce a uniform wind, with no tension on the last wrap to prevent flagging.

P. Provide a separate grounding conductor for each motor and connect at motor box. Provide a supplemental ground connection for motor shaft grounding rings, where applicable.

Q. Shielded instrumentation cable shall have its shield grounded at one end only unless the approved Shop Drawings indicate that the shield will be grounded at both ends. The grounding point shall be at the control panel or at the receiving end of the signal carried by the cable. The termination of the shield drain wire shall be on its own terminal screw. Jumper together the terminal screws, using manufactured terminal block jumpers or a No. 14 green insulated conductor. Connect the ground bus via a green No. 12 conductor to the main ground bus for the panel.

3.02 TESTING

A. Testing shall be in accordance with Specification 16950 – Electrical Tests.

B. Furnish to the Engineer a test report with recorded data of each ground rod location.

END OF SECTION

SECTION 16460

DRY TYPE TRANSFORMERS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Applicable provisions of Section 16010 become a part of this Section as if repeated herein.

1.02 REFERENCE STANDARDS

A. National Fire Protection Association (NFPA):
   1. 70 National Electrical Code

B. American National Standards Institute (ANSI):
   1. C2 National Electrical Safety Code
   2. C57.96 Guide for Loading Dry-Type Distribution and Power Transformers
   3. NETA ATS Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

C. National Electrical Manufacturers Association (NEMA):
   1. ST 20 Dry-Type Transformers for General Applications

D. Underwriters Laboratories (UL):
   1. 5085-1 Low Voltage Transformers - Part 1: General Requirements
   2. 5085-2 Low Voltage Transformers - Part 2: General Purpose Transformers
   3. 5085-3 Low Voltage Transformers - Part 3: Class 2 and Class 3 Transformers

E. U.S. Department of Energy Code of Federal Regulations:
   1. 10 CFR Part 431 Energy Efficiency Program for Certain Commercial and Industrial Equipment (DOE 2016)

F. American Society for Testing and Materials (ASTM):
   1. D635 Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position

G. State of California
   1. Title 24 Building Energy Efficiency Standards

1.03 SUBMITTALS

A. Submit material or equipment data in accordance with the Product Review category of the General Conditions and the submittal requirements of Section 16010.

B. Submit a single complete submittal for all products covered by this Section.

C. Shop Drawings: Submit manufacturer's name and data as required:
   1. Dimensional drawings showing conduit entry and exit locations
   2. Transformer ratings:
      a. kVA
      b. Nominal primary voltage

c. Tap percentages
d. Nominal secondary voltage
e. Percent impedance
f. Weight
g. continuous current
h. Insulation Class
i. Sound Level
j. wiring diagram

3. Product datasheets

D. Submit seismic design certifications and anchorage descriptions as required by Section 01190.

E. Submit certified copies of factory testing.

F. Submit field acceptance test results.

1.04 FACTORY TESTING

A. Tests on transformers shall include the manufacturer's standard tests, including winding resistance, ratio, polarity, phase relation, no-load loss, impedance, full load losses, and dielectric tests. Certified copies shall show compliance with all referenced standards.

1.05 LOCATIONS

A. Refer to Section 16010 for definitions of types of locations.

PART 2 - PRODUCTS

2.01 GENERAL

A. Transformers shall be UL-listed and bear the UL label.

2.02 GENERAL PURPOSE DRY TYPE TRANSFORMERS

A. Transformers shall be dry type, general purpose, compliant with NEMA ST 20 and UL 5085-1 and 5085-2.

B. Energy Efficiency: Transformers shall meet the energy conservation standards of the Department of Energy Code of Federal Regulations 10 CFR Part 431 (also known as "DOE 2016"). The transformers shall meet the requirements of California Title 24, Part 6.

C. Transformers 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.

D. Transformers shall be "K Factor" rated where indicated on the drawings.

E. Ratings
1. KVA: as shown on the drawings
2. Voltage: as shown on the drawings
3. Frequency: 60Hz
4. Sound: not to exceed the requirements of NEMA ST 20
a. 0-9 kVA 40 db
b. 10-50 kVA 45 db

c. 51-150 kVA 50 db

F. Construction
1. Copper windings
2. Taps: 2 above and 2 below rated voltage, spaced at 2-1/2%
3. Insulation (all at 40°C ambient)
a. 2 kVA and smaller: 150°C insulation system, 80°C rise
b. 3 to 15 kVA: 185°C insulation system, 115°C rise
c. 15 kVA and larger: 220°C insulation system, 150°C rise
d. Materials shall be flame-retardant and shall not support combustion as defined in ASTM D635.
4. Equipped with drip shields

G. Manufacturers: Eaton, Schneider Electric, General Electric, or approved equal.

PART 3 - EXECUTION

3.01 TRANSFORMER INSTALLATION

A. Transformers shall be installed as indicated on the Drawings.

B. Transformers shall be connected with flexible, liquid-tight metallic conduit to prevent the transmission of sound through the conduit system. Potted non-ventilated types below 30 KVA shall be installed on resilient vibration-isolating mountings.

C. Transformer grounding shall be sized in accordance with NEC requirements for separately derived systems and shall be connected to the nearest cold water pipe or, if available, structural steel member. Ground rod and connections shall be as detailed in Section 16450. Provide conduit and wire for both the ground rod and cold water pipe or structural steel member connections.

D. Lace secondary conductors to resist short circuit forces. Follow manufacturer's recommendations.

3.02 FIELD ACCEPTANCE TESTS

A. Test per applicable NETA ATS Inspection and Test Procedures. Submit results for review.

END OF SECTION

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SECTION 16500

LIGHTING

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.

B. Work Included: Provide a lighting system complete, including fixtures, lamps, standards, bases, hangers, reflectors, glassware, lenses, auxiliary equipment, ballasts, sockets, and photoelectric cells.

1.02 REFERENCE STANDARDS

A. Federal Regulations
   1. Title 21 Performance Standards for Light Emitting Products CFR 1040

B. Underwriters Laboratories (UL) Standards
   1. 57 Electric Lighting Fixtures
   2. 844 Electric Lighting Fixtures for Use in Hazardous (Classified) Locations

1.03 SUBMITTALS

A. Submit material or equipment data in accordance with the Product Review category of the General Conditions and the submittal requirements of Section 16010.

B. Submit photometric curves for each fixture configuration proposed. Substitutions will not be considered unless the photometric distribution curve indicates the proposed fixture is equal to or exceeds the specified luminaire.

C. Submit shop drawings showing proposed methods for mounting interior lighting fixtures which are not attached directly to the ceiling or wall.

D. Submit seismic design certifications and anchorage descriptions as required by Section 01190.

1.04 GUARANTEE

A. Lamps which fail within 90 days after acceptance by the Owner shall be replaced at no cost to the Owner.

PART 2 - PRODUCTS

2.01 FIXTURES

A. Fixtures shall be of the types, wattages and voltages shown on the Drawings, comply with UL 57, and be UL classified and labeled for intended use. Fixtures for use in hazardous locations shall be UL listed per UL Standard 844.

B. Luminaire wire, and the current carrying capacity thereof, shall be in accordance with the NEC.

C. Luminaires and lighting equipment shall be delivered to the project site complete, with suspension accessories, aircraft cable, stems, canopies, hickeys, castings, sockets, holders, ballasts, diffusers, louvers, frames, recessing boxes and related items, including supports and braces.

2.02 LAMP POSTS AND STANDARDS

A. Lamp posts and standards shall be of the type, configuration, and dimensions shown on the Drawings, and shall be suitable for the indicated lamp mounting height.

B. Furnish complete with anchor bolts, bolt circle template, hand holes, and cover plate.

2.03 EXIT AND EMERGENCY FIXTURES

A. General: Fixture enclosures shall consist of an injection molded, high impact, NEMA 4X gasketed corrosion resistant reinforced polyester fiberglass housing. All hardware shall be stainless steel.

B. Emergency power shall be automatically supplied to light sources from sealed nickel cadmium or spiral wound pure lead batteries with a life expectancy rating of 15 years. Units shall comply with all requirements of UL 924.

C. Electronic solid-state logic shall provide 20 millisecond switching, automatic power cutoff at 87-1/2% cell voltage, recharging of batteries within 12 hours, and pilot light indication of battery and charger conditions. A manual test switch shall be provided to allow checking equipment function.

D. Emergency light fixtures shall be equipped with 12-watt halogen lamps. Provide dual or single head as shown on the Drawings.

E. Exit lights shall have 5-3/4-inch red lettering silk screened on a high impact clear acrylic face.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General:
1. All fixtures and luminaires shall be clean and lamps shall be operable at the time of acceptance.
2. Install luminaires in accordance with manufacturer's instructions, complete with lamps, ready for operation as indicated.
3. Align, mount, and level the luminaires uniformly.
4. Avoid interference with and provide clearance for equipment. Where an indicated position conflicts with equipment locations, change the location of the luminaire by the minimum distance necessary.
5. Where the Drawings indicate that 4 lamp light fixtures are to be "two level" switched, wire the two inner lamps to one ballast and the two outer lamps to the other ballast.

B. Mounting and Supports:
1. Mounting heights shall be as shown on the Drawings. Unless otherwise shown, mounting height shall be measured to the centerline of the outlet box for a wall mounted fixture and to the bottom of the fixture for all other types.

2. For suspended luminaires, the mounting heights shall provide clearances between the bottoms of the luminaires and the finished floors as indicated.
3. Luminaire supports shall be anchored to the structural slab or structural members as indicated. Supports shall maintain the luminaire positions after relamping and cleaning.
4. Surface mounted fixtures shall be rigidly bracketed from mounting surfaces. Luminaires installed in rows shall have a non-cumulative dimensional alignment tolerance of 1/16 inch. Nipples carrying wiring between luminaires shall be watertight.
5. Pendant luminaires shall be provided with 7/32-inch aircraft cable to assure a plumb installation and shall have a minimum 25 degree clear swing from horizontal in all directions.

C. Mount fixtures level and securely support from the ceiling. Provide earthquake clips for fixtures mounted in suspended ceilings.

D. Pendant Fixture Mounting:
1. In office areas with level ceilings, provide stems and canopies to match fixtures.
2. In office areas with sloping ceilings, provide flexible fixture mounting canopies and stems to match fixtures.
3. In other areas, provide flexible fixture hangers, Crouse-Hinds Type ARB; Appleton Type GS; or equal.

E. Mount lamp posts and lighting standards plumb and make free of dents or other damage.

F. Concrete Bases:
1. Templates and anchor bolts shall be obtained before starting any work.
2. Concrete bases shall be constructed in accordance with Section 03300.

G. Battery Operated Emergency Lighting Fixtures:
1. Wall mounted at designated height per manufacturer's instructions.
2. Battery disconnect switch to be left in the "off" position until building power is fully operational.

END OF SECTION

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SECTION 16612

UNINTERRUPTIBLE POWER SUPPLY (UPS)

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Provisions: Applicable provisions of Section 16010 are part of this Section as if repeated herein.

B. Scope: These specifications describe requirements for an Uninterruptible Power System (UPS) consisting of one UPS unit per control panel. The UPS shall automatically maintain AC power within specified tolerances to the critical load, without interruption, during failure or deterioration of the normal power source.

C. The manufacturer shall design and furnish all materials and equipment to be fully compatible with electrical, environmental, and space conditions at the site. It shall include all equipment to properly interface the AC power source to the intended load and be designed for unattended operation.

D. Work included consists of but is not necessarily limited to:
   1. 1500VA UPS unit for each control panel provided under this contract per this specification section.

E. Related Work Specified in Other Sections:
   1. Division 17: Instrumentation and Control Systems

1.02 SYSTEM DESCRIPTION

A. Design Requirements:
   1. The 1500 VA UPS shall be sized to provide a minimum of 1500 VA and a minimum of 1000 W output
   2. Load voltage and bypass line voltage will be 120 VAC, single phase 2 wire. Input voltage will be 120 VAC, single phase, 2 wire
   3. The battery shall support the UPS at 100% of rated load for at least 4 minutes at 25° C at startup

B. Modes of Operation: The UPS system shall operate in the following modes:
   1. Normal: The critical AC load is continuously powered by the UPS inverters. The rectifier/chargers derive power from the utility AC source and supply DC power to the inverters, while simultaneously float charging the battery.
   2. Emergency: Upon failure of utility AC power, the critical AC load is powered by the inverters and obtain power from the battery plant. There shall be no interruption in power to the critical load upon failure or restoration of the utility AC source.
   3. Recharge: Upon restoration of the utility AC source, the rectifier/chargers power the inverters and simultaneously recharge the battery. This shall be an automatic function and shall cause no interruption to the critical AC load.

C. Performance Requirements
   1. The maximum working voltage, current, and di/dt of all solid-state power components and electronic devices shall not exceed 75% of the ratings established by their manufacturer. The operating temperature of solid-state

component sub-assembly shall not be greater than 75% of their ratings. Electrolytic capacitors shall be computer grade and be operated at no more than 95% of their voltage rating at the maximum rectifier charging voltage.

D. Unit Input:
   1. Voltage Range: 82- 144 V
   2. Frequency Range: 60 HZ ±.3 HZ (autosensing

E. Unit Output:
   1. Output Voltage Distortion: Less than 5% of full load
   2. Frequency: 57-67 HZ
   3. Grounding
      a. The AC output neutral shall be electrically isolated from the unit chassis. The unit chassis shall have an equipment ground terminal. Provisions for bonding the system neutral to the service entrance ground (customer supplied cable) shall be provided in the enclosure containing the system bypass and isolation breakers

1.03 SUBMITTALS

A. Submit material or equipment data in accordance with the Product Review category of the General Conditions and the submittal requirements of Section 16010. In addition, the submittals shall also contain the following data, drawings and descriptive material. Supply the UPS with Sufficient Documentation, Including the Following Manuals:
   1. Installation Manual: Submit the installation manual as required by Division 1 of this specification. Installation manual possesses sufficient detail and clarity to enable the Owner's technicians to install the system equipment. Supply the following Drawings and data sheets with the submittal:
      a. Receiving and Installation Instructions
      b. System one-line drawings
      c. Layout drawings of the UPS control panel indicating the front door and rear panel equipment arrangement and dimension. A list of materials and components shall accompany the layout drawings.
      d. A list of recommended standby components
      e. Interconnection drawings
      f. Battery wiring diagram
      g. Accessory wiring diagrams
      h. Line item specification compliance report
      i. Dimension and weights
      j. Manufacturer’s literature

B. Shop Drawings: Submit shop drawings complete with a system single line diagram, equipment outline drawings, elementary diagrams, wiring diagrams, battery performance data and nameplate schedules.

C. Submit catalog cuts as required.

D. Seismic design certifications and anchorage descriptions as required by Section 01190.

E. Spare Parts List: Submit a spare parts list showing recommended parts and quantities as well as complete ordering information for replacement components.

F. Manuals: Provide manuals as specified in Section 16010.

1.03 QUALITY ASSURANCE

A. Comply with the following reference standards:
1. Underwriter's Laboratories (UL): 1012 Power Supplies

PART 2 - PRODUCTS

2.01 MANUFACTURER

A. APC Smart-UPS SMT1500 with UPS Network Management Card AP9613 and Dry Contact I/O Accessory AP9810. No Substitutions allowed.

2.02 EQUIPMENT AND MATERIALS

A. Conformance UL 1778, FCC Part 15 Class A, CSA.

B. Physical Dimensions:
1. Maximum Height: 6.20 Inches.
2. Maximum Width: 5.40 inches.
3. Maximum Depth 14.10 inches.
4. Net Weight: 29 lbs.

C. Surge Protection and Filtering:
1. Surge Energy Rating: 459 Joules
2. Filtering:
a. Full time multi-pole noise filtering.
b. 0.3% IEEE surge let-through.
c. Zero clamping response time.
d. Meeting UL 1449.

D. Communications and Management:
1. Interface Ports:
a. Serial (RJ45)
b. Smart Slot
2. Control Panel:
a. Alpha-numeric LCD display with LED status indicators
b. Alarm On Battery
c. Distinctive Low Battery
d. Configurable Displays

E. Dry Contact I/O Accessory:
1. Remote control and monitoring of an individual UPS.
2. Customizable Input Contacts: Monitors conditions from external devices.
3. Customizable Output Relays: Control output from external devices via output(s).

2.03 FABRICATION

A. Materials:
1. All materials of the UPS shall be new, of current manufacture, high grade and shall not have been in prior service except as required during factory testing. All active electronic devices shall be solid-state. All power semi-conductors shall be hermetically sealed. Control logic and fuses shall be physically

isolated from power train components to ensure operator safety and protection from heat. All electronic components shall be accessible from the front without removing sub-assemblies for service access.

B. Wiring:
   1. Wiring practices, materials and coding shall be in accordance with the requirements of the National Electrical Code, OSHA, and applicable local codes and standards. All bolted connections of bus bars, lugs, and cables shall be in accordance with requirements of the National Electric Code and other applicable standards. All electrical power connections shall be torqued to the required value and marked with a visual indicator.

C. Construction and Mounting:
   1. The UPS shall be in NEMA Type 1 enclosures, designed for floor mounting. The UPS shall be structurally adequate and have provisions for hoisting, jacking, and forklift handling. Maximum cabinet height shall be 80 inches.

D. Cooling:
   1. Adequate ventilation shall be provided to ensure that all components are operated well within temperature ratings.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.02 FIELD QUALITY CONTROL

A. Perform the following procedures and tests by field service personnel during the UPS startup:
   1. Visual Inspection:
      a. Visually inspect all equipment for signs of damage or foreign materials
      b. Observe the type of ventilation, the cleanliness of the room, the use of proper signs, and any other safety related factors
   2. Mechanical Inspection:
      a. Check all the power connections for tightness
      b. Check all the control wiring terminations and plugs for tightness or proper seating
   3. Electrical Pre-check:
      a. Check the DC bus for a possible short circuit
      b. Check input and Bypass power for proper voltages and phase rotation
      c. Check all lamp test functions
   4. Initial UPS Startup:
      a. Verify that all the alarms are in a "go" condition
      b. Energize the system and verify the proper DC, walkup, and AC phase on
      c. Check the DC link holding voltage, AC output voltages, and output wave forms
      d. Check the final DC link voltage and Inverter AC output. Adjust if required
      e. Check for the proper synchronization
      f. Check for the voltage difference between the Inverter output and the Bypass source

g. Provide maintenance manuals

B. Operational Training: Before leaving the site, the field service engineer familiarizes responsible personnel with the operation of the UPS. The UPS equipment is available for demonstration of the modes of operation.

END OF SECTION

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SECTION 16920

MOTOR CONTROL CENTERS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.

B. Work Included: Provide a motor control center, complete, at the location shown on the Drawings.

1.02 REFERENCE STANDARDS

A. National Electrical Manufacturers Association (NEMA) Publications:
   1. ICS 1 General Standards for Industrial Controls and Systems
   2. ICS 2 Standards for Industrial Control Devices, Controllers and Assemblies
   3. ICS 4 Terminal Blocks for Industrial Control Equipment and Systems
   4. ICS 6 Enclosures for Industrial Controls and Systems

B. International Electrical Testing Association (NETA) Publication:
   1. ATS Acceptance Testing Specifications for Electrical Power and Distribution Equipment and Systems

C. Underwriters Laboratories (UL) Publication:
   1. UL 845 Motor Control Centers
   2. UL 489 Molded Case Circuit Breakers
   3. UL 1063 Safety Machine-Tools Wires and Cables

1.03 SUBMITTALS

A. Submit material or equipment data in accordance with the Product Review category of the General Conditions and the submittal requirements of Section 16010.

B. Shop Drawings: Submit shop drawings as specified under "Submittals" in Section 16010 and include the following: a wiring diagram and an elementary control diagram for each unit; an overall connection diagram for the motor control center; a dimensioned outline drawing to scale showing space for conduits, etc.; complete identification of all electrical components in the control center and their interconnections within the motor control center; all connections to external equipment and controls; bus material and ratings; wire marking scheme; and method of installation to resist seismic forces. Where unit arrangement or wiring deviates in any way from that shown on the Drawings, provide a complete record and explanation of such deviations.

C. Regarding the seismic anchorage requirements, refer to Section 01190 for equipment certification and anchorage design

D. Arrange submissions in a logical manner and use the device abbreviation identifications and equipment names as shown on the Drawings, in order to expedite and facilitate review by the Engineer.

E. Spare Parts List: Submit a spare parts list showing recommended parts and quantities as well as complete ordering information for replacement components. Provide instruction books for special control devices and special equipment installed in the control center. Submit these to the Engineer prior to installation of the equipment.

F. Manuals: Provide manuals as specified in Section 16010.

PART 2 - PRODUCTS

2.01 MOTOR CONTROL CENTERS

A. General: The motor control center shall be a free-standing, completely metal enclosed, dead front, dead rear, grouped motor control center arranged as shown on the Drawings. The motor control center shall be suitable for use on a 480Y/277-volt, 3 phase, 4 wire radial system grounded at the supply, with a short circuit capacity of up to 42,000 amperes without a neutral conductor in the motor control center. The motor control center shall conform to all applicable requirements of current NEMA Standards ICS 1 and ICS 2 and be UL listed. Each MCC section shall bear the UL label. The MCC section containing the main circuit breaker shall bear a UL service entrance label. Equipment shall be assembled into standardized drawout units. The motor control center shall be NEMA Class II, Type B construction.

B. Structure and Arrangement:
   1. The motor control center[s] shall consist of NEMA 1 vertical free-standing sections, each at least 20 inches wide, 20 inches deep and 90 inches high, and containing not more than six space units. A space unit shall be the space required for a Size 1 combination starter together with associated control transformer. The motor control center shall be suitable for floor mounting against a wall. Provide a horizontal wireway 6 inches high at the bottom of the motor control center, and a vertical wireway 4 inches wide in each 20 inch-wide structure. Coordinate horizontal wireway dimensions with that of the housekeeping concrete pad (see Part 3) to ensure conformance with the NEC 6'6" rule (NEC 380 8).
   2. Each cubicle shall have an individual door with concealed hinges. Doors shall be part of the structure, shall be readily interchangeable, and shall be interlocked so that the unit power is off before the door can be opened; provide door hinges on the side of the cubicle which ensures compliance with the 30 inch rule in NEC Paragraph 110 16(a). In addition, each unit shall be padlockable in the off position and in the tilted-out disconnected position.
   3. All components shall be within individual control cubicles, except as noted. Control components shall be as specified in Section 16955.
   4. "Future" spaces shall be cubicles arranged for future addition of the door and unit of the size indicated on the Drawings. The vertical bus shall extend to but not be exposed within "future" spaces.
   5. Arrangement and grouping of cubicles shall be substantially as shown on the Drawings. Avoid deviations from the arrangement shown, if possible; otherwise, submit changes to the Engineer for review. The number of vertical free-standing

sections shown on the Drawings is the minimum required. If additional sections are needed to house all equipment, including relays and timers, indicated to be located within the motor control center:

a. Provide such sections at no additional cost to the Owner, and
b. Provide a sufficient number of additional sections such that the total number of future spaces is at least the number shown on the Drawings or 15% of the total motor control center size, whichever is smaller.

C. Buses:
   1. Each motor control section shall have a main 3 phase, 3 wire, horizontal insulated bus rated 600 amperes. Each vertical section shall have a rigid vertical insulated bus rated not less than 300 amperes and extending to all space units; the bus in vertical sections containing either main lugs or main breakers shall have the same ratings as the horizontal bus. Brace buses for 42,000 amperes symmetrical.
   2. Provide the motor control center with a ground bus not smaller than 1/4 square inch in cross sectional area, copper equivalent, extending to all sections. Provide a solderless connector for copper cable at each end of each ground bus, sized for the grounding conductor shown on the Drawings. All solderless connectors shall be NEMA Standard.
   3. All phase and ground buses shall be of copper with silverplated joints and connections, or shall be of aluminum completely tin-plated. If aluminum buses are used, take special precautions at all joints to offset the effects of creep of the aluminum and to minimize effects of contact between dissimilar metals. All terminal lugs shall be suitable for copper conductors.

D. Wiring:
   1. All wiring entirely within the motor control center shall be completely factory installed and shall be thermoplastic machine tool wiring rated 600 volts.
   2. Provide a control terminal block with identified terminals in each cubicle for external control wiring associated with that cubicle. Terminal blocks, in cubicles and on doors, shall be as specified elsewhere herein under Motor Control Units.
   3. Connections of wiring from devices on fixed surfaces to door-mounted devices shall have hinge loops of extra flexible wires securely fastened at each end to permit opening and closing the door without "working" the terminations.
   4. Each control or feeder unit in the motor control sections shall be connected to the vertical bus by means of self-aligning, free-floating, silverplated copper alloy, plug-in pressure stab units. All components shall be mounted on a removable pan secured by quick opening fasteners and aligned by means of guide rails. Units shall be interchangeable.

E. Variable Frequency Drives:
   1. See section 16925 for requirements.

F. Main, tie, and feeder circuit breakers shall be thermal magnetic and of the size shown on the Drawings. Interrupting rating shall be at least 14,000 amperes symmetrical at 480 volts.
   1. Where indicated on the Drawings, provide key interlocks for the main and tie circuit breakers for each pair of motor control centers. Interlocking shall be such that either both main circuit breakers or one main and the tie may be closed at any one time.

G. Surge Protection: Provide each motor control center with one 3 phase, 600 volt, 0.5 mfd sloping capacitor and one 3 phase rotating machine lightning arrester rated for 750 volts phase-to-phase, connected to the main bus assembly.

H. Lighting Transformer and Panelboard:
   1. When indicated on the Drawings, provide a lighting transformer and panelboard built into the motor control center.
   2. Lighting transformer shall be as specified in Section 16460.
   3. Lighting panelboard shall be as specified in Section 16160, except that the boxes need not be hot-dip galvanized.

I. Automatic Transfer Switch:
   1. Provide an integral motor-driven circuit breaker-type transfer switch in each motor control center where shown on the Drawings. Breaker ampacity shall be as shown on the motor control center power one-line diagram. Solid state relay logic panel is not required. Enclosing structure dimensions shall not exceed those shown on the Drawings. Power connections shall be by insulated copper stranded conductor with ampacity adjusted for the structure 30°C rise criterion.
   2. Required accessories, factory wired and mounted, on the front panel shall be red and green indicating lights with associated legend plates, a three-position H O A selector switch, and a N.O. auxiliary contact on each circuit breaker for use with the Data Acquisition System.

J. Power Factor Correction:
   1. When indicated on the Drawings, provide power factor correcting capacitors mounted in cells adjacent to associated starter cells.
   2. Units shall be complete with line side fuses and with neon blown fuse indicating lights mounted on the cell doors. kVac rating shall be as shown on the Drawings.

K. Nameplates and Identification:
   1. Provide the motor control center with manufacturer's nameplate which indicates voltage, phases, number of wires, frequency, and bus ratings.
   2. Provide the motor control center with an identifying nameplate inscribed as shown on the Drawings.
   3. On each cubicle door in the control center, provide an identifying nameplate inscribed as shown on the Drawings.
   4. In those cases where integral legend plates cannot be used, install additional special nameplates on doors to identify selector switches, pushbuttons or other devices, as required by the Drawings or as specified herein. All integral legend plates shall be large size and shall be uniform for all control centers.
   5. Identify all internal wiring using a system consistent with the terminal identification system. Each wire at each terminal shall have attached to it permanent means of identification made of moisture resistant non-fading material.

L. Motor Winding Heater: Unit shall consist of a solid state electronic chassis mounted SCR module equipped with integral aluminum heat sinks and shall be furnished complete with fuses for SCR overcurrent protection and wiring protection. Additional SCR protection shall be provided in the form of a metal oxide varistor for voltage surges and an RC snubber circuit to limit rate of voltage change. Solid state logic shall maintain a +2% output voltage regulation for line voltage variations from 15% to +10% while maintaining a controlled current flow in the motor winding when the motor is not running. Unit shall automatically energize when motor starter contacts open and de-energize when motor starter contacts close. Provide corrosion resistant

warning labels for attachment to motors stating voltage is present at motor at all times. Unit shall operate a separately supplied indicating light to indicate heater operation and fuses condition. Equipment shall be capable of operating in an ambient temperature range from 5°C to 55°C. Equipment shall be Allen Bradley Bulletin 1410 Catalog 1410 E01, DNH "Digifire," or equal.

M. Finish: Paint finish shall be ANSI 61 and the dry film thickness shall be not less than 3 mils.

N. Manufacturer:
   1. The motor control center shall be standard catalog equipment modified as shown on the Drawings or specified herein as normally manufactured by the specified manufacturer.
   2. The motor control center[s] shall be as manufactured by Square D, Allen Bradley, or equal. All shall be factory assembled, except for shipping splits.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install the motor control center level and plumb, and secure to a 3-inch-high housekeeping concrete pad in conformance with the favorably reviewed seismic mounting method. Doors shall swing freely and close tightly.

B. Carefully repair any damage to the structure, components or finish to the satisfaction of the Engineer. Clean all nameplates.

C. Exercise care at all times after installation of motor control center to keep foreign matter, dust, dirt, debris, and moisture out of the control center.

D. Lace incoming and outgoing power conductors to resist short circuit forces. Follow manufacturer's instructions.

E. Provide high-voltage switchboard matting in front of the MCC.

3.02 FIELD TEST

A. Test the motor control center per latest NETA publication.

3.03 TRAINING

A. Provide a training session for up to five (5) owner’s representatives for 3 normal workdays at the job site or other office location chosen by the owner.

B. A manufacturer’s qualified representative shall conduct the training session.

C. At a minimum, the training program shall consist of the following:
   1. Review of the MCC one-line drawings and schedules
   2. Review of the factory record shop drawings and placement of the various cells
   3. Review of each type of starter cell, components within, control, and power wiring
   4. Discuss the maintenance timetable and procedures to be followed in an ongoing maintenance program

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SECTION 16924

VARIABLE FREQUENCY DRIVES (VFD)
OVER 5 HORSEPOWER

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Applicable provisions of Section 16010 become a part of this Section as if repeated herein.

B. Work Included: Provide a VFD controller for each of those motors shown on the Drawings.

C. Related Work Specified Elsewhere:
   1. Section 11002: Electric Motor Drives
   2. Section 16955: Control Devices

1.02 REFERENCE STANDARDS

A. National Electrical Manufacturers Association (NEMA) Publications:
   1. ICS 1 General Standards for Industrial Controls and Systems
   2. ICS 2 Standards for Industrial Control Devices, Controllers and Assemblies
   3. ICS 3 Industrial Systems
   4. ICS 3.1 Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable-speed Drive Systems
   5 ICS 4 Terminal Blocks for Industrial Control Equipment and Systems
   6. ICS 6 Enclosures for Industrial Controls and Systems

B. American National Standards Institute (ANSI) Publication:
   1. C37.90 Relays and Relay Systems Associated with Electric Power Apparatus

C. Institute of Electrical and Electronic Engineers (IEEE) Publication:
   1 519 Harmonic Control and Reactive Compensation of Static Power Converters

1.03 SUBMITTALS

A. Submit material or equipment data in accordance with the Product Review category of the General Conditions and the submittal requirements of Section 16010.

B. Submit shop drawings, including: complete elementary (ladder) diagrams; comprehensive interconnection diagrams for VFD, motor, external control devices and controllers, and other related devices; drawings showing physical arrangement of components; front elevation to scale with overall dimensions, conduit entrance spaces and weights; and Bill of Materials.

C. Submit written descriptions explaining ladder diagram operation, system operation and analog signal processing.

D. Submit comprehensive interconnection diagrams for VFD, motor, wet well level controller, and other related devices.

E. Within 45 days following Notice to Proceed:
   1. Submit a report documenting the results of computer or factory based voltage distortion and commutation notch area simulations. Obtain all data needed for the report. Contact equipment manufacturers and utility Company to obtain impedance and fault duty data. Obtain other data from the field as necessary. The simulations shall model the effects of full load VFD operation on the line side of the VFD line reactor during both utility and standby generator operation. Simulations shall demonstrate compliance with IEEE 519 for general systems.
   2. If simulations show that compliance with IEEE 519 cannot be achieved with the equipment shown on the Drawings, include in the report the manufacturer's recommended design modifications needed to ensure compliance with IEEE 519. Include additional simulation data for the recommended system demonstrating compliance. Simulation shall include specific filtering or impedance modifications necessary. Perform and submit a report on the results of a power factor analysis and document any special switching requirements necessary to eliminate filter induced leading power factors.
   3. Submit sketches of the revised single line diagram and a revised scale drawing of the equipment room layout. Room layout shall show location and mounting requirements for filters, reactors, or other devices required. All additional equipment shall meet the seismic anchorage requirements as described in Paragraph F of this Section.
   4. Simulation report, analysis, and design shall be included in the Contractor's bid price.
   5. Additional filters, reactors, enclosures, conduit, wire, and all other components necessary for a fully functioning system complying with IEEE 519 for general systems shall be included in the Contractor's bid price.

F. Seismic design certifications and anchorage descriptions as required by Section 01190.

G. Submit certified factory test report before equipment is shipped.

H. Manuals: Provide in conformance with Section 16010.

I. Submit certification that VFD, motor, and driven load are compatible throughout the specified speed range.

J. Submit list of manufacturer's recommended spare parts.

K. Submit certified statement from the manufacturer accepting responsibility for providing a fully functioning installation as specified herein.

L. Submit certified test reports of the VFD field tests.

1.04 COORDINATION

A. Motor: Obtain and review the appropriate data for the driven motor and load over the required speed range, for a complete system analysis. Verify that equipment is mutually compatible and free of resonance over the complete operating range. Coordinate the assignment of any critical frequencies with the motor supplier per Sections 11002 and 11303. Prepare the certificate required under Submittals paragraph in this Section, the certificate shall specifically state whether the VFD equipment is rated for variable torque or constant torque applications.

B. Standby Generator: Submit information on waveform distortion and inrush currents, including power factor, to the standby generator manufacturer for calculation of voltage and frequency changes caused by motor starting and stopping. Review standby generator manufacturer's calculations and verify that VFD and generator are compatible. Prepare the certificate required under the Submittals paragraph in this Section.

C. Instrumentation and Controls: Review and coordinate requirements with the instrumentation and controls work of Division 17. Provide all necessary interfacing to produce a complete, fully operational system.

PART 2 - PRODUCTS

2.01 SYSTEM

A. General: Provide integrated, all solid state adjustable frequency drives (VFD) complete with incoming line reactors. Provide all additional components necessary to meet IEEE 519 as described below. System shall comply with NEMA ICS 1, 3, 4, 3.1, 4, and 6.

B. Manufacturers: Products of the following manufacturers are acceptable, subject to conformance with these Specifications:
1. Cutler-Hammer, SVX-9000.
2. Allen-Bradley 1336 Plus II.
3. Or equal.

C. Operation: Accomplish speed control by adjusting the output frequency according to the desired reference speed. Adjust ac voltage and frequency simultaneously to provide the constant volts/Hertz necessary to operate the motor at the desired speed. The VFD must use pulse width modulation (PWM) technology.

D. Rating:
1. Line Voltage: 460 volts, -5% continuous, -10% momentary, +10%, 3 phase.
2. Line Frequency: 60 Hz, 2 Hz
3. Ambient Temperature: 5°C to 40°C
4. Altitude: Up to 3,300 feet above sea level.
5. Service Factor: 1.15
6. Power Factor: Above 0.92 at full speed and rated load.

E. Performance:
1. Efficiency: Above 95% at 100% full speed, above 93% at 70% full speed, both for centrifugal pump loads.
2. VFD Inrush Current: As required to start motor.
3. Duty Cycle: 6 starts per hour.
4. Speed Range: 34% to 100% full speed, with adjustable minimum and maximum speeds.

F. Features:
1. Provisions to accept the following control signals for automatic and manual operation:
   a. Run signal from a single remote contact closure; and
   b. A 4-20 mA dc signal for speed control. The VFD shall provide linear speed control of the motor from minimum speed to maximum speed as the adjustable speed input signal varies from its minimum to maximum. Input impedance shall be 250 ohms resistive.
2. Selector switch for automatic, manual or off.
3. Potentiometer for manual speed control.
4. Motor speed indicator calibrated in percent of full speed.
5. Incoming line circuit breaker.
6. All components necessary to ensure compliance with IEEE 519 for general systems: 5% voltage distortion factor and 22,800 voltmicroseconds commutation notch area. It is the intent of this Specification to achieve a system that operates within the guidelines of IEEE 519 for general systems when operated from the utility and when operated from the standby generator.
7. Fused 480-120 volt control power transformer to provide system control circuitry.
8. Adjustable time delay for delaying motor drive restart after power failure; timer range shall be 0 to 120 seconds, with initial settings differing by 10 seconds for each drive; provide module which causes multiple attempts to restart.
9. Provision for automatic emergency shutdown in any mode, actuated by the following:
   a. Motor thermal protection (see Section 11002).
   b. Any additional abnormal conditions as shown on the Drawings. Provide for manual restart.
10. Auxiliary contacts for remote indication of "Run", "Motor Fail" and "VFD Fail."
11. VFD able to withstand harmonic distortion and notching a defined in IEEE-519 for dedicated system (10% voltage distortion factor and 36,500 volt microseconds commutation watch area).
12. VFD operable with motor disconnected, in order to test VFD.
13. Linearity and repeatability accuracy of 3 phase output of 1% of analog input control signal regardless of input power voltage fluctuations between 437 and 505 volts.
14. Independent acceleration and deceleration controls, adjustable from 2 to 30 Hz per second.

G. Protection: Protect VFD against the following conditions:
1. Reverse phase sequence and single phasing of input power.
2. Input power failure.

3. Input transient voltages, including peak suppression and snubbers, in accordance with ANSI C37.90.
4. Radio and television interference.
5. Output overcurrent.
6. Input overcurrent (see Item 2.01F.5 above).
7. Motor overtemperature.
8. Cabinet overtemperature.
9. Undervoltage: VFD shall automatically shut down if input voltage falls below 414 volts with automatic restart upon return to a stable 437 volts or more.

H. Harmonics Mitigation:
   1. All components necessary to ensure compliance with IEEE 519 for general systems: 5% Voltage Distortion limit for Individual Harmonic and 8% for Total Harmonic Distortion. It is the intent of this Specification to achieve a system that operates within the guidelines of IEEE 519 for general systems when operated from the utility and when operated from the standby generator.
   2. Drive Input Line Reactor: Provide a drive input line reactor mounted within the drive system enclosure for drives that are less than 100 horsepower and meeting the following requirements:
      a. The construction shall be iron core with an impedance of 3 percent.
      b. Winding shall be copper.
      c. Insulation shall be Class H with a 115 °C rise over a 50 °C ambient.
      d. The unit shall be rated for the system voltage, ampacity, and frequency.

I. Construction:
   1. Enclosure, housing controller modules and components shall be free-standing, floor-mounted, NEMA ICS Type 1, and fabricated from steel, 12-gauge minimum. The enclosure shall be dead front and dead back construction with all modules, components, load, line, and control terminations fully front accessible. The enclosure shall be completely self-ventilated and have provision for top and bottom entry of wiring and conduits. The controller enclosure shall have gasketed doors mounted on semi-concealed hinges, with lockable door latches.
      a. Door-mount the following devices:
         1) Power On indicating light.
         2) Manual-Off-Auto selector switch.
         3) On-Off switch.
         4) Manual Speed potentiometer.
         5) Speed Indicator calibrated in percent of full speed.
         6) Motor Run indicating light.
         7) Motor Overtemperature indicating light.
         8) Controller Failure indicating light.
         9) External operating handle for the incoming line circuit breaker.
         10) Cabinet overheat indicating light.
         11) Elapsed time meter.
      c. Provide finish as specified in Section 16920. Provide control components as specified in Section 16955.
      d. Components: Mount components on circuit cards or modules which can be adjusted or replaced in the field without the use of special tools.

J. Factory Test:
   1. Subject VFD and motor control to a complete simulated operational test. Drive a calibrated load at various speeds over the specified speed range to determine VFD efficiency.
   2. Submit certified test report to the Engineer before equipment is shipped.

K. Spare Parts: Furnish two sets of spare power fuses for each size and type of fuse used; furnish a minimum of five fuses of each size and type of control circuit fuse.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Installation shall be in conformance with Section 16010.

B. Provide 3-inch-high concrete housekeeping pad under each VFD; coordinate dimensions to ensure conformance with the NEC 6'6" rule (1987 NEC 380-8).

C. Properly level and plumb VFDs so that doors will open and close freely.

D. Clean and repair scratched or damaged surfaces to "new" condition.

E. Coordinate the location of the isolation transformer, the size of the incoming line circuit breaker, and the size of isolation transformer secondary conductor to comply with NEC Article 240 and 450.

F. Provide the services of a factory trained service technician to inspect and check out each system before energizing.

G. Lace power conductors to resist short circuit forces. Follow manufacturer's instructions.

3.02 FIELD TESTING

A. Provide the services of a factory trained service technician to make final adjustments to equipment and carry out a full operational test in the presence of the Engineer.

B. Replace any failed or damaged parts at no cost to Owner.

C. Following installation and manufacturer's field test, perform a field test under utility and standby operating conditions. Operate the drive from no load to full load and perform a spectrum analysis to verify that the waveform on the line side of the isolation transformer is in compliance with IEEE 519 for general systems. Submit a complete certified test report for review by the Engineer. If compliance has not been attained, provide additional equipment as specified herein and perform the test again.

3.03 TRAINING

A. Service technician shall instruct operating personnel in the operation, maintenance and adjustment of the system and installation.

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SECTION 16950

ELECTRICAL TESTS

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. This Section specifies the work necessary to test, commission, and demonstrate that the electrical system satisfies the requirements of these Specifications and functions as required by the Contract Documents. The work of this Section is applicable to both pre and post energization testing required by the Manufacturer to facilitate sign-off on their respective equipment as well as pre and post energization testing performed by an independent third party entity independent of manufacturers, suppliers and installers of electrical equipment, installations and systems.

B. The Work shall include furnishing the labor, equipment, and power required to support the testing indicated in other Divisions of these Specifications. Electrical testing indicated herein and functional testing of power and controls not tested under Division 17 – Instrumentation shall be completed before commencement of the Initial Operation Period as defined in Section 01650, for each phase of construction as indicated on the Drawings. This scope may require the Contractor to activate circuits, shutdown circuits, run equipment, make electrical measurements, replace blown fuses, and install temporary jumpers, etc.

C. Carry out tests indicated herein for individual items of materials and equipment in other Sections. Testing shall be done in accordance with the manufacturer's instructions, these Specifications, and applicable NETA Acceptance Testing Specifications, NEMA, ANSI, NFPA, and ASTM Standards.

D. Factory Acceptance Testing and other off-site test requirements are included in other Sections.

E. Corrections and Replacements
   1. Before final acceptance, each part of the work shall be thoroughly tested, and each test shall be documented and submitted in accordance with the Contract Documents.
   2. Any materials or equipment failing any test shall be corrected or replaced as required to pass the test at no additional cost to the Owner.
   3. Any materials or equipment failing any test shall be re-tested after correction or replacement to verify compliance.
   4. Any failures shall again be corrected or replaced, and then re-tested.
   5. The correction/replacement/re-testing cycle shall continue until the item passes the required test(s).

1.02 REFERENCE STANDARDS

A. Electric equipment, materials, installation, and testing shall comply with the National Electrical Code (NEC), and shall also conform to the following codes and standards:
   1. American National Standards Institute (ANSI)
   2. InterNational Electrical Testing Association (NETA)
   3. Institute of Electrical and Electronics Engineers (IEEE)

4. Occupational Health and Safety Administration (OSHA)
5. ASTM International Standard E329
6. IEEE 400, Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems
7. IEEE 576, Recommended Practice for Installation, Termination, and Testing of Insulated Power Cable as Used in Industrial and Commercial Applications
8. Telecommunications Industry Association (TIA) 568-C.2, Balanced Twisted-Pair Telecommunications Cabling and Components Standards.

1.03 SUBMITTALS

A. Submit complete system test procedures for review. Test procedures shall include but not be limited to:
   1. Detailed procedures, both pre and post energization testing requirements of the Manufacturer and independent third-party entity, in sufficient detail to verify conformance with these Specifications.
   2. Incorporation of the Test Record Sheets included at the end of this Section.
   3. Detailed comprehensive testing schedule including:
      a. Electrical testing of each major area.
      b. Each major piece of electrical distribution equipment.
      c. Each major electrical subsystem.
      d. Duration of each test.
      e. Milestone test completion date.
      f. Date of test results submittals following completion of the tests.
      g. Names and qualifications of the individual(s) responsible for performing the testing, including a copy of current NETA Technician cards.
      h. Proof of NETA accreditation for the testing agency.

B. Following completion of the test submit the completed test results to the Engineer for review. The results shall include a dedicated section with the "as-left" settings of all devices, relays, circuit breakers, etc.

C. Test results shall be submitted in one submittal.

D. Test reports shall be based on NETA's latest Acceptance Testing Specifications having a sign-off, pass/fail data filed for each line item covered by NETA's Acceptance Testing Specifications latest edition.

1.04 QUALITY ASSURANCE

A. Testing Firm Qualifications:
   1. Corporately and financially independent organization functioning as an unbiased testing authority.
   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 of electrical equipment, installations, and systems.
   4. Supervising engineer accredited as Certified Electrical Test Technologist by NICET or NETA and having a minimum of 5 years testing experience on similar projects.
   5. Technicians certified by NICET or NETA.
   6. Registered Professional Engineer to provide comprehensive project report outlining services performed, results of such services, recommendations, actions taken, and opinions.

7. In compliance with OSHA CFR 29, Part 1910.7 criteria for accreditation of testing laboratories or a full member company of NETA.

B. Test equipment shall have an operating accuracy equal to or greater than requirements established by NETA ATS.

C. Test instrument calibration shall be in accordance with NETA ATS.

1.05 FIELD TESTS

A. All testing shall be performed in the presence of the Owner.

B. Any system material or workmanship that is found to be defective on the basis of acceptance tests shall be reported directly to the Owner.

PART 2 - PRODUCTS

2.01 PRE-ENERGIZATION AND OPERATING TESTS

A. The complete electrical system for each phase of construction shall be performance tested when first installed on-site. Each protective, switching, and control circuit shall be adjusted in accordance with the recommendations of the Protective Device Coordination Study required by Section 16961 and tested by actual operation using current injection or equivalent methods as necessary to ensure that each and every such circuit operates correctly to the satisfaction of the Owner.

1. Instrument Transformers. All instrument transformers shall be tested to verify correct polarity and burden.
2. Protective Relays. Each protective relay shall be demonstrated to operate by injecting current or voltage, or both, at the associated instrument transformer output terminal and observing that the associated switching and signaling functions occur correctly and in proper time and sequence to accomplish the protective function intended.
3. Switching Circuits. Each switching circuit shall be observed to operate the associated equipment being switched.
4. Control and Signal Circuits. Each control or signal circuit shall be observed to perform its proper control function or produce a correct signal output.
5. Metering Circuits. All metering circuits shall be verified to operate correctly from voltage and current sources, similarly to protective relay circuits.
6. Acceptance Tests. Complete acceptance tests shall be performed, after the station installation is completed, on all assemblies, equipment, conductors, and control and protective systems, as applicable, to verify the integrity of all the systems.
7. Relays and Metering Utilizing Phase Differences. All relays and metering that use phase differences for operation shall be verified by measuring phase angles at the relay under actual load conditions after operation commences.

B. Test Report. A test report covering the results of the tests required in the Pre-Energization and Operating Tests shall be delivered to the Engineer prior to energization. Acceptance Testing shall be in accordance with NETA ATS-(2017), Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems, published by the InterNational Electrical Testing Association. Tests shall be provided by both the manufacturer representative and independent third-party NETA accredited testing agency where required.

2.02 FIELD TESTS BY MANUFACTURER'S OR SUPPLIERS

A. All field tests shall be performed by the Manufacturers or Suppliers.

2.03 TEST REQUIREMENTS

A. The following test requirements supplement test and acceptance criteria that may be stated elsewhere.
   1. Lighting: Switching. Circuitry is in accordance with panel schedules. All interior and exterior lighting shall be checked for proper operation.
   2. Activate ground fault tripping by operating test features provided with ground current protective systems and by injecting a known and reasonable current in the ground current sensor circuit. In general, ground fault tripping should occur at a ground current equivalent to 20 percent of phase current. Current injection is not required of circuit 400 amperes or less.

B. Switchgear and Switchboard Assemblies
   1. Visual and Mechanical Inspection
      a. Compare equipment nameplate data with drawings and specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, grounding, and required area clearances.
      d. Verify the unit is clean and all shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
      e. Verify that fuse and circuit breaker sizes and types correspond to drawings and coordination study as well as to the circuit breaker's address for microprocessor-communication packages.
      f. Verify that current and voltage transformer ratios correspond to drawings.
      g. Verify that wiring connections are tight and that wiring is secure to prevent damage during routine operation of moving parts.
      h. Inspect bolted electrical connections for high resistance using one or more of the following methods:
         1) Use of a low-resistance ohmmeter.
         2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
      i. Verify operation and sequencing of interlocking systems.
      j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
      k. Inspect insulators for evidence of physical damage or contaminated surfaces.
      l. Verify correct barrier and shutter installation and operation.
      m. Exercise all active components.
      n. Inspect mechanical indicating devices for correct operation.
      o. Verify that filters are in place and vents are clear.
      p. Perform visual and mechanical inspection of instrument transformers in accordance with Section 2.03.G.
      q. Inspect control power transformers.
         1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
         2) Verify that primary and secondary fuse or circuit breaker ratings match drawings.

3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks

2. Electrical Tests
   a. Perform resistance measurements through bolted electrical connections with a low-resistance ohmmeter.
   b. Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground, for one minute in accordance with NETA ATS Table 100.1.
   c. Perform a dielectric withstand voltage test on each bus section, each phase-to-ground with phases not under test grounded, in accordance with manufacturer's published data. If manufacturer has no recommendation for this test, it shall be in accordance with NETA ATS Table 100.2. The test voltage shall be applied for one minute.
   d. 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.
   e. Perform electrical tests on instrument transformers in accordance with Section 2.03.G.
   f. Perform ground-resistance tests in accordance with Section 2.03.I.
   g. Determine accuracy of all meters and calibrate watthour meters in accordance with Section 2.03.H. Verify multipliers.
   h. Control Power Transformers
      1) Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground. Test voltages shall be in accordance with NETA ATS Table 100.1 unless otherwise specified by the manufacturer.
      2) Perform a turns-ratio test on all tap positions.
      3) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source. Verify correct potential at all devices.
      4) Verify correct secondary voltage by energizing the primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.
      5) Verify correct function of control transfer relays located in the switchgear with multiple control power sources.
   i. Voltage Transformers
      1) Perform secondary wiring integrity test. Verify correct potential at all devices.
      2) Verify secondary voltages by energizing the primary winding with system voltage.
   j. Perform current-injection tests on the entire current circuit in each section of switchgear
      1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 ampere flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.
      2) Perform current tests by primary injection with magnitudes such that a minimum of 1.0 ampere flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

k. Perform system function tests in accordance with NETA ATS Section 8.
l. Verify operation of cubicle switchgear/switchboard space heaters.
m. Perform phasing checks on double-ended or dual-source switchgear to insure correct bus phasing from each source.

3. Test Values – Visual and Mechanical
   a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
4. Test Values – Electrical
   a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Insulation-resistance values of bus insulation shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated. Dielectric withstand voltage tests shall not proceed until insulation-resistance levels are raised above minimum values.
   c. 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 test specimen is considered to have passed the test.
   d. Minimum insulation-resistance values of control wiring shall not be less than two megohms.
   e. Results of electrical tests on instrument transformers shall be in accordance with Section 2.03.G.
   f. Results of ground-resistance tests shall be in accordance with Section 2.03.I.
   g. Accuracy of meters shall be in accordance with Section 2.03.H.
   h. Control Power Transformers
      1) Insulation-resistance values of control power transformers shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated.
      2) Turns-ratio test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio.
      3) Secondary wiring shall be in accordance with design drawings and specifications.
      4) Secondary voltage shall be in accordance with design specifications.
      5) Control transfer relays shall perform as designed.
   i. Voltage transformers
      1) Secondary wiring shall be in accordance with design drawings and specifications.
      2) Secondary voltage shall be in accordance with design specifications.
   j. Current-injection tests shall prove current wiring is in accordance with design specifications.

k. Results of system function tests shall be in accordance with NETA ATS Section 8.
l. Heaters shall be operational.
m. Phasing checks shall prove the switchgear or switchboard phasing is correct and in accordance with the system design.

C. Dry-Type Transformers
1. Visual and Mechanical Inspection
a. Compare equipment nameplate data with drawings and specifications.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, and grounding.
d. Verify that resilient mounts are free and that any shipping brackets have been removed.
e. Verify the unit is clean.
f. Inspect bolted electrical connections for high resistance using one or more of the following methods:
1) Use of a low-resistance ohmmeter.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
g. Verify that as-left tap connections are as specified.
2. Electrical Tests
a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable.
b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage in accordance with manufacturer's published data or in the absence of manufacturer's published data, use NETA ATS Table 100.5. Calculate polarization index.
c. Verify correct secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.
3. Test Values – Visual and Mechanical
a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
c. Tap connections are left as found unless otherwise specified.
4. Test Values – Electrical
a. Compare bolted electrical connection resistances to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Minimum insulation-resistance values of transformer insulation shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.5. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated. The polarization index shall not be less than 1.0.
c. Turns-ratio test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio.
d. Phase-to-phase and phase-to-neutral secondary voltages shall be in agreement with nameplate data.

D. Low Voltage Cables-600 volts Maximum
   1. Visual and Mechanical Inspection
      a. Compare cable data with Drawings and Specifications.
      b. Inspect exposed sections of cables for physical damage and correct connection in accordance with single-line diagram.
      c. Inspect bolted electrical connections for high resistance using one of the following methods:
         1) Use of low-resistance ohmmeter
         2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
      d. Inspect compression-applied connectors for correct cable match and indentation.
      e. Inspect for correct identification and arrangements.
      f. Inspect cable jacket insulation and condition.
   2. Electrical Tests
      a. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. 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 1 minute.
         1) Motor feeders tested with motors disconnected and controller open.
         2) Motor control circuits tested and verified for proper operation with control stations and overcurrent devices connected.
         3) Panelboard feeders tested with feeder breaker open and panelboard connected. If a lighting transformer is associated with the panelboard, it shall be connected and the test made for both primary and secondary sides.
         4) Conductors of main lighting feeders, including lighting panel with branch circuits open.
         5) Prior to performing insulation resistance tests on cables, verify that they are not connected to a solid state device.
         6) Equipment which may be damaged during this test shall be disconnected.
         7) The Engineer shall be consulted if minimum insulation values cannot be obtained.
      b. Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.
      c. Perform continuity test to ensure correct cable connection.
      d. Perform the following industry-standard operational and performance tests on each Category 6 Ethernet cable as detailed in ANSI/EIA-568-C:
         1) Wire map (pass/fail)
         2) Propagation delay (pass/fail)
         3) Delay skew (pass/fail)
         4) Cable length
         5) Insertion loss (attenuation)
         6) Return loss (pass/fail)
         7) Near-end crosstalk (NEXT) (pass/fail)
         8) Power sum near-end crosstalk (PSNEXT) (pass/fail)
         9) Equal level far-end crosstalk (ELFEXT)
         10) Power sum equal level far-end crosstalk (PSELFEXT).

3. Test Values - Visual and Mechanical
    a. Compare bolted connection resistance to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Bolt-torque levels shall be in accordance with NETA ATS Table 100.12 unless otherwise specified by the manufacturer.
4. Test Values - Electrical
    a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Insulation-resistance values shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations shall be investigated.
    c. Cable shall exhibit continuity.
    d. Deviations in resistance between parallel conductors shall be investigated.
    e. Compare Category 6 Ethernet test values against TIA 568-C for determination of pass/fail status.

E. Low Voltage Safety Switches
1. Visual and Mechanical Inspection
    a. Compare equipment nameplate data with drawings and specifications.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage, alignment, grounding, and required clearances.
    d. Verify the unit is clean.
    e. Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.
    f. Verify that fuse sizes and types are in accordance with drawings, short-circuit studies, and coordination study.
    g. Verify that each fuse has adequate mechanical support and contact integrity.
    h. Inspect bolted electrical connections for high resistance using one or more of the following methods:
        1) Use of a low-resistance ohmmeter.
        2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data or NETA ATS Table 100.12
    i. Verify operation and sequencing of interlocking systems.
    j. Verify correct phase barrier installation.
    k. Verify correct operation of all indicating and control devices.
    l. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
2. Electrical Tests
    a. Perform resistance measurements through bolted electrical connections with a low-resistance ohmmeter, if applicable.
    b. Measure contact resistance across each switchblade and fuseholder.
    c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer’s published data. In the absence of manufacturer’s published data, use NETA ATS Table 100.1

d. Measure fuse resistance.

3. Test Values – Visual and Mechanical
   a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
4. Test Values – Electrical
   a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Microohm 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.
   c. Insulation-resistance values shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated. Dielectric withstand voltage tests shall not proceed until insulation-resistance levels are raised above minimum values.
   d. Investigate fuse-resistance values that deviate from each other by more than 15 percent.

F. Low Voltage Power Circuit Breakers
1. Visual and Mechanical Inspection
   a. Compare equipment nameplate data with drawings and specifications.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage and alignment.
   d. Verify that all maintenance devices are available for servicing and operating the breaker.
   e. Verify the unit is clean.
   f. Verify the arc chutes are intact.
   g. Inspect moving and stationary contacts for condition and alignment.
   h. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.
   i. Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism in accordance with manufacturer's published data.
   j. Inspect bolted electrical connections for high resistance using one or more of the following methods:
      1) Use of a low-resistance ohmmeter.
      2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12
   k. Verify cell fit and element alignment.
   l. Verify racking mechanism operation.
   m. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
   n. Perform adjustments for final protective device settings in accordance with the coordination study.

o. Record as-found and as-left operation counter readings.

2. Electrical Tests
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with the circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.1.
   c. Perform a contact/pole-resistance test.
   d. Determine long-time pickup and delay by primary current injection.
   e. Determine short-time pickup and delay by primary current injection.
   f. Determine ground-fault pickup and time delay by primary current injection.
   g. Determine instantaneous pickup by primary current injection.
   h. Test functions of the trip unit by means of secondary injection.
   i. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data.
   j. Verify correct operation of auxiliary features 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
   k. Verify correct operation of any auxiliary features 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.
   l. Verify operation of charging mechanism.

3. Test Values – Visual and Mechanical
   a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
   c. Settings shall comply with coordination study recommendations.
   d. Operations counter shall advance one digit per close-open cycle.

4. Test Values – Electrical
   a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Insulation-resistance values shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated.
   c. 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 breakers by more than 50 percent of the lowest value.
   d. Insulation-resistance values of control wiring shall not be less than two megohms.

e. Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors. If manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS Table 100.7.
f. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
g. Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
h. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances. In the absence of manufacturer's published data, refer to NETA ATS Table 100.8.
i. Pickup values and trip characteristics shall be within manufacturer's published tolerances.
j. Minimum pickup voltage of the shunt trip and close coils shall conform to the manufacturer's published data. In the absence of the manufacturer's published data, refer to NETA ATS Table 100.20.
k. Breaker open, close, trip, trip-free, anti-pump, and auxiliary features shall function as designed.
l. The charging mechanism shall operate in accordance with manufacturer's published data.

G. Instrument Transformers
1. Visual and Mechanical inspection
a. Compare equipment nameplate data with drawings and specifications.
b. Inspect physical and mechanical condition.
c. Verify correct connection of transformers with system requirements.
d. Verify that adequate clearances exist between primary and secondary circuit wiring.
e. Verify the unit is clean.
f. Inspect bolted electrical connections for high resistance using one or more of the following methods:
1) Use of a low-resistance ohmmeter.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12
g. Verify that all required grounding and shorting connections provide contact.
h. Verify correct operation of transformer withdrawal mechanism and grounding operation.
i. Verify correct primary and secondary fuse sizes for voltage transformers.
j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
2. Electrical Tests – Current Transformers
a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
b. Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1000 volts dc for one minute. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations.

c. Perform a polarity test of each current transformer in accordance with ANSI/IEEE C57.13.1.
d. Perform a ratio-verification test using the voltage or current method in accordance with ANSI/IEEE C57.13.1.
e. Perform an excitation test on transformers used for relaying applications in accordance with ANSI/IEEE C57.13.1.
f. Measure current circuit burdens at transformer terminals in accordance with ANSI/IEEE C57.13.1.
g. When applicable, perform insulation-resistance tests on the primary winding with the secondary grounded. Test voltages shall be in accordance with NETA ATS Table 100.5.
h. Perform dielectric withstand tests on the primary winding with the secondary grounded. Test voltages shall be in accordance with NETA ATS Table 100.9.
i. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data.
j. 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.

3. Electrical Tests – Voltage Transformers
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Test voltages shall be applied for one minute in accordance with NETA ATS Table 100.5. For units with solid state components that cannot tolerate the applied voltage, follow manufacturer’s recommendations.
   c. Perform a polarity test on each transformer to verify the polarity marks or H1- X1 relationship as applicable.
   d. Perform a turns-ratio test on all tap positions.
   e. Measure voltage circuit burdens at transformer terminals.
   f. Perform a dielectric withstand test on the primary windings with the secondary windings connected to ground. The dielectric voltage shall be in accordance with NETA ATS Table 100.9. The test voltage shall be applied for one minute.
   g. Perform 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.
4. Test Values – Visual and Mechanical
   a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer’s published data. In the absence of manufacturer’s published data, use NETA ATS Table 100.12.
5. Test Values – Current Transformers

a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Insulation-resistance values of instrument transformers shall not be less than values shown in NETA ATS Table 100.5.
c. Polarity results shall agree with transformer markings.
d. Ratio errors shall be in accordance with C57.13.
e. Excitation results shall match the curve supplied by the manufacturer or be in accordance with ANSI C57.13.1.
f. Measured burdens shall be compared to instrument transformer ratings.
g. Insulation-resistance values of instrument transformers shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.5.
h. 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.
i. Power-factor or dissipation-factor values shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use test equipment manufacturer's published data.
j. Test results shall indicate that the circuits have only one grounding point.

6. Test Values – Voltage Transformers
a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Insulation-resistance values of instrument transformers shall not be less than values shown in NETA ATS Table 100.5.
c. Polarity results shall agree with transformer markings.
d. Ratio errors shall be in accordance with C57.13.
e. Measured burdens shall be compared to instrument transformer ratings.
f. 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 windings are considered to have passed the test.
g. Power-factor or dissipation-factor values shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use test equipment manufacturer's published data.
h. Test results shall indicate that the circuits are grounded at only one point.

H. Metering Devices
1. Visual and Mechanical Inspection
a. Compare equipment nameplate data with drawings and specifications.
b. Inspect meters and cases for physical damage.
c. Clean front panel and remove shipping restraint material.
d. Verify tightness of electrical connections.
e. Record model number, serial number, firmware revision, software revision, and rated control voltage.
f. Verify operation of display and indicating devices.
g. Record passwords.
h. Verify unit is grounded in accordance with manufacturer's instructions.
i. Verify unit is connected in accordance with manufacturer's instructions and project drawings.

j. Set all required parameters including instrument transformer ratios, system type, frequency, power demand methods/intervals, and communications requirements.

2. Electrical Tests
   a. Apply voltage or current as appropriate to each analog input and verify correct measurement and indication.
   b. Confirm correct operation and setting of each auxiliary input/output feature including mechanical relay, digital, and analog.
   c. After initial system energization, confirm measurements and indications are consistent with loads present.
3. Test Values – Visual and Mechanical
   a. Nameplate data shall be per drawings and specifications.
   b. Tightness of electrical connections shall assure a low resistance connection.
   c. Display and indicating devices shall operate per manufacturer's published data.
4. Test Values – Electrical
   a. Measurement and indication of applied values of voltage and current shall be within manufacturer's published tolerances for accuracy.
   b. All auxiliary input/output features shall operate per settings and manufacturer's published data.
   c. Measurements and indications shall be consistent with energized system loads.

I. Grounding System
1. Visual and Mechanical Inspection
   a. Verify ground system is in compliance with drawings, specifications, and NFPA 70 National Electrical Code Article 250.
   b. Inspect physical and mechanical condition.
   c. Inspect bolted electrical connections for high resistance using one or more of the following methods:
      1) Use of low-resistance ohmmeter.
      2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
   d. Inspect anchorage.
2. Electrical Tests
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   b. Perform fall-of-potential or alternative test in accordance with ANSI/IEEE 81 on the main grounding electrode or system.
   c. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and derived neutral points.
3. Test Values – Visual and Mechanical
   a. Grounding system electrical and mechanical connections shall be free of corrosion.
   b. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

c. Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

4. Test Values – Electrical
   a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. The resistance between the main grounding electrode and ground shall be no greater than five ohms for large commercial or industrial systems and one ohm or less for generating or transmission station grounds unless otherwise specified by the owner. (Reference ANSI/IEEE Standard 142)
   c. Investigate point-to-point resistance values that exceed 0.5 ohm.

J. Low Voltage Motor Control Centers
1. Refer to Section 2.03.B for appropriate inspections and tests of the motor control center bus.
2. Refer to Section 2.03.K for appropriate inspections and tests of the motor control center circuit breakers.

K. Molded and Insulated Case Circuit Breakers
1. Visual and Mechanical Inspection
   a. Compare equipment nameplate data with drawings and specifications.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage and alignment.
   d. Verify the unit is clean.
   e. Operate the circuit breaker to insure smooth operation.
   f. Inspect bolted electrical connections for high resistance using one or more of the following methods:
      1) Use of a low-resistance ohmmeter.
      2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12
   g. Inspect operating mechanism, contacts, and arc chutes in unsealed units.
   h. Perform adjustments for final protective device settings in accordance with the coordination study.
2. Electrical Tests
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with the circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.1.
   c. Perform a contact/pole-resistance test.
   d. Determine long-time pickup and delay by primary current injection.
   e. Determine short-time pickup and delay by primary current injection.
   f. Determine ground-fault pickup and time delay by primary current injection.
   g. Determine instantaneous pickup by primary current injection.
   h. Test functions of the trip unit by means of secondary injection.

i. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data.
j. Verify correct operation of auxiliary features 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
k. Verify operation of charging mechanism.

3. Test Values – Visual and Mechanical
   a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
   c. Settings shall comply with coordination study recommendations.
4. Test Values – Electrical
   a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Insulation-resistance values shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated.
   c. Microohm 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 breakers by more than 50 percent of the lowest value.
   d. Insulation-resistance values of control wiring shall not be less than two megohms.
   e. Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors. If manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS Table 100.7.
   f. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
   g. Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
   h. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances. In the absence of manufacturer's published data, refer to NETA ATS Table 100.8.
   i. Pickup values and trip characteristics shall be within manufacturer's published tolerances.
   j. Minimum pickup voltage of the shunt trip and close coils shall conform to the manufacturer's published data. In the absence of the manufacturer's published data, refer to NETA ATS Table 100.20.
   k. Breaker open, close, trip, trip-free, anti-pump, and auxiliary features shall function as designed.

l. The charging mechanism shall operate in accordance with manufacturer's published data.

L. Variable Frequency Drives
1. Visual and Mechanical Inspection
a. Compare equipment nameplate data with drawings and specifications.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, and grounding.
d. Verify the unit is clean.
e. Ensure vent path openings are free from debris and that heat transfer surfaces are clean.
f. Verify correct connections of circuit boards, wiring, disconnects, and ribbon cables.
g. Motor running protection:
1) Verify drive overcurrent setpoints are correct for their application.
2) If drive is used to operate multiple motors, verify individual overload element ratings are correct for their application.
3) Apply minimum and maximum speed setpoints. Verify setpoints are within limitations of the load coupled to the motor.
h. Inspect bolted electrical connections for high resistance using one or more of the following methods:
1) Use of a low-resistance ohmmeter.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12
i. Verify correct fuse sizing in accordance with manufacturer's published data.
2. Electrical Tests
a. Perform resistance measurements through bolted connections with low-resistance ohmmeter.
b. Test the motor overload relay elements by injecting primary current through the overload circuit and monitoring trip time of the overload element.
c. Test input circuit breaker by primary injection.
d. Perform insulation-resistance tests on all 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, follow manufacturer's recommendation.
e. Test for the following parameters in accordance with relay calibration procedures or as recommended by the manufacturer:
1) Input phase loss protection
2) Input overvoltage protection
3) Output phase rotation
4) Overtemperature protection
5) DC overvoltage protection
6) Over-frequency protection
7) Drive overload protection
8) Fault alarm outputs
f. Perform continuity tests on bonding conductors.
g. Perform startup of drive in accordance with manufacturer's published data. Calibrate drive to the system's minimum and maximum speed control signals.

h. Perform operational tests by initiating control devices.
   1) Slowly vary drive speed between minimum and maximum. Observe motor and load for unusual noise or vibration.
   2) Verify operation of drive from remote start/stop and speed control signals.
i. Measure fuse resistance.

3. Test Values – Visual and Mechanical
   a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
4. Test Values – Electrical
   a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Overload test trip times at 300 percent of overload element rating shall be in accordance with manufacturer's published time-current curve.
   c. Input circuit breaker test results shall be in accordance with Section 2.03.K.
   d. Insulation-resistance values of control wiring shall not be less than two megohms.
   e. Relay calibration test results shall be in accordance with Section 2.03.M.
   f. Continuity of bonding conductors shall be in accordance with Section 2.03.I.
   g. Control devices shall perform in accordance with system requirements.
   h. Operational tests shall conform to system design requirements.
   i. Investigate fuse resistance values that deviate from each other by more than 15 percent.

M. Solid State Protective Relays
1. Visual and Mechanical Inspection
   a. Compare equipment nameplate data with drawings and specifications.
   b. Inspect relays and cases for physical damage. Remove shipping restraint material.
   c. Tighten case connections. Inspect cover for correct gasket seal. Clean cover glass. Inspect shorting hardware, connection paddles, and/or knife switches. Remove any foreign material from the case. Verify target reset.
2. Electrical Tests
   a. Perform insulation-resistance test on each circuit-to-frame. Determine from the manufacturer's instructions the allowable procedures for this test for solid-state and microprocessor-based relays.
   b. Inspect targets and indicators.
      1) Determine pickup and dropout of relay targets.
      2) Verify operation of all light-emitting diode indicators.
      3) Set contrast for liquid-crystal display readouts.
      4) Test and record for minimum trip on all taps and leave on tap to be used. Submit recorded test data to the Engineer.

5) The minimum trip accuracy for protective relays is +/-5% and the time curve calibration is +/-% from manufacture's rating and curves for the particular relay.
6) Primary side current injection shall be performed on each current transformer (CT) to verify complete functional protection system.

c. Functional Operation
1) 25 – Sync Check Relay
   a) Determine closing zone at rated voltage.
   b) Determine maximum voltage differential that permits closing at zero degrees.
   c) Determine live line, live bus, dead line, and dead bus set points.
   d) Determine time delay.
   e) Verify dead bus/live line, dead line/live bus and dead bus/dead line control functions
2) 27 – Undervoltage Relay
   a) Determine dropout voltage.
   b) Determine time delay.
   c) Determine the time delay at a second point on the timing curve for inverse time relays.
3) 32 – Reverse Power Relay
   a) Determine minimum pickup at maximum torque angle.
   b) Determine closing zone.
   c) Determine maximum torque angle.
   d) Determine time delay.
   e) Verify the time delay at a second point on the timing curve for inverse time delay
4) 46 – Current Balance Relay
   a) Determine pickup of each unit.
   b) Determine percent slope.
   c) Determine time delay.
5) 47 – Phase Sequence or Phase Balance Voltage Relay
   a) Determine positive sequence voltage to close the normally open contact.
   b) Determine positive sequence voltage to open the normally closed contact (undervoltage trip).
   c) Verify negative sequence trip.
   d) Determine time delay to close the normally open contact with sudden application of 120 percent of pickup.
   e) Determine time delay to close the normally closed contact upon removal of voltage when previously set to rated system voltage.
6) 49T – Temperature (RTD) Relay
   a) Determine trip resistance.
   b) Determine reset resistance.
7) 50 – Instantaneous Overcurrent Relay
   a) Determine pickup.
   b) Determine dropout.
   c) Determine time delay.
8) 51 – Time Overcurrent
   a) Determine minimum pickup.

b) Determine time delays at two points on the time current curve.

9) 59 – Overvoltage Relay
   a) Determine overvoltage pickup.
   b) Determine time delay to close the contact with sudden application of 120 percent of pickup.

10) 81 – Frequency Relay
   a) Verify frequency set points.
   b) Determine time delay.
   c) Determine undervoltage cutoff.

11) 87 – Differential'
   a) Determine operating unit pickup.
   b) Determine the operation of each restraint unit.
   c) Determine slope.
   d) Determine harmonic restraint.
   e) Determine instantaneous pickup.

d. Control Verification
   1) Verify that each of the relay contacts performs its intended function in the control scheme including breaker trip tests, close inhibit tests, 86 lockout tests, and alarm functions.

e. System tests
   1) After the equipment is initially energized, measure magnitude and phase angle of all inputs and compare to expected values.
   2) Test critical logic and controls including source transfer logic, tie breaker interlocks, generator starting and stopping, etc.

f. Test Values
   1) Use manufacturer's recommended tolerances when other tolerances are not specified.
   2) When critical test points are specified, the relay shall be calibrated to those points even though other test points may be out of tolerance.

N. Standby Generator System
1. Visual and Mechanical Inspection
   a. Compare equipment nameplate data with drawings and specifications.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment, and grounding.
   d. Verify the unit is clean.
   e. Inspect for blockage of ventilating passageways.
   f. Inspect for proper operation of jack water heaters.
   g. Inspect integrity of engine cooling and fuel supply systems.
   h. Verify that there is no excessive mechanical and electrical noise.
   i. Inspect for overheating of engine or generator.
   j. Inspect proper installation of vibration isolators.
   k. Inspect proper cooling liquid type and level
2. Electrical and Mechanical Tests
   a. Perform insulation-resistance tests in accordance with ANSI/IEEE Standard 43.
      1) Machines larger than 200 horsepower (150 kilowatts): Test duration shall be ten minutes. Calculate polarization index.
      2) Machines 200 horsepower (150 kilowatts) and less:

Test duration shall be one minute. Calculate the dielectric-absorption ratio

b. Test protective relay devices in accordance with Section 2.03.M.
c. Verify phase rotation, phasing, and synchronized operation as required by the application.
d. Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
e. Conduct performance test in accordance with ANSI/NFPA 110.
f. Verify correct functioning of the governor and regulator.

3. Test Values – Visual and Mechanical
   a. Anchorage, alignment, and grounding should be in accordance with manufacturer's published data and system design.
4. Test Values – Electrical
   a. The recommended minimum insulation resistance (IR 1 min) test results in megohms shall be in accordance with NETA ATS Table 100.11
      1) The polarization index value shall not be less than 2.0.
      2) The dielectric absorption ratio shall not be less than 1.4.
   b. Protective relay device test results shall be in accordance with Section 2.03.N.
   c. Phase rotation, phasing, and synchronizing shall be in accordance with system design requirements.
   d. Low oil pressure, overtemperature, overspeed, and other protection features shall operate in accordance with manufacturer's published data and system design requirements.
   e. Vibration levels shall be in accordance with manufacturer's published data and shall be compared to baseline data.
   f. Performance tests shall conform to manufacturer's published data and ANSI/NFPA Standard 110.
   g. Governor and regulator shall operate in accordance with manufacturer's published data and system design requirements.

O. Uninterruptible Power Supplies
1. Visual and Mechanical Inspection
   a. Compare equipment nameplate data with drawings and specifications.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment, and grounding.
   d. Verify the unit is clean.
   e. Test all electrical and mechanical interlock systems for correct operation and sequencing.
   f. Inspect bolted electrical connections for high resistance using one or more of the following methods:
      1) Use of a low-resistance ohmmeter.
      2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
   g. Verify operation of forced ventilation.
   h. Verify that filters are in place and vents are clear.
2. Electrical Tests
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   b. Test static transfer from inverter to bypass and back. Use normal load, if possible.

c. Set free running frequency of oscillator.
d. Test dc undervoltage trip level on inverter input breaker. Set according to manufacturer's published data.
e. Test alarm circuits.
f. Verify synchronizing indicators for static switch and bypass switches.
g. Perform electrical tests for UPS system breakers in accordance with Section 2.03.K.
h. Perform electrical tests for UPS system automatic transfer switches in accordance with Section 2.03.R.
i. Perform electrical tests for UPS system batteries in accordance with Section 2.03P.

3. Test Values – Visual and Mechanical
   a. Electrical and mechanical interlock systems shall operate in accordance with system design requirements.
   b. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   c. Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
4. Test Values – Electrical
   a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Static transfer shall function in accordance with manufacturer's published data.
   c. Oscillator free running frequency shall be within manufacturer's published tolerances.
   d. DC undervoltage shall trip inverter input breaker.
   e. Alarm circuits shall operate in accordance with design requirements.
   f. Synchronizing indicators shall operate in accordance with design requirements.
   g. Breaker performance shall be in accordance with Section 2.03.K.
   h. Automatic transfer switch performance shall be in accordance with Section 2.03.R.
   i. Battery test results shall be in accordance with Section 2.03P.

P. Battery System – Valve-Regulated Lead Acid
1. Visual and Mechanical Inspection Plan
   a. Verify that batteries are adequately located.
   b. Verify that battery area ventilation system is operable.
   c. Verify existence of suitable eyewash equipment.
   d. Compare equipment nameplate data with drawings and specifications.
   e. Inspect physical and mechanical condition.
   f. Verify adequacy of battery support racks or cabinets, mounting, battery spill containment system, anchorage, alignment, grounding, and clearances.
   g. Verify electrolyte level. Measure pilot-cell electrolyte temperature.
   h. Verify the units are clean.
   i. Verify application of an oxide inhibitor on battery terminal connections.
   j. Inspect bolted electrical connections for high resistance using one or more of the following methods:

1) Use of a low-resistance ohmmeter.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12

2. Electrical Tests
   a. Perform resistance measurements through all bolted connections with a low-resistance ohmmeter.
   b. Measure negative post temperature.
   c. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
   d. Verify all charger functions and alarms.
   e. Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.
   f. Measure intercell connection resistances.
   g. Perform internal ohmic measurement tests.
   h. Perform a load test in accordance with manufacturer's published data or ANSI/IEEE 1106.
   i. Measure the battery system voltage from positive-to-ground and negative-to-ground.
3. Test Values – Visual and Mechanical
   a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
4. Test Values – Electrical
   a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Negative post temperature shall be within manufacturer's published data or IEEE 1188.
   c. Charger float and equalize voltage levels shall be in accordance with battery manufacturer's published data.
   d. The results of charger functions and alarms shall be in accordance with manufacturer's published data.
   e. Cell voltages shall be in accordance with manufacturer's published data.
   f. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   g. Cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical cells that are in a fully charged state, or shall be in accordance with manufacturer's published data.
   h. Results of load tests shall be in accordance with manufacturer's published data or ANSI/IEEE 1188.
   i. Voltage measured from positive to ground shall be similar in magnitude to the voltage measured from negative to ground.

Q. Battery Chargers
   1. Visual and Mechanical Inspection Plan
      a. Compare equipment nameplate data with drawings and specifications.

b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, and grounding.
d. Verify the units are clean.
e. Inspect bolted electrical connections for high resistance using one or more of the following methods:
    1) Use of a low-resistance ohmmeter.
    2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12
f. Inspect filter and tank capacitors.
g. Verify operation of cooling fans and presence of filters.

2. Electrical Tests
    a. Perform resistance measurements through all bolted connections with a low-resistance ohmmeter.
    b. Verify float voltage, equalize voltage, and high voltage shutdown settings.
    c. Verify current limit.
    d. Verify correct load sharing (parallel chargers).
    e. Verify calibration of meters in accordance with Section 7.11.
    f. Verify operation of alarms.
    g. Measure and record input and output voltage and current.
    h. Measure and record ac ripple current and voltage imposed on the battery.
    i. Perform full-load testing of charger.
3. Test Values – Visual and Mechanical
    a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
4. Test Values – Electrical
    a. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Float and equalize voltage settings shall be in accordance with the battery manufacturer's published data.
    c. Current limit shall be within manufacturer's recommended maximum.
    d. Results of load sharing between parallel chargers shall be in accordance with system design specifications.
    e. Results of meter calibration shall be in accordance with manufacturer's published data.
    f. Results of alarm operation shall be in accordance with manufacturer's published data and system design.
    g. Input and output voltage shall be in accordance with manufacturer's published data.
    h. AC ripple current and voltage imposed on the battery shall be in accordance with manufacturer's published data.
    i. Charger shall be capable of manufacturer's specified full load.

R. Automatic Transfer Switch
1. Visual and Mechanical Inspection

a. Compare equipment nameplate data with drawings and specifications.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, grounding, and required clearances.
d. Verify the unit is clean.
e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
f. Verify that manual transfer warnings are attached and visible.
g. Verify tightness of all control connections.
h. Inspect bolted electrical connections for high resistance using one or more of the following methods:
    1) Use of a low-resistance ohmmeter.
    2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
i. Perform manual transfer operation.
j. Verify positive mechanical interlocking between normal and alternate sources.

2. Electrical Tests
    a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    b. Perform insulation-resistance tests on all 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 for control devices that cannot tolerate the applied voltage, follow manufacturer's recommendation.
    c. Perform a contact/pole-resistance test.
    d. Verify settings and operation of control devices.
    e. Calibrate and set all relays and timers in accordance with Section 2.03.M.
    f. Verify phase rotation, phasing, and synchronized operation as required by the application.
    g. Perform automatic transfer tests:
        1) Simulate loss of normal power.
        2) Return to normal power.
        3) Simulate loss of emergency power.
        4) Simulate all forms of single-phase conditions.
    h. Verify correct operation and timing of the following functions:
        1) Normal source voltage-sensing and frequency-sensing relays.
        2) Engine start sequence.
        3) Time delay upon transfer.
        4) Alternate source voltage-sensing and frequency-sensing relays.
        5) Automatic transfer operation.
        6) Interlocks and limit switch function.
        7) Time delay and retransfer upon normal power restoration.
        8) Engine cool down and shutdown feature.

3. Test Values – Visual and Mechanical
    a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

b. Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

4. Test Values – Electrical
   a. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Insulation-resistance values of control wiring shall not be less than two megohms.
   c. 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.
   d. Control devices shall operate in accordance with manufacturer's published data.
   e. Relay test results shall be in accordance with Section 2.03.M.
   f. Phase rotation, phasing, and synchronization shall be in accordance with system design specifications.
   g. Automatic transfers shall operate in accordance with manufacturer's design.
   h. Operation and timing shall be in accordance with manufacturer's and system design requirements

S. Fiber Optic Cables
1. Visual and Mechanical Inspection
   a. Compare cable, connector, and splice data with drawings and specifications.
   b. Inspect cable and connections for physical and mechanical damage.
   c. Verify that all connectors and splices are correctly installed.
2. Optical Tests
   a. Perform cable length measurement, fiber fracture inspection, and construction defect inspection using an optical time domain reflectometer.
   b. Perform connector and splice integrity test using an optical time domain reflectometer.
   c. Perform cable attenuation loss measurement with an optical power loss test set.
   d. Perform connector and splice attenuation loss measurement from both ends of the optical cable with an optical power loss test set.
3. Test Values – Visual and Mechanical
   a. Cable and connections shall not have been subjected to physical or mechanical damage.
   b. Connectors and splices shall be installed in accordance with industry standards.
4. Test Values – Optical
   a. The optical time domain reflectometer signal shall be analyzed for excessive connection, splice, or cable backscatter by viewing the reflected power/distance graph.
   b. The optical time domain reflectometer signal shall be analyzed for excessive connection, splice, or cable backscatter by viewing the reflected power/distance graph.

c. Attenuation loss measurement shall be expressed in dB/km. Losses shall be within the manufacturer's recommendations when no local site specifications are available.
d. Attenuation loss measurement shall be expressed in dB/km. Losses shall be within the manufacturer's recommendations when no local site specifications are available.

T. Test ground fault interrupter (GFI) receptacles and circuit breakers for proper operation by methods sanctioned by the receptacle manufacturer.

U. A functional test and check of electrical components is required prior to performing subsystem testing and commissioning. Compartments and equipment shall be cleaned as required by other provisions of these Specifications before commencement of functional testing. Functional testing shall comprise:
1. Visual and physical check of cables, circuit breakers, transformers, and connections associated with each item of new and modified equipment.
2. Verification that electrical equipment has been labeled with Arc Flash protection boundary and PPE levels, as required by Section 16961.
3. Setting of protective relays in conformance with results of the Short Circuit Study required by Section 16961 and testing of relays to assure that relays will trip at the current value and time required by the Study.
4. Circuit Breakers:
   a. Circuit breakers that have adjustable time or pick-up settings for ground current, instantaneous overcurrent, short-time overcurrent, or long-time overcurrent, shall be field-adjusted by a representative of the circuit breaker manufacturer.
   b. Time and pickup setting shall correspond to the recommendations of the Short Circuit Study.
   c. Setting shall be tabulated and proven for each circuit breaker in its installed position.
   d. Test results shall be certified by the person performing the tests and shall be submitted to the Engineer.

V. Subsystem testing for each phase of construction shall occur after the proper operation of alarm and status contacts has been demonstrated or otherwise accepted by the Owner and after process control devices have been adjusted as accurately as possible. Alarm conditions shall be simulated for each alarm point, and alarm indicators shall be checked for proper operation. It is intended that the Contractor will adjust limit switches and level switches to their operating points prior to testing and will set pressure switches, flow switches, and timing relays as dictated by operating results.

W. Subsystems shall be defined as individual and groups of pumps, conveyor systems, chemical feeders, air conditioning units, ventilation fans, air compressors, etc.

X. After initial settings have been completed, each subsystem shall be operated in the manual mode and it shall be demonstrated that operation is in compliance with the Contract Documents. Once the manual mode of operation has been proven, automatic operation shall be demonstrated to verify such items as proper start and stop sequence of pumps, proper operation of valves, proper speed control, etc.

Y. Voltage Field Test:
1. Check and record voltage at point of termination of SDG&E supply system after the installation is essentially complete and has been made operational.

2. Check and record voltage amplitude and balance between phases for loaded and unloaded conditions.
3. Unbalance Corrections:
    a. Notify the Owner if balance (as defined by NEMA) exceeds 1%, or if voltage varies throughout the day and from loaded to unloaded condition more than plus or minus 4% of nominal.
4. Voltage Balance Report:
    a. Submit Voltage Balance Report for each switchboard, distribution panel-board, load center, motor control center, and transformer.

Z. Equipment Line Current Tests:
1. Check and record line current in each phase for each major piece of electrically-operated equipment.
2. Make a line current check after SDG&E has made final adjustments to supply voltage magnitude or balance.
3. If any phase current for any piece of equipment is above rated nameplate current, prepare a supplement to the Equipment Line Current Report that identifies any causes of problems and corrective action that was taken.
4. Submit Equipment Line Current Report for each point of connection to motors, transformers, branch circuit distribution connections, and incoming utility service connection.

2.04 TEST REPORTS

A. The test report shall include the following:
1. Summary of project.
2. Description of equipment tested.
3. Description of test.
4. Test data.
5. Analysis and recommendations.

B. Test data records shall include the following minimum requirements:
1. Identification of the testing organization.
2. Equipment identification.
3. Humidity, temperature, and other atmospheric conditions that may affect the results of the tests/calibrations.
4. Date of inspections, tests, maintenance, and/or calibrations.
5. Identification of the testing technician.
6. Indication of inspections, tests, maintenance, and/or calibrations to be performed and recorded.
7. Indication of expected results when calibrations are to be performed.
8. Indication of "as-found" and "as-left" results.
9. Sufficient spaces to allow all results and comments to be indicated.

C. The Contractor shall submit the complete report to the Engineer for review.

TABLE 100.18

THERMOGRAPHIC SURVEY
SUGGESTED ACTIONS BASED ON TEMPERATURE RISE
(AS PER PARAGRAPH 2.02.H.5)

Temperature difference (ΔT) based on comparisons between similar components under similar loading.	Temperature difference (ΔT) based upon comparisons between component and ambient air temperatures.	Recommended Action
1ºC - 3ºC	1ºC - 10ºC	Possible deficiency; warrants investigation
4ºC - 15ºC	11ºC - 20ºC	Indicates probable deficiency; repair as time permits
- - - - - -	21ºC - 40ºC	Monitor until corrective measures can be accomplished
>15ºC	>40ºC	Major discrepancy; repair immediately

Temperature specifications vary depending on the exact type of equipment. Even in the same class of equipment (i.e., cables) there are various temperature ratings. Heating is generally related to the square of the current; therefore, the load current will have a major impact on ΔT. In the absence of consensus standards for ΔT, the values in this table will provide reasonable guidelines.

An alternative method of evaluation is the standards-based temperature rating system as discussed in Chapter 8.9.2, Conducting an IR Thermographic Inspection, Electrical Power Systems Maintenance and Testing, by Paul Gill, PE, 1998.

It is a necessary and valid requirement that the person performing the electrical inspection be thoroughly trained and experienced concerning the apparatus and systems being evaluated, as well as knowledgeable of thermographic methodology.

PART 3 - EXECUTION

3.01 FIELD TESTS

A. The Contractor shall provide ten Working Days' notice to the Owner prior to any field testing to permit witnessing of the testing.

TEST RECORD SHEETS

The test record sheets listed below shall be used to record testing of electrical equipment and of the electrical installation as required by these specifications. Sample copies of each sheet are attached.

Sheet No.	Title
1	Insulation Resistance (Power, Control Wire, and Cable) Test Record
2	Insulation Resistance (Instrument Wire and Cable) Test Record
3	Ground Electrode Testing Test Record
4	Neutral Grounding Resistor Test Record
5	Bonding Resistance Readings (Nonelectrical Equipment/Structures) Test Record
6	Bonding Resistance Readings (Electrical Equipment) Test Record
7	Insulation Resistance (Transformer) Test Record
8	Insulation Resistance (Equipment) Test Record
9	Insulation Resistance (Rotating Equipment) Test Record
10	Equipment Absorption Ratio and Polarization Index Test Record
11	Electric Motor Run-In Test Record

INSULATION RESISTANCE
(POWER, CONTROL WIRE, AND CABLE)
TEST RECORD

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

AMBIENT TEMPERATURE: _____ ºC _____ ºF DATE: _____

NOTES: 1. Perform Insulation Resistance Test (megger) between each conductor and all other conductors and metallic sheath for cables with nonshielded conductors. Test between each conductor and shield for multiconductor cables with shielded conductors. Record lowest reading for each cable.

2. Use 1,000-V test set for cable rated 600 volts and 2,500-V test set for cable rated over 600 volts.

3. Readings will vary inversely with temperature and cable length. When the use of temperature correction factors is specified, attach a second sheet with computed values. Indicate on each sheet "measured" or "temperature corrected."

Panel No. Circuit No. Feeder No.	Wire Tagging	Cable Rated Voltage	Wire or Cable				Insulation Resistance (megohms) *	Initials
			Quantity	Size	From	To		

*Minimum acceptable values:

Cable Rated Voltage	Test Duration	Resistance for Cable Only	Cable/Wire Size or Amperage (megohms)	Resistance When Cable Connected to Equipment (ohms)

DISTRIBUTION:

CONTRACTOR/Date _____

INSULATION RESISTANCE
(INSTRUMENT WIRE AND CABLE)
TEST RECORD

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

AMBIENT TEMPERATURE: _____ ºC _____ ºF DATE: _____

NOTES: 1. Record only the lowest value.

2. MP - Multi-pair cable. SP - Single pair cable.
3. Megger with instruments disconnected.
4. Use 250 volt (or lower voltage, when specified) range on DC test set.
5. Readings will vary with temperature and cable length.

Cable Number or Instrument Number	Indicate MP or SP Type (2)	Conductor to Conduit (Single Pair Non-Shielded Cables) (megohms)	Conductor to Conductor (megohms) (1)	Shield to Conductor to Shield (megohms) (1)	Overall Shield to Shield (Multipair Cables Only) (megohms) (1)	Lead and Armor (Multipair Cables Only) (megohms)	Shield to Conduit (Single Pair Cables Only) (megohms)	Initials

DISTRIBUTION:

CONTRACTOR/Date _____

GROUND ELECTRODE TESTING
TEST RECORD

TEST EQUIPMENT: _____ (Note 1) _____ (Note 2)

REFERENCE DRAWING: _____ _____

NOTES: 1. Record resistance-to-earth for each electrode with all other conductors disconnected. Resistance not to exceed 25 ohms for any single anode.

2. Check continuity from each electrode to any test bar or other electrode such that the complete ground loop is tested.

Rod Number	Resistance to Earth (ohms)	Ambient Temperature (ºC/ºF)	Weather	Taps	Initials/Date

DISTRIBUTION:

CONTRACTOR/Date _____

NEUTRAL GROUNDING RESISTOR
TEST RECORD

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

NOTES:
1. Use 1,000-volt test set for 600-volt equipment and below, 2,500-volt test set for equipment rated over 600 volts.
2. Resistor must be disconnected from ground and neutral during Insulation Resistance (megger) and DC Overpotential Tests.
3. Resistor must be disconnected from neutral during Cold Resistance Test.
4. Apply DC Overpotential Test between terminals and ground for the complete device. (The voltage applied between the terminals of each assembly and its grounded enclosure shall be twice the rated AC voltage plus 1000 V when rated 600 V or less, or 2.25 times the rated AC voltage plus 2000 V when rated over 600 V for 1 minute.) This test is a Pass/Fail test based purely on withstand alone.
5. Inspect assembly for damage and missing parts.
6. Check to assure that the center tap ratio is correct, when CT is supplied with resistor.

Verify resistor reterminated.

Tag. No.	Cold Res. (ohms)	Insul. Res. (megohms)*	Overpot. (4)	CT Ratio Pri-Sec	Reterm (4)	Initials/Date

*Minimum acceptable values:

VOLTAGE CLASS	INSULATION RESISTANCE (megohms)

DISTRIBUTION:

CONTRACTOR/Date _____

BONDING RESISTANCE READINGS
(NONELECTRICAL EQUIPMENT/STRUCTURES)
TEST RECORD

TEST EQUIPMENT USED: _____ WEATHER: _____

NOTES: 1. Vessels, tanks, and structural steel bonded to the main grounding system, dedicated ground rod or foundation, as indicated on drawings listed below.

2. Measure resistance from ground wiretap (or anchor bolt) to tagged equipment frame or structural steel.

EQUIPMENT TAG NO. OR STRUCTURE	DRAWING	MEASURED RESISTANCE (ohms)	INITIALS/DATE

DISTRIBUTION:

CONTRACTOR/Date _____

BONDING RESISTANCE READINGS
(ELECTRICAL EQUIPMENT)
TEST RECORD

TEST EQUIPMENT USED: _____ WEATHER: _____

NOTES: 1. Electrical equipment bonded to the main grounding system or dedicated ground rod, as indicated on drawings listed below.

2. Measure resistance from ground wiretap to tagged equipment bus bars, tagged equipment enclosures, and any other points indicated on the drawings.

EQUIPMENT TAG NO. OR STRUCTURE	DRAWING	MEASURED RESISTANCE (ohms)	INITIALS/DATE

DISTRIBUTION:

CONTRACTOR/Date _____

INSULATION RESISTANCE
(TRANSFORMER)
TEST RECORD

SUBSTATION NO.: _____ TEST EQUIPMENT: _____

NOTES:
1. Use 1,000-V test set for 600-volt equipment and below, 2,500-V test set for equipment rated 601 - 5,000 volts, and 5,000-V test set for equipment rated over 5,000 volts.
2. Test voltage to be applied for 1-minute duration, and reading taken.
3. Neutral must be disconnected from ground during test.
4. Record temperature of surrounding air temperature for dry-type transformers.
5. Readings will vary inversely with temperature. When the use of temperature correction factors is specified, attach second sheet with computed values. Indicate on each sheet "measured" or "temperature corrected."

Equip. Tag No.	RESISTANCE IN (megohms) *						Pri to Sec	Voltage Rating (kV)	Pri-Sec or Air	Liquid Temp. (ºC/ºF)
	Primary			Secondary						
	∅A to G	∅B to G	∅C to G	∅A to G	∅B to G	∅C to G				

*Minimum acceptable values:

VOLTAGE CLASS	RESISTANCE (megohms)

TESTER'S INITIALS/DATE _____

DISTRIBUTION:

CONTRACTOR/Date _____

INSULATION RESISTANCE (EQUIPMENT)
TEST RECORD

TEST EQUIPMENT: _____ SUBSTATION: _____

AMBIENT TEMPERATURE: _____ ºC _____ ºF DATE: _____

REFERENCE DRAWING: _____ REF. SEC.: _____

NOTES: 1. Use 1,000-V test set for equipment rated 600 volts and below, 2,500/5,000-V test set for equipment rated over 600 volts.

2. For equipment with solid state control circuits, consult manufacturer's literature for maximum test voltages.

Switchgear or MCC (or other)	INSULATION RESISTANCE (megohms) *						Test Voltage (kV)	Rated Voltage (kV)	Initials/Date
	∅A to G	∅B to G	∅C to G	∅A to ∅B	∅B to ∅C	∅C to ∅A			

*Minimum acceptable values:

EQUIPMENT VOLTAGE CLASS	RESISTANCE (megohms)

TESTER'S INITIALS/DATE _____

DISTRIBUTION:

CONTRACTOR/Date _____

INSULATION RESISTANCE (ROTATING EQUIPMENT)
TEST RECORD

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

AMBIENT TEMPERATURE: _____ ºC _____ ºF DATE: _____

EQUIP. TEMP., IF KNOWN: _____ ºC _____ ºF HOW KNOWN: _____

NOTES:
1. Use 1,000-V test set for equipment 600-volt and below, 2,500/5,000-V test set for equipment rated over 600 volts.
2. Test duration shall be 1 minute, note if otherwise: _____.
3. Isolate all motor leads from one another and from frame, test phase separately, wherever practical.
4. Document testing of low voltage and medium voltage equipment on separate sheets.
5. Readings will vary inversely with temperature. When the use of temperature correction factors is specified, attach second sheet with computed values. Indicate on each sheet "measured" or "temperature corrected."

Equip. Tag No.	INSULATION RESISTANCE (megohms) *						Rated Voltage	Equipment Initial/Date
	∅A to G	∅B to G	∅C to G	∅A to ∅B	∅B to ∅C	∅C to ∅A		

*Minimum acceptable values:

VOLTAGE CLASS	RESISTANCE (megohms)

DISTRIBUTION:

CONTRACTOR/Date _____

EQUIPMENT ABSORPTION RATIO AND POLARIZATION INDEX
TEST RECORD

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

AMBIENT TEMPERATURE: _____ ºC _____ ºF DATE: _____

EQUIP. TEMP., IF KNOWN: _____ ºC _____ ºF REL. HUMIDITY: _____

NOTES: 1. Perform test as indicated on Test Records for each individual equipment type. Reference the following sheets:

Transformers	8
Equipment	9
Motors and Generators	10

2. Absorption Ratio = 1-Minute Resistance Value / 30-Second Resistance Value

3. Polarization Index = 10-Minute Resistance Value / 1-Minute Resistance Value

OHMS TO GROUND 30-SECOND READING ∅A TO GROUND	OHMS TO GROUND 1-MINUTE READING ∅A TO GROUND	OHMS TO GROUND 10-MINUTE READING ∅A TO GROUND	DIELECTRIC ABSORPTION RATIO	POLARIZATION INDEX
OHMS TO GROUND 30-SECOND READING ∅B TO GROUND	OHMS TO GROUND 1-MINUTE READING ∅B TO GROUND	OHMS TO GROUND 10-MINUTE READING ∅B TO GROUND	DIELECTRIC ABSORPTION RATIO	POLARIZATION INDEX
OHMS TO GROUND 30-SECOND READING ∅C TO GROUND	OHMS TO GROUND 1-MINUTE READING ∅C TO GROUND	OHMS TO GROUND 10-MINUTE READING ∅C TO GROUND	DIELECTRIC ABSORPTION RATIO	POLARIZATION INDEX

TESTER'S INITIALS/DATE _____

DISTRIBUTION:

CONTRACTOR/Date _____

ELECTRIC MOTOR RUN-IN
TEST RECORD

TEST EQUIPMENT: _____ REFERENCE DRAWING: _____

NOTES: 1. Duration of tests to comply with specifications.

TEST	REMARKS	INITIALS/DATE
RESISTANCE: Bonding resistance measured from motor frame to main ground/earth system tap. _____ ohms		
VOLTAGE: Actual voltage measured at Motor Control Center. _____ volts		
ROTATION CHECK: Bump motor to verify rotation. Motor to be uncoupled.		
NO LOAD CURRENT: At beginning of test _____ amps At end of test _____ amps		
TEMPERATURE OF BEARING: Check bearing for high temperature: Before start: 15 minutes after start 30 minutes after start 1 hour after start 2 hours after start 3 hours after start		
VIBRATION: Make visual inspection during run-test. Record any unusual vibration in remarks column.		
NOISE: Record any unusual noise in remarks column.		

DISTRIBUTION:

CONTRACTOR/Date _____

SECTION 16955

CONTROL DEVICES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.

B. Work Included: Furnish and install all control devices complete, including, as applicable, enclosures, engraved escutcheons or nameplates, gaskets, lenses, lamps and mounting provisions.

C. Related Work Specified Elsewhere:
   1. Section 16920: Motor Control Center[s]
   2. Section 16924: Variable Frequency Drives (VFD) Over 5 Horsepower
   3. Section 17510: Panels

1.02 REFERENCE STANDARDS

A. National Electrical Manufacturers Association (NEMA) Publications:
   1. ICS1 General Standards for Industrial Controls and Systems
   2. ICS2 Standards for Industrial Control Devices, Controllers and Assemblies
   3. ICS6 Enclosures for Industrial Controls and Systems

1.03 SUBMITTALS

A. Submit material or equipment data in accordance with the Product Review category of the General Conditions and the submittal requirements of Section 16010.

PART 2 - PRODUCTS

2.01 GENERAL

A. All control devices shall conform to applicable provisions of NEMA Standards ICS1 and ICS2.

2.02 CONTROL AND TIMER RELAYS

A. General: Relays shall be provided as necessary to perform switching functions required of control panels and other control circuits. Relays shall be of the following types (abbreviations in parentheses correspond to labels on the Drawings):
   1. Size 0 Magnetic Contactors (MS): Provide Size 0 magnetic contactors for driving Size 4 and Size 5 ac operated motor starters. Provide Size 0 contactors of the same type and manufacture as the motor starter contactors.
   2. Relays (CR):
      a. Provide machine tool relays for the following applications:
         1) All relays driving 120 Vac motor starters up to and including Size 3.

2) All relays driving non-motor loads up to 6 amps (or 720 VA).

b. Provide machine tool type relays with convertible contacts rated 10 amperes continuous with NEMA Rating Designation A600 for ac applications and N600 for dc applications. Coils shall be designed for continuous duty and shall have the voltage rating indicated on the Drawings.

c. Relays shall be the magnetically held type unless designated otherwise on the Drawings. For each relay provide one spare Form C contact over and above the number indicated on the Drawings. In addition, for latching relays, provide coil clearing contacts as necessary.

d. Manufacturer: Square D, Class 8501, Type X; General Electric CR120B; or equal.

3. General Purpose Control (GR) or (AR) Relays (plug-in):

a. Provide plug-in style 2-, 3-, or 4-pole enclosed relays with integral neon or LED indicators for the following applications:

1) Relay logic (relays driving other relays, including machine tool relays) operating at voltages up to 120 Vac.

2) Control power switching.

3) All relays driving non-motor loads up to 2 amps (240 VA) at 120 Vac.

b. Provide relay sockets rated for 10 amp, 240 Vac with screw-type barriered terminals.

c. Manufacturer: Square D, Class 8501, Type R; Allen-Bradley Bulletin 700; or equal.

4. Timing Relays (TR) and (TD):

a. General: Relays designated TR shall be machine tool industrial relays, while those designated as TD shall be general purpose plug-in time delay relays.

b. Timing Relay (TR): Timing relay shall be machine tool industrial relay with solid-state timer and external adjustment dial. Range shall be 0 to 120 seconds unless indicated otherwise on the Drawings. Relay shall include an LED indicator and instantaneous and time-delay contacts rated at 10 amps, meeting NEMA A600 designation. Timing relay shall be "on delay" or "off delay" as indicated on the Drawings and shall be Allen Bradley Type RT-RTA; Square D; or equal.

c. Time Delay Relays (TD): Relay shall be solid-state with multi-range programmable settings. The relays shall include a calibrated front dial and LED indicator and shall be complete with socket. Relays shall be "on delay" or "off delay" type as indicated on the Drawings. Provide an additional form C contacts over and above the number indicated on the Drawings. Relay contacts shall be rated 10 amp, 120 Vac. Relays shall be ATC Type 328; Idec Type RTEL; or equal.

5. General Requirements:

a. Provide relays rated for 1 million operations at 10 amp, 120 Vac, at power factor of 0.2.

b. Where timing relays are interfaced to motor starters or adjustable speed motor controllers, provide auxiliary machine-tool relays or Size 0 magnetic contactors. Refer to previous specifications for machine-tool relays and Size 0 magnetic contactors.

c. Where timing relays or control relays require additional contacts, provide auxiliary control relays, properly sized for the application as described previously in this Section.

2.03 INTRINSICALLY SAFE RELAYS (ISR)

A. Unit shall be fixed sensitivity type and either UL or FM approved for use with a remote pilot device (dry contact) located in Class 1, Division 1, Groups C and D atmospheres. Supply power shall be 120 Vac, 60 Hz. Provide load contacts as shown on the Drawings, except provide a minimum of one single-pole double-throw set. Contact ratings shall be 10 amperes or better at 120 Vac. Unit shall be BW Series 53; Warrick Series 7; or equal. See Section 16999.

2.04 ELAPSED TIME METERS (ETM)

A. Elapsed time meters shall be of the synchronous motor-driven type having a minimum of six (6) decimal digits where the least significant digit shall represent tenths (1/10ths) of hours. Unless specified otherwise, they shall not be equipped with a reset button. They shall be for panel mounting with a square bezel approximately 2-1/2 inches on a side. Meter voltage shall be not more than 120 Vac for meters mounted in instrumentation panels. Elapsed time meters shall be ATC 5702; Yokogawa/General Electric Series 200; Type 240; or equal.

2.05 CONTROL PANEL ACCESSORIES

A. Relays, timers and other internally mounted equipment shall be of the types specified in other sections of these Specifications.

B. Panel face mounted equipment shall be of the types specified in other sections of these Specifications.

C. Standards: All control devices shall conform to applicable provisions of NEMA Standards ICS 1 and ICS 2.

D. Pushbuttons, Selector Switches and Pilot Lights:
   1. Shall be heavy-duty oiltight units; each unit shall have an engraved escutcheon plate unless nameplates are indicated on the Drawings or are necessary because of length of identification. Pushbuttons and selector switches shall have contacts rated 10 amperes continuous, Rating Designation A600 in conformance with NEMA ICS 2.
   2. Pushbuttons used as emergency stop devices shall have a padlockable means for maintaining an open circuit. Indicating lights shall be push-to-test transformer type with lenses of the colors shown on the Drawings.

E. Multiposition control switches shall have rotary action, round knurled handle and the number of positions and stages shown on the Drawings. They shall be suitable for panel mounting. Each position shall have a positive detent. Contacts shall have a continuous current rating of 10 amperes at 300 Vac. Switches shall have integral indicator.

F. For 4-20 mAdc and 1 to 5 Vdc signal selector switches, provide oiltight selector switches with electronic duty gold contact blocks. Provide sliding contacts for reliable operation without benefit of thermal cleaning action.

G. Manufacturer: Provide Microswitch heavy-duty oiltight manual controls, Type PT, with electronic duty gold contact blocks; Allen-Bradley Bulletin 800T oiltight selector switch with stackable "Logic-Reed" contact blocks; or equal.

H. Colors and Descriptions:
   1. Indicating Lamps: Unless otherwise noted on the Drawings, the following color code and inscriptions shall be followed for the lenses of all indicating lights.

Indicating Lamp Inscription	Color
ON/START	Red
OFF/STOP	Green
CLOSED	Green
LOW	Amber
FAIL	Red
HIGH	Amber
OPEN	Red
POWER ON	White
RESET	Red
AUTO	Blue

2. Lettering shall be black on white and amber lenses. Lettering shall be white on red and green lenses.
3. Pushbuttons: Follow color coding for indicating lamp above.
4. All unused or noninscribed buttons shall be black. Lettering shall be black on white and yellow buttons. Lettering shall be white on black, red and green buttons.

I. Panel Lights and Receptacles: Panels shall be internally lighted by fluorescent lamps, provided with guards and a toggle switch located convenient to each access door. One duplex GFI type receptacle shall be provided in each panel section. The lights and receptacles shall be wired to outgoing terminal blocks for 120 volt, 60 Hertz, single phase supply.

J. Nameplates: Unless specified otherwise in the Drawings, nameplates shall be black lamacoid with minimum 3/16-inch-high white letters for major area titles, 5/32-inch for component titles, and 1/8-inch for subtitles, and shall be fastened with a permanent but dissolvable adhesive or by screws.

2.06 CONTROL STATIONS

A. Provide control stations complying with NEMA ICS 6 for manual control functions as follows and as shown on the Drawings: start-stop pushbutton, hand-off-auto, forward-reverse-jog-stop, etc. Control stations shall include selector switches, pushbuttons, and indicators as specified in this Section.

B. Enclosures shall be as follows:
1. Dry Locations: NEMA Type 12
2. Corrosive Locations: NEMA Type 4X
3. Hazardous Locations (Gases): NEMA Type 7
4. Hazardous Locations (Dust): NEMA Type 9
5. Wet Locations: NEMA Type *[4] [4X]*

C. Nameplates: Provide an engraved plastic nameplate for each control station and escutcheons or nameplates for devices mounted thereon.

D. Provide pushbuttons, selector switches, indicators, etc., as shown on the Drawings and as required. Provide control devices with NEMA ratings matching that of the control station.

E. Manufacturer: Provide Allen-Bradley; Westinghouse; Crouse-Hinds; or equal.

PART 3 - EXECUTION

3.01 GENERAL

A. Identify all control devices with engraved plastic nameplates or escutcheons, as applicable. Install control devices as recommended by the manufacturer.

3.02 PROBES AND HOLDER

A. Adjust potentiometer to suit conductivity of water.

END OF SECTION

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SECTION 16961

POWER SYSTEM STUDIES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.

1.02 SCOPE OF WORK

A. Obtain the services of an independent firm to provide complete Short-Circuit and Protective Device Coordination studies, and Arc Flash Risk Assessment for the electrical system as defined below. The firm performing the work shall have been regularly engaged in short-circuit and protective device coordination services for a period of at least 10 years.

B. The firm performing the work shall be responsible for the collection of all data required to perform the studies, including the electrical utility company's short-circuit current contribution.

C. For the purpose of this specification Section, the "Electrical System" shall be defined as the entire power distribution system, including the utility company's main service disconnect down through the main circuit breaker on each 240/120VAC panelboard of all distributed branch circuits. Some equipment not modified as part of this contract is required to be included in the studies defined in this Section. Items within the "Electrical System" are comprised of:
   1. All utility transformers
   2. All 480 VAC generators, transfer switches, switchboards, panelboards, distribution, power conditioning, motor control, and motors
   3. All 480-208 VAC and 480-240 VAC transformers feeding panelboards
   4. All 240 VAC panelboards.

D. The Short-Circuit Study shall provide for the calculation of fault currents at each piece of gear in the Electrical System for the entire Site. Fault currents shall be calculated for scenarios of utility and standby power, as outlined in this Section.

E. The Protective Device Coordination Study shall include trip characteristics for all protective devices in the Site Electrical System, from the utility company's main service disconnect through the main circuit breaker on each 240/120 VAC panelboard of all distributed branch circuits. Trip characteristics shall be analyzed for scenarios of utility and standby power, as outlined in this Section.

F. The Arc Flash Risk Assessment shall provide for arc flash incident energy calculations at all panels as required by NFPA 70E.

G. Reports:
   1. Reports for the Short-Circuit Study, Protective Device Coordination Study, and Arc Flash Risk Assessment shall be stamped and signed by a California Registered Electrical Engineer.
   2. Report calculations shall be generated by a software analysis application with proven accuracy and reliability at performing 3-phase fault calculations.

1.03 REFERENCE STANDARDS

A. Institute of Electrical and Electronics Engineers, Inc. (IEEE)

B. American National Standards Institute (ANSI)

C. The National Fire Protection Association (NFPA)

D. InterNational Electrical Testing Association (NETA) Standard for Acceptance Testing Specifications (ATS)

E. NFPA 70E, Standard for Electrical Safety in the Workplace

F. IEEE 1584, Guide for Performing Arc-Flash Hazard Calculations

G. Occupational Safety and Health Administration (OSHA) (29 CFR PART 1910), Occupational Safety and Health Standards for General Industry

1.04 SUBMITTALS

A. Submit data in accordance with the Product Review category of the General Conditions and the submittal requirements of Section 16010.

B. Submit credentials of firm performing the studies to demonstrate sufficient experience with performing this type of work, as specified herein.

C. Preliminary: Preliminary Short-Circuit Study, Protective Device Coordination Study, and Arc Flash Risk Assessment shall be submitted to the Engineer for review prior to release of equipment drawings for manufacturing. If formal completion of the studies may cause delay in equipment manufacturing, approval from the Engineer may be obtained for preliminary submittal of sufficient study data to ensure that the selection of device and characteristics will be satisfactory.

D. Results of the Short-Circuit Study, Protective Device Coordination Study, and Arc Flash Risk Assessment shall be summarized in a final report. Submit hardbound copies of the complete final report and one digital copy in PDF on a CD. Electronic delivery shall contain full searchable text, and include any computer models developed for the studies at no additional cost.

E. Sample arc flash warning labels for each piece of equipment. Submit copies of labels at full size, with all required information as calculated by the Arc Flash Risk Assessment.

1.05 DATA COLLECTION

A. The firm performing the Short-Circuit Study, Protective Device Coordination Study, and Arc Flash Risk Assessment shall furnish the Contractor with a listing of required data. The Contractor shall collect and furnish all required data. The Contractor shall expedite collection of the data to eliminate unnecessary delays and assure completion of the studies as required for final acceptance of the equipment shop drawings and/or prior to the release of the equipment for manufacturing.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS

A. The Short-Circuit Study and Protective Device Coordination Study shall be performed as outlined in InterNational Electrical Testing Association (NETA) Standard for Acceptance Testing Specifications, Section 6 with exceptions as included in this Section.

B. In order to select relays and fuse characteristics as required for optimum coordination, the coordination study shall be performed as soon as the vendors for the new electrical equipment are identified. Relays and fuse selection by the power distribution equipment suppliers shall be based on the results of the favorably reviewed study.

C. The studies shall be submitted to the Engineer for acceptance before final acceptance of power distribution equipment submittals and before any settings are made on equipment.

D. The final report for the Short-Circuit Study, Protective Device Coordination Study, and Arc Flash Risk Assessment shall be bound in a standard 8 1/2-inch by 11 inch sized report. The selection of all protective relay types, current transformers, and fuse types and ratings shall be the responsibility of the manufacturer and shall be based on the preliminary draft of the coordination study, which shall be submitted with the equipment shop drawings (or earlier). The studies shall be accepted by the Engineer before any equipment is shipped. See Paragraph 1.03 for submittal requirements.

E. The report shall include a single line diagram depicting the entire Electrical System included in the analysis. At a minimum, the single line diagram shall be on an 11-inch by 17-inch sheet, and include the following information:
   1. Equipment/bus tags which match the contract documents
   2. Equipment/bus ampacity ratings
   3. Motor horsepower
   4. Protective device frame rating, trip setting, and curve options, as applicable
   5. Transformer primary/secondary voltages, kVA rating, and impedance
   6. Conductor materials, insulation types, and lengths

F. The studies shall be run on each of the following scenarios:
   1. Utility power
   2. Generator power

3.02 SHORT-CIRCUIT STUDY

A. Provide a complete Short-Circuit Study. The study shall include, but shall not be limited to, the following, as applicable:
   1. Full compliance with applicable ANSI and IEEE Standards.
   2. Performed on nationally recognized computer software, such as ETAP or SKM Power Tools.
   3. Overall system impedance diagram. The diagram shall include the power company's impedance and X/R ratios and circuit element impedances (e.g., transformers, generators, motors, VFDs, feeders, distribution buses as applicable).

4. Available three phase and ground fault asymmetrical and symmetrical short-circuit fault currents at each piece of electrical equipment, bus, transformer, etc.
5. The momentary and interrupting rating of all elements of the distribution system shall be listed. The maximum available short-circuit fault current available at each element shall be calculated.
6. Executive summary describing the distribution system, the procedures used to develop the study, utility related information furnished by the utility company, including the name and telephone number of the individual supplying the information, identification of all assumptions made in the preparation of the study, identification of any problem areas, and a definitive statement concerning the adequacy of the distribution system to interrupt and withstand the maximum possible short-circuit fault current.
7. Computer printouts for the three phase, single phase and ground fault studies. Printouts shall indicate the short-circuit fault current available at each major equipment and distribution bus within the medium and low voltage distribution systems.

3.03 PROTECTIVE DEVICE COORDINATION STUDY

A. Provide a complete Protective Device Coordination Study. The Protective Device Coordination Study shall include, but shall not be limited to:
   1. Utility protective devices.
   2. Service entrance.
   3. Low voltage power system transformers.
   4. Low voltage switchgear, switchboards, power distribution panels and motor control centers.
   5. Power factor correction and harmonic mitigation equipment.
   6. Motor starters and variable frequency drives.
   7. Standby generators.
   8. A tabulation of all the settings for every over current protective device, timer, power system relays (e.g., ANSI 50, 51), circuit breaker, recommended fuse and current transformer ratings, etc.
   9. Transformer excitation current.
   10. Motor and cable damage curves in accordance with the manufacturer's recommendations.
   11. Select relay types (e.g., inverse, very inverse, extremely inverse, overcurrent with or without voltage restraint, timers), current transformer ratings and types, fuse, residually or zero sequence connected ground faults protection, etc. that will allow the system to be protected within the equipment fault ratings and provide the maximum possible coordination between the protective devices.
   12. Provide recommended settings for protective devices, such as relays and circuit breakers, to achieve the best selectivity to minimize system disturbances during fault clearing.
   13. Provide a complete set of time-current coordination curves on log-log paper for every protective relay, circuit breaker, fuse, timer, etc. serving or located in the electrical equipment furnished for the project, including the utility protective devices. Provide a separate time-current curve for each unique feeder system, without displaying parallel devices powered from a common bus. The time-current curves shall display the coordination from the lowest device in the distribution system up through the utility's protective device. Clearly identify each device curve displayed on the graph, by color coding

and text callouts. Include specific settings used for the curve (as applicable) in the text callout. A single line diagram depicting the portion of the distribution system under study shall appear with each curve. The minimum size log paper to be submitted shall be 11-inch by 17-inch.

14. Time current curves shall include transformer ANSI damage and inrush curves, cable damage curves, circuit breaker and fuse ratings and settings, protective relay settings, and any other information required by ANSI and good design practices. As a minimum, provide curves for:
    a. Each medium voltage and low voltage feeder down to 480-volt motor control centers and panelboards.
    b. Each main, tie and feeder circuit breakers located in medium voltage and low voltage switchgear, motor control centers and panelboard. Include the largest feeder circuit breaker in each motor control center and panelboard.
    c. Each ground fault protective device provided for the medium voltage and low voltage power distribution systems.

B. The report shall include a reference to any part of the Electrical System where selectivity cannot be achieved, and a brief explanation of the cause. Provide recommendations where applicable for alternate methods that would improve selectivity.

3.04 ARC FLASH RISK ASSESSMENT

A. Provide a detailed Arc Flash Risk Assessment. The analysis shall include, but shall not be limited to:
    1. Determine potential arc flash incident energies, arc flash boundaries, shock hazard boundaries and proper personal protection equipment (PPE) for all energized electrical equipment.
    2. The study shall determine worst-case scenarios for the arc flash energy level calculations, and any suggested changes to the protection scheme or equipment selection that will result in improved system reliability and safety.
    3. The study shall indicate the worst-case values for each of the scenarios listed in Paragraph 3.01E. Provide values in tabular format including at a minimum, location of fault, incident energy, arc flash boundary, working distance, acting protective device, protective device activation time, and arcing fault current.
    4. Provide executive summary, including introduction, methodology, information sources, key assumptions, NFPA 70E considerations and calculations.
    5. Develop and install arc flash warning labels based on arc flash study results.

3.05 FIELD ADJUSTMENT

A. All field adjustment and modifications shall be performed in the presence of the Owner, before energizing equipment.

B. Adjust relay and protective device settings according to the recommended settings table provided by the coordination study. Field adjustments shall be completed by the equipment manufacturer.

C. Make minor modifications to equipment as required to accomplish conformance with Short-Circuit and Protective Device Coordination studies.

3.06 MODIFICATIONS

A. Notify the Owner in writing of any required major equipment modifications. Major modifications to the equipment shall not be allowed unless otherwise approved in writing by the Engineer and the Owner.

3.07 ARC FLASH WARNING LABELS

A. The vendor shall provide a 4 inch by 4 inch thermal transfer type label of high adhesion polyester for each work location analyzed. Labels shall be machine printed, with no field markings.

B. The label shall have an orange header, compliant with ANSI Z535, with the wording, "WARNING, SHOCK & ARC FLASH HAZARD", and shall include the following information:
   1. Location designation
   2. Nominal voltage
   3. Arc flash boundary
   4. Minimum arc rating at working distance (in calories/centimeter-squared)
   5. Working distance
   6. Shock boundaries
   7. Limited approach distance
   8. Restricted approach distance
   9. Required personal protective equipment
   10. Engineering report number, revision number and issue date.
   11. Where voltage exceeds 600 VAC or incident energy is greater than 40 cal/cm2, label header shall be changed to "DANGER, SHOCK & ARC FLASH HAZARD."

C. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.
   1. For each 600, 480 and applicable 240 VAC panelboards and disconnects, one arc flash label shall be provided.
   2. For each industrial control panel, provide one arc flash label.
   3. For each transformer, provide one arc flash label at both the front and rear access points, as applicable.
   4. For each low voltage motor control center, at least one arc flash label shall be provided. Motor control centers larger than five sections shall bear one arc flash label for each five sections. Back-to-back or turned corner configurations shall be treated as two motor control centers for the purpose of labeling.
   5. For each 96-inches of low voltage switchboard, one arc flash label shall be provided.
   6. For each standalone VFD or motor starter, one arc flash label shall be provided.
   7. For each switchgear, provide one arc flash label for each the front and rear of the incoming compartment and one arc flash label on each compartment that houses a draw-out device.
   8. For each medium voltage motor control center, provide one arc flash label each for the front and rear of the incoming compartment, one label for each individual starter or switch operating handle, and one label each for any draw-out power drawers.
   9. Where equipment includes a "maintenance mode" bypass setting on a protective device as a temporary arc-flash reduction measure, provide one

arc flash label at the applicable protective device which indicates the calculated values when maintenance mode is enabled. This label shall be clearly marked to indicate what it represents.

D. The Contractor shall affix the labels in accordance with the following:
   1. Labels shall be in a clearly visible location on the front panel of the equipment near the incoming service or main protective device. Labels on equipment with bottom-entry incoming service shall be placed a minimum of 60-inches from the bottom of the equipment.
   2. Labels affixed to outdoor equipment which includes an outer door and inner deadfront panel shall be placed on the deadfront panel to avoid fading due to exposure to the elements.
   3. For labels affixed to removable compartment doors or covers, the removable cover shall be clearly marked to identify the specific compartment for which it is intended to be used.

3.08 ARC FLASH TRAINING

A. The equipment manufacturer shall provide arc flash training to the Owner's staff. At a minimum, the training shall include potential arc flash hazards associated with working on energized equipment and maintenance procedures in accordance with the requirements of NFPA 70E, Standard For Electrical Safety Requirements For Employee Workplaces. The training shall be recorded in a video format and provided on a DVD or solid-state media to the Owner.

END OF SECTION

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SECTION 16999

INTRINSICALLY SAFE SYSTEMS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.

B. Work Included: All necessary labor, material, tools, equipment and components to form a complete and acceptable intrinsically safe control, signal and wiring system in each and every Class I, II and III, Division 1 hazardous location, as shown on the Drawings and specified herein.

C. Work Excluded: Electrical work outside of hazardous locations, unless electrically connected to work within hazardous locations.

1.02 REFERENCE STANDARDS

A. American National Standards Institute (ANSI) Publication:
   1. C39.5 Safety Requirements for Electrical and Electronic Measuring and Controlling Instrumentation

B. Instrument Society of America (ISA) Publication:
   1. RP12.6 Installation of Intrinsically Safe Instruments in Class I Hazardous Locations

C. National Electrical Manufacturers Association (NEMA) Publication:
   1. Engineering Bulletin No. 60

D. National Fire Protection Association (NFPA) Standards:
   1. 70 National Electrical Code (NEC)
   2. 493 Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II and III, Division 1 Hazardous Locations

E. Underwriters Laboratories (UL) Standards:
   1. 698 Industrial Control Equipment for Use in Hazardous (Classified) Locations
   2. 913 Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II and III, Division 1, Hazardous Locations

1.03 DEFINITIONS

A. Terms used herein shall be defined per NFPA 493. In addition, the following definitions shall apply:
   1. Apparatus: Electrical or electronic equipment and devices such as relays, timers, pushbuttons and supervisory switches.
   2. Intrinsically Safe: Any product or installation so designed and installed that it is inherently incapable of releasing sufficient energy, electrical or thermal, under normal or faulted condition to cause ignition or combustion of a specific hazardous atmospheric mixture in its most easily ignited concentration.
   3. Different Intrinsically Safe Systems: Intrinsically Safe Systems (ISS): (1) operating at different voltage levels or polarities, or (2) having different signal

ground reference points, or (3) approved for different hazardous location groups.

4. External Wiring: Wiring made outside the apparatus, generally by the Contractor and in accordance with the Specifications and Drawings of the manufacturer of the apparatus and the Engineer.
5. Intrinsically Safe System (ISS): A complete electrical installation consisting of apparatus, associated apparatus, internal and external wiring designed and installed to be intrinsically safe. It may consist of one or more intrinsically safe circuits.
6. Intrinsic Safety Barrier: A device or system or devices that will, when properly installed, render any circuit intrinsically safe.
7. Normal Atmospheric Conditions: For the purposes of this specification, 104°F (40°C) or less, O2 concentration not greater than 21% and pressure of one atmosphere.
8. Signal Ground Reference Point: A single grounding point to which all the grounding conductors of any single intrinsically safe system are connected. It may be used as the ground reference for more than one ISS.

1.04 SUBMITTALS

A. Submit material or equipment data in accordance with the Product Review category of the General Conditions and the submittal requirements of Section 16010.

B. Shop Drawings: For each item listed below, submit manufacturer's name, data, outline drawings and certification of suitability for operation in Division 1 locations:
   1. Control Panels:
      a. Outline drawings including dimensions and type of enclosure.
      b. Front and internal layout drawings.
      c. Internal wiring diagrams.
   2. Relays:
      a. Manufacturer, type and model number.
      b. Current and voltage ratings.
      c. Catalog cuts.
   3. Barriers and Protective Devices:
      a. Manufacturer, type and model number.
      b. Current and voltage ratings.
      c. Catalog cuts.
   4. Wire: Catalog cuts.
   5. Associated Apparatus:
      a. Manufacturer, type and model number.
      b. Current, voltage and/or wattage ratings.
      c. Catalog cuts.
   6. Devices (Switches, etc.):
      a. Manufacturer, type and model number.
      b. Current, voltage and/or wattage ratings.
      c. Catalog cuts.
   7. Conduit and Fittings: Catalog cuts.

C. Manuals: Furnish manuals as specified in Section 16010.

PART 2 - PRODUCTS

2.01 GENERAL

A. "Intrinsically safe" applies to electrical systems taken as a whole, including apparatus, associated apparatus and interconnecting wiring. Apparatus is only a part of the ISS. All apparatus for installation in an ISS shall have suitable UL or FM listing as required by OSHA.

2.02 PANELS

A. Control panels for use in intrinsically safe systems shall be in conformance with the requirements of specification Section 17510.

B. Control panels for use in ISSs shall conform to the fabrication practices recommended in NFPA 493.

2.03 RELAYS

A. See Section 16955.

2.04 BARRIERS

A. Separation of different intrinsically safe systems from each other, or ISS wiring from non-ISS wiring, may be either by separation of a minimum of 2 inches or by metallic barriers. Metallic barriers shall comply with the requirements of NFPA 493, Paragraph 3.1.

2.05 PROTECTIVE COMPONENTS

A. Shunt diode barriers shall be either fuse or resistor protected and so designed and installed as to limit voltage and current when operating in normal or faulted condition.

B. Transformers used as protective components shall conform to the requirements outlined in NFPA 493, Paragraph 3.5.1.

C. Current limiting resistors used as protective components in an ISS shall conform to the requirements outlined in NFPA 493, Paragraph 3.5.3.

D. Blocking capacitors connected between an intrinsically safe circuit and a non-intrinsically safe circuit shall conform to the requirements outlined in NFPA 493, Paragraph 3.5.4.

2.06 MISCELLANEOUS COMPONENTS

A. All components affecting intrinsic safety shall, in normal operation, be designed to operate at no more than 2/3 of their rated current, voltage or power.

B. Plug-in circuit boards and components shall not be interchangeable with non-identical boards or components in the same equipment.

C. Cells and batteries used as power supplies to ISS's shall conform to the requirements outlined in NFPA 493, Paragraph 3.7.

2.07 CONDUIT

A. All conduit associated with ISS's shall conform to the requirements of Specification Section 16120 for hazardous locations and with the recommendations of ISA RP12.6.

2.08 WIRE

A. All wire associated with ISS's shall be identified as such by appropriate means as outlined in ISA RP12.6, Sections 4 and 6.

B. Bright blue colored wire shall be used exclusively for intrinsically safe wiring.

C. Wire shall have minimum insulation thickness of 0.25 mm (0.01 inch), and shall have a grade of insulation capable of withstanding an ac test voltage of 500 volts rms or twice the normal working voltage of the intrinsically safe circuit, whichever is greater.

D. Wire used for non-intrinsically safe circuits in the same enclosure or raceway with wiring associated with an intrinsically safe circuit shall have a grade of insulation capable of withstanding an ac test voltage of twice the sum of the normal operating voltages of the intrinsically safe and the non-intrinsically safe circuit plus 1,000 volts rms, but with a minimum rating of 1,500 volts rms.

E. All wiring shall be in accordance with the requirements of both NFPA 493 and ISA RP12.6.

PART 3 - EXECUTION

3.01 INSPECTION

A. Inspect all apparatus, associated apparatus, conduits, fittings and wire for damage, defects, completeness, and correct operation before installing. Inspect previously installed related work, where applicable, and verify that it is ready for and suitable for installation of and connection to the intrinsically safe system.

3.02 INSTALLATION

A. Install all intrinsically safe apparatus, associated apparatus, and related wiring in accordance with specification Section 16010, Section 16110, Section 16120, Section 16955, and Section 17510.

B. Install conduit and wiring in hazardous locations in accordance with the National Electrical Code, Articles 500 through 517.

C. Grounding:
   1. Provide a single signal ground reference point for the ISS with only a single connection to the plant equipment grounding system.
   2. The minimum size grounding conductor shall be #10 AWG.
   3. Ground all metal enclosures by one of the following methods:
      a. Ground the panel to building structural steel which is, in turn, connected to the signal ground reference point.
      b. Ground the panel to the plant equipment ground grid which is, in turn, connected to the signal ground reference point.
      c. Bond to the intrinsic safety barrier ground bus or directly to the signal ground reference point by means of a separate conductor.

4. Connect the intrinsic safety barrier ground bus to the signal ground reference point by means of a single grounding conductor.
5. The resistance between the most remote safety barrier ground bus and the signal ground reference point shall not be greater than 1 ohm.

D. Multi-conductor cables which have the potential of transmitting gases from the hazardous location to the non-hazardous location shall have their cores sealed in such a manner as to prevent such transmission.

3.03 TESTING

A. Factory testing and checkout of control panels and apparatus shall conform to the requirements of Specification Section 16900, and Section 17510.

B. Field Testing: Perform tests outlined in specification Section 16010 and Section 16120.

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SECTION 17010

INSTRUMENTATION AND CONTROLS, GENERAL REQUIREMENTS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Work Included:
1. Provide all tools, equipment, materials, and supplies and be responsible for all labor required to complete the installation, startup and operational testing of a complete and operable Instrumentation and Control (I&C) System as indicated on the Drawings and as specified herein.
2. Provide all the necessary equipment components and interconnections along with the services of manufacturers' engineering representatives necessary to ensure that the Owner receives a completely integrated and operational I&C System as herein specified.
3. Provide all terminations for wiring at field-mounted instruments, equipment enclosures, alarm, and status contacts.
4. Provide all Instrumentation and Control wire required for a fully functioning I&C System as shown on the Drawings except for wire specifically specified in Division 16.

B. Work Specified in Other Divisions:
1. Process piping, installation of inline instrumentation, air compressors, main air supply headers, and other mechanical work and equipment as specified in Divisions 11 and 15.
2. Instruments and controls that are provided as part of a package system.
3. Division 16 work, including all instrumentation and controls conduit, and only that wire specified in Division 16. Refer to Division 16 Specifications for specific requirements for wire, conduit, grounding, and other electrical equipment.

C. Software Development:
1. Provide testing of installation of field instruments and their connection to the PLC automation input/output modules.
2. Coordinate field testing and verification of operation with the Engineer and the Owner.

1.02 REFERENCE STANDARDS

A. American National Standard Institute (ANSI):
1. Y14.15a Drafting Practice
2. C62.1 Surge Arresters

B. Instrumentation Society of America (ISA):
1. S5.4 Instrument Loop Diagrams
2. S20 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves

1.03 I&C SUBCONTRACTOR QUALIFICATIONS

A. The Prime Contractor shall employ an I&C Subcontractor who has demonstrated experience in purchasing, calibrating, fabricating, installing and testing the Instrumentation and Control (I&C) products listed in this Specification Section.

B. The I&C Subcontractor shall have been regularly engaged for a period greater than five years in performing all aspects of the type of work specified in this Section and shown on the Drawings and must be qualified to perform tasks discussed in Section 1.04 below.

C. System Responsibility: Contractor's attention is directed to the fact that the control system as specified in this section is an integrated system and therefore shall be provided by a single, competent, qualified instrumentation system supplier (hereinafter in this section referred to as the I&C Subcontractor), who shall have total responsibility for the work of this section. Entire system including calibration, validation, start-up, operation testing and training shall be performed by qualified personnel, possessing all the necessary equipment and who have had experience performing similar work. The control system shall be integrated using the latest, most modern proven design and shall, as far as practical, be of one manufacturer. Overall system performance shall be guaranteed by the specified I&C Subcontractor.

D. The Contractor shall select Freedom Automation Inc. (760) 639-4100; no equal the I&C Subcontractor to perform the work under this section. The qualified I&C Subcontractor shall perform said work but it shall be understood that this shall not relieve the Contractor from any responsibility under the Contract. Although many references made herein are to work requirements and responsibilities of the I&C Subcontractor such references shall only mean that responsibility shall pass through the I&C Subcontractor but in the final analysis shall rest with the Contractor.

E. The I&C Subcontractor shall be responsible for the correct installation for all hardware and systems specified in this Section. Certain Primary Elements, Final Control Elements, etc., although provided as a part of this Section, shall be installed in the process lines under other sections of these Specifications; however, this installation shall be under the direct supervision of the I&C Subcontractor.

F. The I&C Subcontractor shall be responsible to see that all components of the instrumentation system, including primary measuring, indicating, transmitting, receiving, recording, totalizing, controlling and alarming devices and all appurtenances, are completely compatible and shall function as outlined, and he shall furnish such additional equipment, accessories, etc. as are necessary to meet these objectives at no additional cost to the Owner.
   1. The radio communication system will be commissioned as part of this work. The work associated with the radio communication system is described in specification section 17330.

1.04 I&C SYSTEM INTEGRATION

A. General: Entire system installation including calibration, verification, startup, operation testing, and training shall be performed by qualified personnel, possessing all the necessary skills and equipment, and who have had experience performing similar installations. Instrumentation and control systems drawings are diagrammatic only; it is the responsibility of the Contractor to obtain technical data, determine performance requirements, develop instrumentation detail installation designs, and coordinate the selection of specified equipment with Contractor supplied equipment to meet the design conditions stated.

B. System Responsibilities:
   1. Ensure that all components of the instrumentation system, including primary measuring, indicating, transmitting, receiving, recording, totalizing, controlling, and alarming devices and all appurtenances are completely compatible and shall function as outlined.
   2. Furnish and install such additional equipment, accessories, etc., as are necessary to meet these objectives at no additional cost to the Owner.
   3. Ensure that all components of the instrumentation system, including equipment specified under other Divisions, are completely compatible and function properly as a system. Provide such additional equipment, accessories, etc., as are necessary to meet these objectives at no additional cost to the Owner.
   4. For control components, devices, and systems specified in Divisions 15, 16, and 17, or shown on the Drawings.

      a. Provide technical advice to mechanical and electrical subcontractors as necessary regarding their installation of instruments.
      b. Verify the correctness of installation of all instruments.
      c. Verify that the proper type, size, and number of control wires with their conduits are provided.
      d. Verify that the proper type, size, and number of pneumatic tubes with their conduits are provided.
      e. Verify that proper electric power circuits provided for all components and systems.
      f. Resolve all manufacturer's installation discrepancies between requirements and the detail requirements of the Drawings and Specifications.
      g. Supervise final signal connections, both electric and pneumatic, to all process instrumentation and control equipment.
      h. Adjust, startup, and test all process instrumentation and control equipment.
      i. Provide specified documentation and training.

   5. While the Drawings provide sufficient information to establish the form and function of the systems and their relationships, the responsibility for system integration and performance rests solely with the Contractor.
   6. Site and Instrument Inspection: Inspect site for conformance to Drawings, paying special attention to space allocation and dimensions shown or required on Drawings. Inspect each instrument and piece of equipment for damage, defects, completeness, and correct operation before installing.
   7. Software Development: Coordinate with the Owner to facilitate software development of PLC and HMI software. Provide any required information, data, or equipment manual as required.
   8. This list is to serve as a guide and not intended to be a comprehensive list of system integration responsibilities.

1.05 SUBMITTALS

A. Submit material or equipment data in accordance with the requirements of Section 16010.

B. Shop Drawings: Submit shop drawings (diagrams) for review in complete bound sets indexed by Specification number, with exterior tabs marked by subject. Submit manufacturer's catalog cuts for each item for which shop drawings are not required. Manufacturer's catalog cuts, specifications or data sheets shall be clearly marked to delineate the options or styles to be furnished. Show dimensions, physical configurations, methods of connecting instruments together, mounting details, and wiring schematics. Drawings shall be complete with device tag numbers, wire numbers and terminal board numbers. Submit fabrication details, nameplate legends, and control panel internal wiring and piping schematic drawings. Submit panel graphic drawings where applicable. Include material lists and/or bills of material.
   1. Loop Diagrams:
      a. Submit Instrument Loop Diagrams per ISA S5.4 to provide necessary detail for connection of analog instrument and control system components including those components specified in other sections of these Specifications.
      b. Provide with the Instrument Loop Diagrams all instrument model numbers, ranges, set points, sizes, process fluids, specification reference numbers, and all other information listed as "desirable and optional items of information" per ISA S5.4.
   2. Interconnection Diagrams:
      a. Submit point-to-point type interconnection diagrams conforming to ANSI Y14.15a. Include each conduit run, with wirefill noted for each run. Include electric panel and circuit numbers for all sources of 120 Vac power. Show conduit and wiring interconnections between each control panel, instrument, multiplexer or telemetry unit, motor control center, motor combination starter, valve actuator, and other field-mounted device. Include all equipment and appurtenances provided in this contract regardless of the Division in which it is specified.
      b. Add to all diagrams the instrument model numbers, instrument ranges, setpoints, sizes, process fluids, specification reference numbers and other information listed as "desirable and optional items of information per ISA S5.4."

C. Specification Forms:
   1. Submit completed Specification Forms per ISA S20, including those instrumentation and control components directly related to process control, but specified in other Divisions of these Specifications.
   2. Include on each form the assigned tag numbers, manufacturer's part numbers, and device data. More than one tag numbered item may be included on a sheet.

D. Record Drawings: Submit a revised set of shop drawings that incorporates all change orders and modifications made during performance of the work. In addition

to updated loop diagrams and interconnect diagrams, submit equipment and device wiring diagrams and other drawings as necessary to depict the "as-built" condition of equipment. Include all installed field and panel conduit and piping/tubing runs and routing, tray systems, supports, mounting details, interconnection diagrams with cable, wire, tube and termination numbers. Coordinate all drawings with the conductor identification requirements in Sections 16120 and 16124. Submit a copy of CAD produced drawings on magnetic media or CD/DVD in AutoCAD DWG format.

E. Operation and Maintenance Manuals: Furnish Operation and Maintenance Manuals, including Instruction Manuals and Part Lists, for equipment provided under Division 17. Obtain data from manufacturers, and format and bind.
   1. Contents: At a minimum, include the following information in manuals for each instrument, equipment, subsystem and/or control loop, as applicable:
      a. General, introduction and overall description, purpose, functions, simplified theory of operations, etc.
      b. Specifications (including equipment specification data sheet as described above under Shop Drawings), sufficiently detailed for reordering exact duplicates of the original items.
      c. Installation instructions, procedures, sequences, tolerances, and precautions.
      d. Operational procedures.
      e. Shutdown procedures.
      f. Maintenance, calibration, and repair instructions.
      g. Parts list and a list of manufacturer recommended spare parts for each item specified. Refer to other sections of these Specifications.
      h. Calibration curves, rating tables, and any other data showing the relationship of the variable inputs and the calibrated output of all measuring devices and controlled equipment.
      i. Include actual calibration sheet for all instruments in the manual. See Paragraph 2.13.
   2. Format:
      a. Use drawings and pictorials to illustrate the text to the extent necessary to insure a clear, concise presentation. If manuals have been written to cover a family of similar instruments or equipment, strike out inapplicable information in a neat fashion or emphasize applicable portion by heavily weighted arrows, circles or boxes; whichever provides the clearest and neatest presentation.
      b. Group manuals by system control panels, including field instrumentation connected or associated with the panel. Where identical instruments are used in more than one control loop or subsystem, include only one instruction manual, per panel grouping; however, an index by tag number for all instruments shall identify its location in that manual.
      c. Provide control loop and/or subsystem operational descriptions to identify the function of each instrument and its relation to the other instruments in the loop.
   3. Binding: Bind each manual in a cover which indicates the panel or process area to which it applies manufacturer's name, local address and telephone number, and year of purchase. Punch and bind manuals. Include system name and subcontractor's name on binding.

4. Digital Copies: Provide digital copies of the material in Adobe PDF file format on CD/DVD ROM.

F. Special Tools and Accessories: Submit special tools, instruments, and accessories for maintaining instruments and equipment requiring periodic repair and adjustment as specified elsewhere herein. Also, furnish special lifting and handling devices for equipment requiring such devices.

G. Test Reports: Submit the following test reports as described herein:
1. Instrument Calibration Data Sheets (Paragraph 2.13)
2. Factory Testing of Control Panels (Paragraph 2.14)
3. Instrument Verification Report (Paragraph 3.07.B)
4. Final Operational Testing (Paragraph 3.07.C)

H. Demonstration and Final Operation Test Plan and Results: Submit a document that outlines all procedures to be used in final operational testing of instrument and control systems. Include a description of each system, the scope of testing, test methods and materials, testing instruments and recorders, a list of functional parameters to be recorded on each item, and Shop Drawings showing temporary bypasses, jumpers, and devices.

1.06 QUALITY ASSURANCE

A. Standard of Quality: The Contractor shall provide equipment of the types and sizes specified which has been demonstrated to operate successfully. Provide equipment which is new and of recent proven design.

1.07 INSPECTIONS

A. The Engineer may observe the fabricated equipment at the factory before shipment to job site. Provide the Engineer with sufficient prior notice so that an observation can be arranged at the factory.

B. Observation of the equipment at the factory by the Engineer will be made after the manufacturer has performed satisfactory checks, adjustments, tests and operations.

C. Favorable review of the equipment at the factory only allows the manufacturer to ship the equipment to the project site. The Contractor shall be responsible for the proper installation and satisfactory startup operation of the equipment to the satisfaction of the manufacturer and the Engineer.

1.08 DRAWINGS

A. Drawings: The Instrumentation Drawings are diagrammatic; exact locations of instrumentation products shall be determined in the field in consultation with the Engineer. Except where special details are used to illustrate the method of installation of a particular piece or type of equipment or material, the requirements or descriptions in this Specification shall take precedence in the event of conflict.
1. Locations of equipment, inserts, anchors, motors, panels, pull boxes, manholes, conduits, stub-ups, fittings, power and convenience outlets, and ground wells

are approximate unless dimensioned; verify locations with the Engineer prior to installation. Field verify scaled dimensions on Drawings.

2. Review the Drawings and Specification Divisions of other trades and perform the instrumentation work that will be required for the installations.
3. Should there be a need to deviate from the Instrumentation Drawings and Specifications, submit written details and reasons for all changes to the Engineer for review and comment. Deviations will only be allowed if they are approved by Engineer.

1.09 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Box, crate, or otherwise enclose and protect instruments and equipment during shipment, handling, and storage. Keep all equipment dry and covered from exposure to weather, moisture, corrosive liquids and gases or any element, which could degrade the equipment. Protect painted surfaces against impact, abrasion, discoloration, and other damage. Notify the Engineer in writing in the event that any equipment or material is damaged. Obtain prior favorable review by the Engineer before making repairs to damaged products.

PART 2 - PRODUCTS

2.01 MATERIALS AND STANDARD SPECIFICATIONS

A. Provide instruments, equipment and materials suitable for service conditions and meeting standard specifications such as ANSI, ASTM, ISA, and SAMA. The intent of this Specification is to secure instruments and equipment of a uniform quality and manufacture throughout the plant. All instruments in the plant of the same type shall be made by the same manufacturer.

2.02 NAMEPLATES

A. For each piece of equipment, provide a manufacturer's nameplate showing his name, location, the pertinent ratings, and the model designation.

B. Identify each piece of equipment and related controls with a rigid laminated engraved phenolic nameplate. Engrave nameplates with the inscriptions indicated on the Drawings and, if not so indicated, with the equipment name. Securely fasten nameplates in place using two stainless steel screws or, where favorably reviewed by the Engineer, with epoxy cement. Where no inscription is indicated on the Drawings, furnish nameplates with an appropriate inscription furnished by the Engineer upon prior request by the Contractor.

C. Each control device, including pushbuttons, control switches, and indicating lights, shall have an integral legend plate or nameplate indicating the device function. These shall be inscribed as indicated on the Drawings or as favorably reviewed by the Engineer.

D. Provide CAUTION or SAFETY nameplates to alert operators of special conditions that may result in faulty equipment operations. Devices containing batteries that must be replaced periodically must be clearly identified. Nameplates are not required if the device senses and displays a low battery warning.

2.03 NAME TAGS

A. All instruments shall be identified by name tags. Field equipment shall be tagged with the assigned instrumentation tag number listed in the Instrument Index.

B. Name tags shall be stainless steel with engraved or stamped black characters of 3/16-inch minimum height. Tags shall be attached to equipment with a tag holder and stainless steel band with a worm screw clamping device. Use 20-gauge stainless steel wire where banding is impractical. For field panels or large equipment cases use stainless steel screws; however, such permanent attachment shall not be on an ordinarily replaceable part.

2.04 FIELD-MOUNTED EQUIPMENT

A. All instrument and control equipment mounted outside of protective structures shall be equipped with suitable surge protective devices to protect the equipment from damage due to electrical transients induced in the interconnecting lines from lightning discharges or nearby electrical devices. Protective devices used on 120 Vac inputs to field mounted equipment shall be secondary valve surge protectors conforming to the requirements of ANSI C62.1.

2.05 EQUIPMENT OPERATING CONDITIONS

A. All equipment shall be rated for normal operating performance with varying operating conditions over the following minimum ranges:
   1. Electrical Power: 120 Vac ±10 percent, 60 Hz, unregulated, except where specifically stated otherwise on the Drawings or in the Specifications, or when two-wire, loop-powered devices are specified.
   2. Air: 85, ±5, psig.
   3. Field Instruments:
      a. Outdoor Areas:
         Ambient Temperature: -10°F to +120°F.
         Ambient Relative Humidity: 5 percent to 100 percent.
         Weather: Rain, snow, and sleet.

2.06 EQUIPMENT LOCATIONS

A. Provide equipment and materials suitable for the types of locations in which they are located as defined under Division 16. All equipment specified for field mounting shall be weatherproof and splash proof as a minimum. If electrical or electronic components are contained within the equipment, they shall be housed in NEMA 4X enclosures.

2.07 ANALOG SIGNAL INDICATED UNITS

A. For all instruments with local or remote indicators, provide indicators scaled in actual engineering units, i.e., gallons per minute, feet, psi, etc., rather than 0 to 100 percent, unless noted otherwise on the Drawings or Instrument Index.

2.08 SIGNAL TRANSMISSION

A. Analog: Signal transmission between electric or electronic instruments shall be 4-20 mA and shall operate at 24 Vdc. Signal output from all transmitters and controllers shall be current regulated and shall not be affected by changes in load resistance within the unit's rating. Where practical, milliampere signals from the field shall be converted to a voltage signal at the external terminals of each panel, and all instruments within a panel shall be parallel wired.

B. Nonstandard transmission systems such as impulse duration, pulse rate, and voltage regulated will not be permitted except where specifically noted in the PLC I/O List or shown on the Drawings. When transmitters with nonstandard outputs do occur, their output shall be converted to 4-20 mA prior to transmission.

C. Discrete: All alarm and status signals shall be 24 VDC unless specified otherwise.

2.09 TUBING, PIPE, FITTINGS AND SUPPORTS

A. General: Instrument tubing listed below is required for all instruments and control valves. Select the appropriate tubing materials to satisfy service conditions except where specifically shown on Installation Detail Drawing.
   1. Copper Tubing: Soft-annealed copper tubing shall be 1/4-inch O.D. x 0.030-inch wall. Copper tubing shall be seamless copper, Type DHP, bright annealed after coiling, dehydrated and sealed in 50-foot aluminum coils, per ASTM B75. Use for instrument or valve connections only.
   2. Copper Tubing: Hard-drawn copper tubing shall be in accordance with ASTM B88. Sizes shall be 3/8-inch standard: 3/8-inch O.D. x 0.030-inch wall in 20-foot straight lengths with plastic capped ends. Use for header or branch service only.
   3. Stainless Steel: Stainless tubing shall be Type 304 seamless, cold drawn and annealed per ASTM A269. Sizes shall be 1/4-inch O.D. x 0.045-inch wall. Use for instrument or valve connections.
   4. Pneumatic Tubing: Pneumatic tubing for panel internals shall be 1/4 O.D. rigidwall, clear polyethylene, 250 psi rating. Tubing shall be supported in plastic duct or conduit where appropriate. Use for enclosed or indoor instrument or valve connections.
   5. Fittings:
      a. Copper Tube: Solder joint fittings shall be seamless wrought copper per ASTM B75. Compression fittings shall be Brass equal to Imperial or Swagelok.
      b. Stainless Steel Tube: Weld joint fittings shall be Type 304 stainless. Compression fittings shall be Type 316 stainless steel equal to Imperial or Swagelok.
      c. Supports for Tubing: Supports located in areas exposed to the weather or corrosive atmosphere shall be Type 304 stainless steel Unistrut or equal or made of steel conforming to ASTM A276. Supports not exposed to the weather or corrosive atmosphere shall be carbon steel painted.
      d. Weld joint fittings shall be permitted for header and branch service only. Instrument and valve connections shall be compression-type only. Use unions on as necessary to simplify instrument removal.
   6. Valves:

a. Pipe, Pipe Fittings, and Valves: Main-line piping material and root valves for instrumentation shall be as specified in Division 15.
b. Instrument valves shall be 1/4-inch, 3/8-inch or 1/2-inch from Whitey or Hoke to match tubing material and size.
c. Pressure and differential pressure cells shall include bleed and block valve manifolds to allow maintenance and calibration.

2.10 PANEL/RACK/ENCLOSURE BAY POWER SUPPLIES

A. For two-wire transmitters, provide a 24 Vdc regulated power supply from the appropriate PLC control panel.

B. Manufacturer: Provide Idec, or approved equal.

2.11 INSTRUMENT CALIBRATION

A. Each analog field instrument shall be calibrated at 0 percent and 100 percent of span and calibration checked at 0 percent, 25 percent, 50 percent, 75 percent and 100 percent of span for compliance with linearity and hysteresis accuracy. Use a test instrument to simulate inputs and read outputs that are at least 10 times greater than the specified accuracy of the instrument being calibrated. Such test instruments have accuracies traceable to the National Institute of Standards and Technology (NIST). Digital instruments shall be calibrated over 10 points for accuracy, linearity and hysteresis.

B. Submit a written report to the Engineer on each instrument. This report shall include a laboratory calibration sheet or the manufacturer's standards calibration sheet on each instrument and calibration reading as finally adjusted within tolerances.

C. The Contractor may, at his option, choose to perform calibration on an instrument by acquiring the services of an independent test lab, or by obtaining the required test instruments and performing the calibration.

D. Include calibration sheets in O&M manual specified in Paragraph 1.05E.

PART 3 - EXECUTION

3.01 MOUNTINGS

A. Mount and install equipment as indicated. Mount field instruments on pipe mounts or other similar means in accordance with suppliers' recommendation. Where mounted in control panels, mount according to requirements of that Section.

B. Equipment specified for field mounting shall be suitable for direct pipe mounting or surface mounting, surface-mounted indicators and equipment with calibration adjustments or requiring periodic inspection shall be mounted not lower than 3 feet 6 inches nor higher than 6 feet above walkways, platforms, catwalks, and the like.

C. Note that applicable specifications require detail drawings showing seismic sway bracing design and anchorage requirements for their equipment. Seismic zone requirements are specified in Division 1.

D. All devices shall be accessible to operators for servicing, operating, reading, etc. Provide permanent platforms to assure devices are continuously accessible.

3.02 PROCESS CONNECTIONS

A. Provide instrument impulse tubing (see Part 2) to meet the intended process service and ambient environmental condition for corrosion resistance, etc. Install impulse tubing with a continuous slope according to service to promote self-draining or venting back to the process. Terminate connection to process lines or vessels in a service rated roof valve, provided under other Divisions, which will permit closing off the impulse line or removal of the element without requiring shut down of the process. Include blowdown of drip legs and valves for terminations of impulse lines at the instruments.

B. Process vessels, line penetrations, and root valves shall be furnished and installed under other Divisions of these Specifications. Instrument tubing and valve manifolds are installed as part of this Specification.

3.03 FIELD WIRING

A. Ring out signal wiring prior to termination and perform surge withstand tests where required (see Section 16010, Part 3 for methods). Verify wire number and terminations are satisfactory as designated on the Loop and Interconnect Diagrams. Verify all terminations are tight and shields are uniformly grounded at one location.

3.04 ELECTROMAGNETIC INTERFERENCE (EMI)

A. Construction shall proceed in a manner which minimizes the introduction of noise (RFI/EMI) into the I&C System.

B. Cross analog signal wires and wires carrying ac power or control at right angles.

C. Separate analog signal wires from wires carrying ac power or switched ac/dc control within control panels as much as possible. Provide the following minimum separations within such equipment unless indicated otherwise on the Drawings:

Power Wiring Capacity	Separation (Inches)
120 Vac or 10 Amps	12
240 Vac or 50 Amps	18
480 Vac or 200 Amps	24

3.05 SIGNAL GROUNDING

A. A single-point grounding system for instrument signals is required for all instrument panels. This instrument single point grounding system does not use building steel or conduit systems for its ground path.

1. Ground all signal shields and signal grounds within each instrument panel, rack, or enclosure. The shields at the far ends of these signal cables must be disconnected (floated) from any ground to prevent ground loops.
2. Do not connect the rack or enclosure frames to the signal grounding buses.

3.06 PREPARATION

A. Ensure that installation areas are clean and that concrete or masonry operations are completed prior to installing instruments and equipment. Maintain the areas in a broom-clean condition during installation operations.

3.07 FIELD TESTING

A. General: The purpose of the field testing is to verify instruments are calibrated and operationally performing their intended function. Provide the services of factory trained and experienced engineers to perform verification and operational testing as prescribed below. Since the initial calibration of instruments may not satisfy the final operation of system, perform recalibration or adjust setpoints as required to satisfy the performance requirements of the system. Notify the Engineer and Owner in writing a minimum of 48 hours prior to the proposed date for commencing final operational testing and acceptance.

B. System Verification Testing: Verify that each instrument shown on the Instrument Schedule is operating and calibrated as specified in the Instrument Schedule by simulating inputs at the primary element in each system loop and verify performance at loop output devices (i.e. recorder, indicator, alarm, etc., except controllers). Simulate inputs at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span or with on-off inputs, as applicable. During system verification:
   1. Make initial or provisional settings on levels, alarms, etc. listed in the Instrument Schedule.
   2. Verify controllers by observing that the final control element moves in the proper direction to correct the process variable as compared to the set point.
   3. Cause malfunctions to sound alarms or switch to standby to check system operation.
   4. Check all loop instruments thoroughly for correct operation.
   5. Immediately correct all defects and malfunctions disclosed by tests.
   6. Submit a report certifying completion of verification of each instrument system. This report shall include a data sheet on each instrument tested that indicates instrument tolerances, instrument calibration verification, data and initial settings made to devices.

C. Operational Testing: Operational testing shall consist of both manually and automatically controlled system tests.
   1. The Contractor shall be responsible for performing manually controlled tests, and shall submit documentation on the results of these tests in accordance with this specification section. All manually controlled tests shall be successfully completed before automatically controlled tests will be started, including any required correction actions.
   2. Automatically controlled tests will be performed by the Owner. The Contractor shall assist the Owner with the automatically controlled tests as necessary.

3. Testing shall include, but not be limited to:
    a. Making final adjustments to levels, alarms, etc.
    b. Optimum tuning of controllers.
    c. Checking all alarms, failure interlocks, and operational interlocks.
    d. Verifying all input and outputs are fully functional and coordinated with the Owner.
    e. Immediately correcting all defects and malfunctions and retesting.

D. Submit the witnessed test results and a transmittal letter indicating that all required systems have been tested satisfactorily and the systems meet all the functional requirements of their applicable specifications.

3.08 INSTRUCTION OF OWNER'S PERSONNEL

A. Provide the services of a factory trained and field experienced instrumentation engineer to conduct group training of up to five of the Owner's designated personnel in the operation of each instrument system. This training shall be for the time period of five working days and shall be performed during the operational testing period. Include instruction covering basic system theory, operating principles and adjustments, routine maintenance and repair, and "hands on" operation. The text for this training shall be the Operation and Maintenance Manuals furnished under these Specifications.

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SECTION 17010A

INSTRUMENTATION SCHEDULE

Type	Loop Number	Description	Range	Setpoint	P&ID	Spec Section	Spec Para.
YCR-050		Generator Fuel Low			I-3	16205	
YSF-050		Generator Fail			I-3	16205	
YSR-050		Generator Running			I-3	16205	
LSL-050A		Generator Fuel Low			I-3	16205	
LSH-051A		Generator Fuel Leak			I-3	16205	
ZSC-151		Gate Closed Switch			I-4	15135	2.01
ZSO-151		Gate Open Switch			I-4	15135	2.01
LSHH-151		Level Switch High High (Wetwell 1)		EL 163.00'	I-4	17141	2.01
LSLL-151		Level Switch Low Low(Wetwell 1)		EL 146.89'	I-4	17141	2.01
LSH-155		Level Switch High (Diversion Manhole)		EL 163.00'	I-4	17141	2.01
ZS-184		Intrusion Switch for WETWELL 1			I-4	17200	2.03
MSH-110		Moisture Switch for Pump 110		per mfr	I-4	11303	2.01
TSH-110		Temperature Switch for Pump 110		per mfr	I-4	11303	2.01
MSH-120		Moisture Switch for Pump 120		per mfr	I-4	11303	2.01
TSH-120		Temperature Switch for Pump 120		per mfr	I-4	11303	2.01
LT-153		Level Transmitter (Wetwell 1)	0-40 ft	9 – 40 ft	I-4	17140	2.01
ZSC-251		Gate Closed Switch			I-4	15135	2.01
ZSO-251		Gate Open Switch			I-4	15135	2.01
LSHH-251		Level Switch High High (Wetwell 2)		EL 163.00'	I-4	17141	2.01
LSLL-251		Level Switch Low Low(Wetwell 2)		EL 146.89'	I-4	17141	2.01
ZS-284		Intrusion Switch for WETWELL 2			I-4	17200	2.03
MSH-210		Moisture Switch for Pump 210		per mfr	I-4	11303	2.01
TSH-210		Temperature Switch for Pump 210		per mfr	I-4	11303	2.01
MSH-220		Moisture Switch for Pump 220		per mfr	I-4	11303	2.01
TSH-220		Temperature Switch for Pump 220		per mfr	I-4	11303	2.01
LT-253		Level Transmitter (Wetwell 2)	0-40 ft	9 – 40 ft	I-4	17140	2.01
PI-110		Pressure Indicator	0-50 psig		I-5	15050	2.06
ZSC-9201		Valve Closed			I-5	15050	2.06
PI-120		Pressure Indicator	0-50 psig		I-5	15050	2.06
ZSC-9202		Valve Closed			I-5	15050	2.06
PI-210		Pressure Indicator	0-50 psig		I-5	15050	2.06
ZSC-9204		Valve Closed			I-5	15050	2.06
PI-220		Pressure Indicator	0-50 psig		I-5	15050	2.06

Type	Loop Number	Description	Range	Setpoint	P&ID	Spec Section	Spec Para.
ZSC-9205		Valve Closed			I-5	15050	2.06
PIT-250		Pressure Transmitter	0-50 psi		I-5	17150	2.01
FIT-250		Flow Transmitter	350-4000 gpm		I-5	17120	2.01
FE-250		Flow Element	350-4000 gpm		I-5	17120	2.01
LSH-154		Level Switch		EL 172.00'	I-5	17141	2.01
ZS-100		Instrusion Switch (Electrical room)			I-5	17200	2.03
ZS-102		Instrusion Switch (Generator room)			I-5	17200	2.03

Notes:

1. Instrument Schedule is not intended to represent a bill of material or a complete list of all required instruments.
2. Settings indicated are considered "Initial Settings." Final settings shall be accomplished in field to suit actual operating conditions.
3. Pressure gauge shall be provided by the Division 15 contractor.

END OF SECTION

SECTION 17120

FLOW MEASUREMENT

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Requirements of Division 1 and Sections 17010 and 11001 form a part of this Section. This Section specifies flow measurement devices for process instrumentation, auxiliary equipment and supplies directly related to the installation of and operation of these flow measurement devices, to perform the required functions in conjunction with information and equipment specified in other Sections of Division 17.

B. Furnish and install flow meters and all appurtenant work suitable for wastewater, at ambient temperatures, complete and operable, and capable of continuous operation.

1.02 SUBMITTALS

A. Shop drawings to be submitted in this Section shall be made in one package. Submit material or equipment data in accordance with the requirements of Section 16010.

B. Shop Drawings:
   1. In addition to the requirements of Section 17010, shop drawings shall include for each type of instrument: supply voltage and frequency, electrical load, accuracy, description of operation, operating instructions, and calibration procedure.
   2. Furnish shop drawings for each item of mechanical equipment presenting sufficient data to determine compliance to these Specifications. Submit completed ISA S20 forms for each device and physical dimensions. Submit manufacturer's recommended upstream and downstream straight piping lengths, recommended location of any pressure taps, and estimates of pressure losses through the device.

C. Installation Method: The proposed method of mounting sensors and instruments shall accompany all shop drawings.

D. Parts List: Submit a Parts List with current net prices and a list of recommended spares.

E. Factory Testing and Calibration:
   1. All meters shall be factory tested. Perform a factory test and/or provide certification of calibration from an independent test laboratory. Calibration curves based on factory and/or laboratory testing (see option below) shall be provided for the Engineer's review. Furnish calibration curves in units of output (inches or rpm/gpm) versus measured flow.

2. As an option to laboratory testing each meter, the calibration curves of six (6) "like devices" may be substituted provided the calibration data is available from at least one identical device (pipe size, flow range, and type plus accessories such as extension registers).

F. Manuals: Furnish manufacturer's installation, lubrication, operation and maintenance manuals, bulletins, and spare parts lists.

G. Affidavits: Furnish affidavits from the manufacturers stating that the meters have been properly installed and tested and each is ready for full time operation.

1.03 QUALITY ASSURANCE

A. Manufacturer: In addition to the requirements of Section 17010, flow measurement devices furnished shall be manufactured by firms regularly and currently engaged in the design and manufacture of similar equipment. All equipment furnished shall be new and of current design.

B. Maintainability: All equipment shall be designed for ease of maintenance and repair, and access to critical parts shall not require a major disassembly. Internal field adjustments where permitted or required herein shall be easily accessible upon removal of a panel or cover.

C. Materials and Installation: Materials and installation shall comply with the requirements of the current editions of referenced electrical codes and standards, and the codes and standards referred to shall be used for establishing the minimum quality of the materials and equipment supplied and installed. All equipment of the same type shall be products of the same manufacturer. Capacities of all equipment shall not be less than that indicated on the Drawings or as specified.

1.04 SEISMIC PROTECTION

A. Seismic restraint for metering devices, which are integral with piping, shall be as specified for the piping system in which they are installed. Seismic design certification and anchorage descriptions are required by Section 01190 of Division 1.

1.05 INDICATING UNITS

A. Provide flow indication in GPM, CFS, MGD, etc. Do not use indicators that read 0 to 100 percent, 4-20 mA, etc.

1.06 SERVICE CONDITIONS

A. Refer to Section 17010.

PART 2 - PRODUCTS

2.01 MAGNETIC FLOWMETER

A. General: Magnetic meters shall utilize the principle of electromagnetic induction to produce an output proportional to the rate of fluid flow. A set of pulsed DC, electrically powered coils shall generate a magnetic field, which in turn induces a

voltage in the flowing fluid, which is sensed by a pair of electrodes in contact with the fluid.

1. Protect coils from contact with the fluid. The electrodes shall be made of Type 316 stainless steel. The meters shall be housed in a NEMA 4 enclosure. The metering tube shall be lined with hard rubber. Meters shall be resistant to electrode coating. The probe sensor shall be designed to be inserted in water pipes and shall not be affected by solids, air bubbles, oil, or coating. The probe sensor wetted parts shall be of Type 316 stainless steel.
2. The meters shall be designed to operate from a 120 Vac, 60 Hz, single phase power supply. A 10 percent variation in power line voltage or frequency shall not affect the meter output accuracy in excess of 1 percent of full scale.
3. Provide magnetic flowmeters suitable for fluids with conductivities as low as 5.0 micromho/cm.
4. Each magnetic flow meter system shall have an accuracy within 1 percent of actual for flow velocities between 10 percent and 100 percent of full scale. Meters shall have a repeatability within 0.25 percent of full scale.
5. Each magnetic flow meter shall be equipped with a signal converter to transmit an analog 4-20 mADC signal proportional to flow rate. The signal will include Hart communications capability. Output span and zero shall be manually adjustable. Provide span adjustment capable of producing 100 percent analog output at flow rates that are 30 percent of maximum. Signal shall be linear with flow within the accuracy specified above. The converter shall be integrally mounted with the meter housing.
6. The signal converter shall have the capability of positive zero return for shutdown conditions.

B. The magnetic flow meters shall have flanged end connections. Field coils shall be either completely encapsulated in the meter lining material or a protective shield shall be provided suitable for withstanding the scouring velocities of the process fluid at the maximum flow rates.

C. Grounding: Provide a grounding circuit for each magnetic meter. Furnish and install grounding rings or protective shield when meter is installed in nonconductive line.

D. Manufacturer: Meters and signal converters for full pipe magnetic flow meters shall be Krohne, or approved equal.

E. Special Tools: Furnish special tools, which are necessary for the replacement of parts and the adjustment of the equipment.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Provide installation, testing, calibration, verification, and startup instructions in accordance with Sections 15050 and 17010.

3.02 FIELD TESTING

A. All flow devices are to be field tested against a secondary standard at the normal (or expected) process flow rates.

B. The Contractor may select at his option to either install a second flow device of known calibration in the line to verify flow device calibration or perform fluid capacity tests such as volumetric measurement per unit time.

END OF SECTION

SECTION 17140

LEVEL MEASUREMENT

PART 1 - GENERAL

1.01 DESCRIPTION

A. Work Included: Level measurement devices for process instrumentation, auxiliary equipment, and supplies directly related to the installation of and operation of these level measurement devices, to perform the required functions in conjunction with information and equipment specified in other Sections of Division 17. Refer to the Instrument Index in Section 17010 for a listing of required devices.

B. Requirements of Section 17010 form a part of this Section.

C. Furnish and install level measurement instruments and all appurtenant work suitable for wastewater, at ambient temperatures, complete and operable, and capable of continuous operation.

1.02 SUBMITTALS

A. Shop drawings to be submitted in this Section shall be made in one package. Submit material or equipment data in accordance with the requirements of Section 16010.

B. Shop Drawings:
   1. In addition to the requirements of Section 17010, shop drawings shall include for each type of instrument: supply voltage and frequency, electrical load, accuracy, description of operation, operating instructions, and calibration procedure.
   2. Furnish shop drawings for each item of mechanical equipment presenting sufficient data to determine compliance to these Specifications. Submit completed ISA S20 forms for each device and physical dimensions. Submit manufacturer's recommended location.

C. Installation Method: The proposed method of mounting sensors and instruments shall accompany all shop drawings.

D. Parts List: Submit a Parts List with current net prices and a list of recommended spares.

E. Manuals: Furnish manufacturer's installation, lubrication, operation and maintenance manuals, bulletins, and spare parts lists.

1.03 QUALITY ASSURANCE

A. Manufacturer: In addition to the requirements of General Requirements, level measurement devices furnished shall be manufactured by firms regularly and

currently engaged in the design and manufacture of similar equipment. All equipment furnished shall be new and of current design.

B. Maintainability: All equipment shall be designed for ease of maintenance and repair, and access to critical parts shall not require a major disassembly. Internal field adjustments where permitted or required herein shall be easily accessible upon removal of a panel or cover.

C. Materials and Installation: Materials and installation shall comply with the requirements of the current editions of referenced electrical codes and standards, and the codes and standards referred to shall be used for establishing the minimum quality of the materials and equipment supplied and installed. All equipment of the same type shall be products of the same manufacturer. Capacities of all equipment shall not be less than that indicated on the Drawings or specified.

PART 2 - PRODUCTS

2.01 LEVEL INDICATOR – NON-CONTACT RADAR

A. General: This type of level sensor shall use the following principle. A burst of microwave energy in the form of a “chirp” of a specific frequency profile is directed toward a target surface of interface. The interface may be air-liquid, air-solid, liquid-solid, and also liquid-liquid if the densities of the two liquids are sufficiently different and provide a clearly definable interface. The return time and frequency profile of the reflected radiation is measured and converted into an electrical signal proportional to the distance from the sensor to the interface, or alternatively the distance from another reference level, such as the tank bottom, when the sensor is top mounted. As such, these are radio emitters regulated by FCC Part 15, and all applications must be approved by the vendor as conforming.

B. Specific Requirements:
1. Specific applications shall be as shown on the Drawings. Level ranges, output signals and setpoints are specified in the Instrument List.
2. Sensor shall be certified by the vendor as complying with FCC Part 15 for the specific application and mounting geometry in the design.

C. Construction: The level sensing system shall consist of a sensing element with a solid-state electronic controller-converter housed in a Class 1 Div. 1 case. All instruments and sensors to be installed in hazardous locations shall be rated for the class, division, and group indicated on the Drawings.

D. Mounting:
1. The level element shall be flange mounted. Level element installation shall be per manufacturer’s instructions.

E. Power: The system shall loop powered and provide a 2-wire 4-20 milliamp type output.

F. Manufacturer: Radar level sensors shall be Vega, VEGAPULS C 23 or approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Installation, testing, calibration, validation, startup, and instruction shall be in accordance with Section 17010.

END OF SECTION

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SECTION 17141

LEVEL DETECTION

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This Section specifies level measurement devices for process instrumentation, auxiliary equipment and supplies directly related to the installation of and operation of these pressure measurement devices, to perform the required functions in conjunction with information and equipment specified in other Sections of Division 17.

B. Requirements of Section 17010 form a part of this Section.

C. Furnish and install level measurement instruments and all appurtenant work suitable for the process fluid, at ambient temperatures, complete and operable, and capable of continuous operation.

1.02 SUBMITTALS

A. Shop drawings to be submitted in this Section shall be made in one package. Submit material or equipment data in ac accordance with the requirements of Section 17010.

B. Shop Drawings: In addition to the requirements of Section 17010, shop drawings shall include for each type of instrument: contact rating, description of operation, operating instructions, and calibration procedure.

C. Installation Method: The proposed method of mounting sensors and instruments shall accompany all shop drawings.

D. Parts List: Submit a Parts List with current net prices and a list of recommended spares.

1.03 QUALITY ASSURANCE

A. Manufacturer: In addition to the requirements of Section 17010, level detection devices furnished shall be manufactured by firms regularly and currently engaged in the design and manufacture of similar equipment. All equipment furnished shall be new and of current design.

B. Maintainability: All equipment shall be designed for ease of maintenance and repair, and access to critical parts shall not require a major disassembly. Internal field adjustments where permitted or required herein shall be easily accessible upon removal of a panel or cover.

C. Materials and Installation: Materials and installation shall comply with the requirements of the current editions of referenced electrical codes and standards, and the codes and standards referred to shall be used for establishing the minimum quality of the materials and equipment supplied and installed. All equipment of the same type shall be products of the same manufacturer. Capacities of all equipment shall not be less than that indicated in the Instrument Index.

PART 2 - PRODUCTS

2.01 LEVEL SWITCH - FLOAT TYPE, GENERAL PURPOSE

A. Float switches shall be direct acting and consist of a Type 316 stainless steel housing, mounting clamp, flexible 3-conductor cable with a synthetic rubber jacket and a non-mercury switch. The float housing shall be a sphere of at least 4½ inches in diameter. The switch shall be embedded in a metal housing inside the float. The lead cable shall be #14 AWG with 105 strands per conductor, made specifically for underwater use and heavy flexing service. The switch shall be connected to two of the three conductors of the cable. The third conductor shall be an internal ground and shall be colored green. The switch shall have a 20 ampere rating at 115 Vac. An additional synthetic rubber jacket shall act as a hinge between the float and where the cable is held by the stationary clamp.

B. The clamp shall be stainless steel with an adapting fitting and two yokes for mounting on a vertical 1-inch pipe. A liquid rise of 1 inch from the reset position shall operate the float switch, and reset shall occur when the liquid level drops 1 inch.

C. Operating temperature shall be 0°F to +180°F. Weight and buoyancy shall be such that contaminants, like a cake of grease, will not result in the float switch changing operating level more than 1 inch.

D. A NEMA 4X stainless steel junction box shall be supplied for termination of the float cables to allow wiring and conduit to be run from the junction box to a control panel. It shall have terminal blocks for the required number of circuits and shall accept sealed fittings furnished with the float switch.

E. Provide intrinsically-safe relays (IR) for switches used in hazardous locations where shown on the Drawings.

F. The float switches shall be Flygt ENM-10 or approved equal.

G. The float switches shall controlled by a handswitch with a manual option to operate the system off of float switches.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Installation, testing, calibration, validation, startup and instruction shall be in accordance with Section 17010 and manufacturer’s requirements.

END OF SECTION

SECTION 17150

PRESSURE MEASUREMENT

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Requirements of Division 1 and Section 17010 form a part of this Section. This Section specifies pressure measurement devices for process instrumentation, auxiliary equipment and supplies directly related to the installation of and operation of these pressure measurement devices, to perform the required functions in conjunction with information and equipment specified in other sections of Division 17. Refer to the Instrument Index in Section 17010 for a listing of required devices.

1.02 SUBMITTALS

A. Shop drawings to be submitted in this section shall be made in one package under the Product Review Category of Shop Drawings.

B. Shop Drawings: In addition to the requirements of Section 17010, shop drawings shall include for each type of instrument: supply voltage and frequency, electrical load, accuracy, description of operation, operating instructions, and calibration procedure.

C. Installation Method: The proposed method of mounting sensors and instruments shall accompany all shop drawings.

D. Parts List: Submit a Parts List with current net prices and a list of recommended spares.

1.03 QUALITY ASSURANCE

A. Manufacturer: In addition to the requirements of Section 17010, pressure measurement devices furnished shall be manufactured by firms regularly and currently engaged in the design and manufacture of similar equipment. All equipment furnished shall be new and of current design.

B. Maintainability: All equipment shall be designed for ease of maintenance and repair, and access to critical parts shall not require a major disassembly. Internal field adjustments where permitted or required herein shall be easily accessible upon removal of a panel or cover.

C. Materials and Installation: Materials and installation shall comply with the requirements of the current editions of referenced electrical codes and standards, and the codes and standards referred to shall be used for establishing the minimum quality of the materials and equipment supplied and installed. All equipment of the same type shall be products of the same manufacturer. Capacities of all equipment shall not be less than that indicated in the Instrument Index.

PART 2 - PRODUCTS

2.01 PRESSURE TRANSMITTERS - ELECTRONIC

A. General:
1. Electronic indicating-type pressure transmitters shall convert a gauge or absolute pressure measurement to a 4-20 mAdc linear electrical output signal capable of transmission into at least a 600 ohm maximum load at 24 Vdc or less. Signal and power transmission shall be provided on a single pair of wires. Operating ambient temperature limits shall be at least -40° to +82°C.
2. Range shall be as indicated in the Instrument Index. Overrange protection shall be at least 1-1/2 times span without degradation of accuracy. Reference accuracy shall be ±1/2 percent or better.

B. Construction:
1. The transmitter enclosure shall be NEMA 4X rated except where explosion-proof is required as noted on the Drawings. The process connection for clean liquid service shall be 1/4-inch NPT. Enclosure and wetted surface material shall be corrosion resistant and suitable for the process fluid.
2. Transmitters shall be liquid-filled employing diaphragm where shown on the Drawings. Use optional remote seal with capillary length selected to suit installation needs, such as location, elevation, or orientation. Standard seal flange shall be a 3-inch 150-pound USAIS lap joint flange. A mating transmitter ANSI flange shall be provided with each transmitter per Section 15050.

C. Hazardous Locations: Transmitters shall be intrinsically safe or protected by barrier or explosion-proof enclosure for applications in hazardous locations. See Electrical Drawings.

D. Manufacturers: Rosemount, Model 3051; or equal.

2.02 DIAPHRAGM PRESSURE SEALS

A. General:
1. Units shall consist of corrosion-resistant lower housing and diaphragm, and instrument mounting upper housing. Lower housing shall have a 1-inch NPT female process and a 3/8-inch flushing connection terminated with a 3/8-inch hose bibb and shall be Type 316 stainless steel. Diaphragm shall be Type 316 stainless steel, unless otherwise noted. Upper housing shall have bleed screw, NPT female instrument connection, and shall be steel, unless otherwise noted. Filling fluid shall be suitable for a temperature range of -17° to +260°F.
2. Where noted on the Drawings, capillary assembly shall be furnished to connect diaphragm seal to instrument.

B. Manufacturer: Units shall be Mansfield & Green, Type SG; Ashcroft, Type 101; or equal.

2.03 INSTRUMENT MANIFOLDS

A. General: Test valve manifolds shall be used with all pressure and differential pressure transmitters installed in clean liquid (no entrained solids) service. Test

manifolds shall be corrosion resistant with integral 2-valve assembly (block and bleed) for pressure transmitters and 3-valve assemblies (block and bypass with manometer ports) for differential pressure transmitter installation.

B. Mounting: Pipe mounting brackets shall be provided with each manifold.

C. Manufacturer: Anderson-Greenwood Company, M Series, Hoke, or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. On systems requiring diaphragm seals, the Contractor shall order (or assemble) a completely filled system. The filling fluid shall be silicone oil. Interconnecting piping shall be kept short. The filled system shall retain the same calibration requirements of the individual components.

B. Installation, testing, calibration, validation, startup and instruction shall be in accordance with Section 17010.

END OF SECTION

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SECTION 17200

PANEL MOUNTED AND MISCELLANEOUS FIELD INSTRUMENTS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Provisions: Requirements of Division 1 and Sections 17010 and 16955 form a part of this Section.

B. Work Included: This Section specifies the panel mounted and miscellaneous field instruments and equipment to perform the required functions in conjunction with information and equipment specified in other Sections of Division 17.

C. Unit Responsibility: It shall be the responsibility of the qualified single firm as described in Section 17010 of this Division to ensure that the instruments and equipment furnished under this Section are compatible with the equipment furnished under sections of this Division and other Divisions of these Specifications, and that the signal transmission methods are compatible.

D. Control and Performance Terminology used hereinafter in this Section shall be as defined in ISA-51.1-1979 - (R1993) “Process Instrumentation Terminology”.

E. Cases: Cases or front of panel mounted instruments shall be of uniform design and color scheme wherever possible. Front of case colors shall be compatible with panel colors, subject to final approval by the Owner. Normally, compatible standard colors of the manufacturer shall be acceptable.

F. Panel Mounted Equipment:
   1. All flush mounted miniature electronic controllers, recorders, and stations shall be a matching style family of instruments utilizing multiple unit mounting cases and back of panel plug-in cable connections. The overall height shall be 6 inches. A nine station multi-unit case shall fit standard 19-inch rack spacing. Each multi-unit case and instrument shall be equipped for standby manual operation.
   2. All front panel mounted instruments shall be capable of withdrawing chassis to all service and test positions without affecting operation, and complete removal by a single plug connection from the front.
   3. All back of panel mounted signal conditioners and auxiliaries shall be mounted in plug-in card files with labeled adjustment and test point at front of card edge.
   4. All instruments shall accept 4-20 mAdc or 1 to 5 Vdc input signals and shall produce 4-20 mAdc or 1 to 5 Vdc output signals as specified in the Schedules. Internal panel signals may be of either type. All analog signals coming to or leaving the panel shall be 4-20 mAdc.
   5. Where IP65 requirements apply the panel mounted equipment shall be ordered with hardware to keep the IP65 integrity of the UL Listed Panel.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Panels: See Section 17510.

1.03 SUBMITTALS

A. Shop drawings to be submitted in this Section shall be made in one package under the Product Review Category of Shop Drawings.

B. Refer to Section 17010 for additional submittals required for each item herein.

1.04 QUALITY ASSURANCE

A. Manufacturer: In addition to the requirements of Section 17010, instrumentation and control equipment furnished shall be manufactured by firms regularly and currently engaged in the design and manufacture of similar equipment. All equipment furnished shall be new and of the most recent design. Except where specified otherwise, the instruments furnished under this Section shall be as manufactured by manufacturer as specified in the instrumentation specifications.

B. Maintainability: All equipment shall be designed for ease of maintenance and repair, and access to critical parts shall not require a major disassembly. Internal field adjustments where permitted or required herein shall be easily accessible upon removal of a panel or cover.

C. Materials and Installation: Materials and installation shall comply with the requirements of the current editions of referenced electrical codes and standards, and the codes and standards referred to shall be used for establishing the minimum quality of the materials and equipment supplied and installed. All equipment of the same type shall be products of the same manufacturer. Capacities of all equipment shall not be less than that indicated on the Drawings or specified.

D. All equipment, panel layouts and design shall conform to UL 508A.

PART 2 - PRODUCTS

2.01 PROCESS VARIABLE INDICATORS

A. Vertical single or dual channel process variable indicators shall have a vertical display at least 3 inches long, shall have a reference accuracy of ±2.0% or better, and the indicating pointer shall be driven by the output of a solid state electronic amplifier. Zero and span adjustment shall be provided. Indicating scale graduations shall be readable to 1% of full scale. Input signal shall be 1 to 5 Vdc or 4-20 mA as indicated on the Instrument Schedule. An optional single or dual integral alarm unit may be provided. Provide Ametek Dixson BB101P, Crompton 263 panel meter or Engineer approved equal.

B. Large Case Process Indicators shall be provided as shown on the Drawings and/or specified herein. Scale units shall be as specified in the Instrument Schedule. The pointer shall be servo driven with feedback and null balancing. Accuracy shall be 0.5% of full scale. Input signal shall be 1 to 5 Vdc or 4-20 mAdc. An optional integrator and 7 digit totalizer shall be provided where shown on the Drawings. When specified, SPDT alarm switches shall be provided, rated at 2 amperes, 120 Vac, 60 Hz. Indicators shall have 4-3/8-inch minimum scale length, and hinged

locking door with glass window. Dimensions shall be 15 inches by 14 inches by 8 inches deep maximum. Operating power shall be 120 Vac, 60 Hz.

C. Digital Indicators shall be provided where indicated and shall display the decimal value of a numerically coded input. Accessories shall be provided to accept analog voltage or current inputs or other digitally coded inputs as specified in the Instrument Schedule. The number and size of the digits shall be as specified. The displayed digits shall be luminous and easily visible in a well lighted control room. The display style shall be the choice of the I&C Subcontractor, except that all displays shall be of the same style. The accuracy of the display shall be within ± one digit but not less than ±0.1% for analog inputs. There shall be no error with digital inputs. Automatic ranging and polarity selection and sign indication shall be provided.

2.02 SIGNAL CONDITIONERS AND CONVERTERS

A. General: Signal conditioners and converters shall be provided as shown on the Drawings and/or as specified herein. They shall have all solid state circuits on plug-in printed circuit boards and housed in card cases or single cases for in-panel mounting and weatherproof or explosion-proof cases for field mounting depending on the area rating. Accuracy shall be ±0.25% unless shown otherwise. They shall be as manufactured by Phoenix Contact, PR Electronics; or Engineer approved equal.

B. Signal Selectors: Signal selectors, if required, shall receive up to four dc control signals and shall retransmit the lower, the intermediate, or the higher of the signals. Signal selectors shall be back-of-panel mounted.

C. Signal Isolators and Impedance Converters: Signal isolators and impedance converters shall be provided for all field-located transmitters to prevent ground loops and ensure system compatibility and shall be either field-mounted or back-of-panel mounted in the control panels.

D. Volt-to-Current Converters: Volt-to-current converters shall be provided where indicated to receive a 1 to 5 Vdc input and convert this signal to a 4-20 mAdc current output, proportional to the sensed variable. Zero and span adjustment shall be provided. Unit shall be back-of-panel mounted.

2.03 INTRUSION SWITCH

A. Limit switches used for intrusion detection shall be heavy duty snap action type, with the following features:
1. Metal body
2. 20°F - 185°F temperature operating range
3. Double-pole, double-throw
4. Spring return
5. 600V class contacts
6. NEMA enclosure rated for the environment in which the switch is installed
7. 1/2-inch NPT conduit entry
8. Provide lever arm where required

B. Manufacturer: Schneider Electric, series 9007CR, or approved equal.

2.04 CONTROL PANEL ACCESSORIES

A. Relays, timers and other internally mounted equipment shall be of the types specified in other Sections of these Specifications.

B. Panel face mounted equipment shall be of the types specified in other Sections of these Specifications.

C. Standards: All control devices shall conform to applicable provisions of NEMA Standards ICS 1 and ICS 2.

D. Pushbuttons, selector switches and pilot lights shall be heavy-duty oil tight units. Pushbuttons and selector switches shall have contacts rated 10 amperes continuous, Rating Designation A600 in conformance with NEMA ICS 2.
   1. Pushbuttons used as emergency stop devices shall have a padlockable means for maintaining an open circuit. Indicating lights shall be push-to-test transformer type with lenses of the colors shown on the Drawings.
   2. Multiposition control switches shall have rotary action, round knurled handle and the number of positions and stages shown on the Drawings. They shall be suitable for panel mounting. Each position shall have a positive detent. Contacts shall have a continuous current rating of 10 amperes at 300 Vac. Switches shall have integral indicator.
   3. For 4-20 mAdc and 1 to 5 Vdc signal selector switches, provide oiltight selector switches with electronic duty gold contact blocks. Provide sliding contacts for reliable operation without benefit of thermal cleaning action.
   4. Manufacturer: Provide Senasys heavy duty oil tight manual controls, with electronic duty gold contact blocks; Allen-Bradley Bulletin 800T oil tight selector switch with stackable "Logic-Reed" contact blocks; or Engineer approved equal.

E. Colors and Descriptions:
   1. Indicating Lamps: Unless otherwise noted in the individual Loop Specifications, refer to Section 16955 for color code and inscriptions for the lenses of all indicating lights and annunciators.
   2. Lettering shall be black on white and amber lenses. Lettering shall be white on red and green lenses.
   3. Pushbuttons: Follow color coding for indicating lamp above. All unused or non-inscribed buttons shall be black. Lettering shall be black on white and yellow buttons. Lettering shall be white on black, red and green buttons.

F. Nameplates: Unless specified otherwise in the Drawings, nameplates shall be black lamacoid with minimum 3/16-inch-high white letters for major area titles, 5/32-inch for component titles, and 1/8-inch for subtitles, and shall be fastened with a permanent but dissolvable adhesive or by screws.

2.05 INSTRUMENT LOOP POWER SUPPLIES

A. General:
   1. For each two-wire transmitter, provide a 24 Vdc regulated 50 mA power supply with 120 Vac input. Output voltage may be 24 Vdc ±5% manufacturing tolerance at no load, but shall hold within 1% from no load to full load at 120 Vac ±10% input.

2. Line-to-load regulation shall be within 0.1% from no-load to full load. Ripple shall be less than 15 mV peak-to-peak.

B. Manufacturer: Provide IDEC, or equal power supplies for instrument loop power.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Installation, testing, calibration, verification, startup, and instruction shall be in accordance with Section 17010.

B. Wiring: Refer to Section 17010, Part 3 and contract drawings.

C. Switching Circuit Schematics: Schematics shown are detailed. Contractor to verify panel wiring, with manufacturer's data, prior to assembly. Substituted components and circuits used shall be subject to review and Engineer approval prior to procurement. All switching circuits shall be checked and verified by testing before shipment.

D. Control Voltage:
1. When the control voltage is not specified in the schematics, the Contractor may elect to use the 120 Vac power, as supplied from the power panels supplies under Division 16; however, he shall provide a separate low voltage circuit for the indicating lamps or provide individual transformers with lamps. In any event the lamp voltage shall not exceed 30 Vac or dc.
2. Manual disconnect switches (and relays if necessary) shall be provided internal to the panel to isolate process related groups of circuit elements from panel power and foreign voltages to permit troubleshooting without disabling controls for other processes. Safety interlock switches shall be provided on access doors to disconnect local and foreign voltages if required by safety codes of applicable regulating authorities.

E. Supply Voltage:
1. When the supply voltage is not specified in the schematics, or an Engineer approved substitution requires a differing power supply than what is shown on the contract Drawings, the Contractor shall inform the Engineer and locate the closest power source (120VAC or 24 VDC) for the instrument.

END OF SECTION

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SECTION 17330

PROGRAMMABLE LOGIC CONTROLLER (PLC)

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Provisions: Requirements of Division 1 and Section 17010 form a part of this Section.

B. Related Sections Include:
   1. Section 16955: Control Devices - control relays
   2. Section 17010: Instrumentation and Controls, General Requirements
   3. Section 17330A: PLC Process Control Strategies
   4. Section 17510: Panels

1.02 SUBMITTALS

A. The following items shall be submitted in this Section shall be made in one package under the Product Review category of Shop Drawings.
   1. Catalog cuts for PLC panel components. These shall include, but not be limited to the central processing unit, input modules, output modules, program storage device, interfacing equipment, power line voltage regulation transformer, power line surge protection device, Ethernet switches, fiber optic media converters and, fiber optic patch panels.
   2. An Input/Output (I/O) record containing a textual description for each item of input and output, connection diagram addressing (rack, module, channel and address numbers), and data table bit and data table word assignments.
   3. A typewritten document containing startup, operation, and maintenance procedures.
   4. The Factory and Field Witnessed Test procedure.
   5. The Factory and Field Witnessed Test results.
   6. Documentation to confirm that the spare memory requirement is complied with.
   7. Catalog information on laptop computer and programming software packages.
   8. Spare Parts Items: As specified herein.

1.03 QUALITY ASSURANCE

A. Provide PLCs, which comply with NEMA Standard ICS 3-304. This standard applies to the construction, programming, performance, test, installation, protection, and safety of PLCs.

B. UL Listed Industrial Control Panel, equipment and components shall be certified for US and Canada.

1.04 UL LABEL

A. Programmable controller enclosures shall bear the UL label. See Section 17510.

1.05 APPENDICES

A. 17330-A: PLC Process Control and Strategies.

PART 2 - PRODUCTS

2.01 PROGRAMMABLE LOGIC CONTROLLERS

A. General: System Integrator shall provide PLC hardware as described herein, and as shown on the drawings. Minimum PLCs to be provided are listed below. Additional PLCs may be networked as part of the system if required to split responsibilities of packaged equipment Vendors and panel builder subcontractor.

B. Pump Controller/PLC: Provide the pump controller with the following functions as designated in the Drawings.
   1. The pump controller shall provide user ready automatic control of pumps with an intuitive HMI interface.
   2. Pump control of up to 4 pumps (minimum); including pump grouping and pump alternation.
   3. Hand-Off-Auto Control:
      a. Hand mode (semi-automatic, non-maintained manual mode), the pump switches off at the deactivation set point and then resets to Auto mode for the next pump run cycle.
      b. Hand mode (fully manual, maintained mode). To pump beyond the off (deactivation) set point, the Hand-Off-Auto button must be held down by the user for failsafe control.
   4. Level set point adjustment for pump activation, deactivation and station level alarms.
   5. Level device input capability shall include: 4-20mA analog signal, conductive probe or floats.
   6. Pre-configured station optimization features:
      a. Maximum pump off time
      b. Maximum pumps to run
      c. Maximum starts per hour
      d. Inter-pump start and stop time delays
      e. Maximum pump run time
      f. Blocked pump detection
      g. Pump operation control (profile programming) capability
   7. “Locked level” alarm function to indicate a level device fault.
      a. User-defined % change within a specified time period
      b. Different set point values for low use or high use time periods (user defined)
   8. Pump alternation modes shall include:
      a. Fixed lead pump assignment
      b. Normal alternation
      c. User defined alternation
      d. Alternation by the number of hours run or the number of starts within a specified time period
   9. Pump decommissioning modes shall include:
      a. Decommissioned pump is automatically removed from the pump controller.

b. Internal remote monitoring data tag shall flag the decommissioned status of a pump.

10. 3-phase supply voltage monitoring and supply fault management for the following conditions:
    a. Under-voltage
    b. Over-voltage
    c. Phase fail
    d. Phase rotation
11. Monitoring of dc power supply, battery voltage, and internal controller temperature
12. Motor protection features:
    a. 3-phase current monitoring for each pump
    b. Over- and under-current trip
    c. Ground/earth fault
    d. Current phase imbalance fault
    e. I2T fault
    f. Insulation resistance testing for motor windings
13. Flow measurement:
    a. Calculated flow via liquid level draw down data
14. Fault module capability as follows:
    a. Automatic restart function after fault condition is no longer present
    b. Manual reset of fault required (if user intervention of fault reset is slected)
15. Remote control via remote telemetry monitoring to include the following:
    a. Changing the mode of pumps (hand/off/auto)
    b. Reset of pump faults and station faults
    c. Changing pump and alarm setpoints
    d. Changing operational profiles
16. Security
    a. User defined password management for access to programming areas in the controller
    b. Automatic data logging of personnel who have entered the programming areas
    c. Automatic logging of all unsuccessful login attempts with a date and time stamp
    d. Digital input option for controlled access to programming areas
17. SD/USB ports shall be available for the following operations:
    a. Firmware upgrades
    b. Save and load pump controller configuration
    c. Download data logs
    d. Export or import Modbus and DNP3 points list
18. Input / Output Characteristics
    The pump controller inputs and outputs shall be modular and shall be expandable.
    a. Available I/O types shall include:
        1. Digital inputs (voltage free input), also configurable as counters
        2. Digital outputs (240V, 5A resistive)
        3. Analog inputs (10bit)
        4. Analog outputs (10bit)
    b. Digital inputs shall be configurable based on specific pump sensor arrangements:
        1. Seal sensor (conductive)
        2. PTC Thermistor
        3. Flygt FLS & CLS
        4. Conductive probe (for liquid level sensing)
19. Status Induction
    The following paraments shall be displayed on the main screen:

a. Liquid level in percentage, meters, feet or other custom defined units
b. Set points for pump control and alarms
c. Pump status (running or stopped)
d. Pump availability
e. Pump fault indication
f. 3-phase voltage supply values
g. Date and time indication
h. User configurable options to display pump information and station status

20. Communications
    a. The pump controller shall include the following data communication ports:
        1. (2) Ethernet ports (10Mbit/s)
        2. (1) USB device port
        3. (1) SD card port
    b. The pump controller shall support the following communication types:
        1. TCP/IP

21. Manufacturer:
    Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to the following:
    1. PLC:
        Allen Bradley CompactLogix, per Districts standards.b.

F. PLC Enclosure:
1. The PLC hardware shall be furnished completely assembled and wired in control panel (see Section 17510). Provide for serviceable layout of parts. Provide enclosure finish and color to match the motor control center.
2. Note that certain selector switches, pushbuttons, relays, and instruments shall be furnished and installed in addition to the programmable logic controller hardware.

G. Uninterruptible Power Supply (UPS): Provide a UPS unit rated for 200% of entire control panel load with batteries sized to provide at least 90-minute service at full load. Provide Intellipower or approved equal.

H. Managed Ethernet Switches: Provide 10/100 Mbps combined copper cable and fiber optic cable managed switches in PLC panels and where shown on the Drawings. Switches shall meet the following specifications:
1. Full duplex capability.
2. IGMP snooping.
3. Port mirroring.
4. VLAN.
5. Auto-negotiation and manually configurable speed/duplex.
6. Wire speed switching fabric.
7. SNMP for switch management.
8. IEEE 802.1 Spanning Tree Protocol.
9. Port Trunking.
10. Latest version of the manufacturer’s software for configuring and monitoring Ethernet switches shall be provided. If more than one software package is available, provide the package with the greatest capability. If specialty cable is needed to connect between PC and switches, provide cable.
11. Each field Ethernet switch shall have at least one spare (unused) RJ45 port.

12. All Ethernet switches shall be compatible models from a single manufacturer. The switches shall be Stratix by Rockwell Automation, or approved equal.

I. Radio Telemetry System

1. A radio link shall be provided enabling the Rainbow Municipal Water District SCADA system to communicate with the Thoroughbred Lift Station site. Radio system shall consist of integrated radios with integral dish antennas. The supplier shall coordinate radio frequency requirements with District. The radio system will require radios to be installed at the Thoroughbred Lift Station. The radio installed at Thoroughbred Lift station will communicate link to the District SCADA system via a new radio at Hutton 1 Tank installed and commissioned by the District.
2. The Contractor shall perform a physical site survey to determine any local obstructions including buildings, trees, and hills that might interfere with the radio transmission.
3. Data interface: Ethernet RJ-45, as appropriate for the control hardware used in the project. Ethernet shall be capable of connecting to TCP/IP based industrial protocols.
4. Radios
    i. Frequency: 5.725 GHz to 5.860 GHz.
    ii. RF connectors: Cat-5E or Cat-6 shielded RJ45.
    iii. Mounting: Tower.
    iv. Grounding: As described herein.
    v. Bands: UNII-3.
    vi. Power supply: Power-Over-Ethernet (POE).
    vii. Lighting arrestor shall be installed at the base of the tower and connected to earth ground. Surge protector shall be installed in a junction box at the height of the radio/antenna mount.
    viii. Ubiquiti PowerBeam PBE-5AC-500-ISO with integrated dish antenna or approved equal.

J. Antennas and accessories

1. The radio/antenna shall be mounted on a 30-foot minimum hinged telescoping aluminum tower as manufactured by Aluma, Universal Tower, or approved equal. Tower shall include guy wire attachments, manual hand-crank, and safety stop mechanism with interlocks.
2. The location of the tower as shown on the plans. The tower shall be oriented to provide space for tilting the tower when servicing the antenna is needed.
3. The radio/antenna combination unit shall be mounted on top of the tower pointed at the appropriate direction as determined by the radio propagation study (provided by the District).
4. At the base of the antenna tower and the reservoir there shall be a lightning arrester mounted and electrically grounded. The arrester shall be L-Com HGLN-CAT6 or approved equal.
5. Telemetry, radio, and computing equipment must be supplied power from a completely separate circuit from the panelboard. No additional outlets are to be permitted on this circuit. Lightning arresting equipment shall be installed on this circuit in accordance with the manufacturer's recommendations. Arresters shall be Joslyn Model 1250-32 or approved equal.
6. One conduit is required to be installed between the Control Panel enclosure and the antenna mast/tower base. The conduit is to be used for the radio antenna cables, provided as part of the radio equipment assembly. The conduit shall be routed from the base of the antenna mast to the enclosure in a manor to ensure that any water

entering the conduit will not flow into the enclosure. A radio ground wire (#4 XHHW Green wire) shall be installed in the conduit. Install ¾ inch conduit on the mast routed from the base junction box up to near the radio assembly. At the base, the conduit shall be connected to the junction box via flex cable allowing the mast to be lowered without damage to the attached conduit. The ¾ inch conduit shall be terminated within 16 inches of the radio antenna, and shall be clamped to the radio mast, and shall be provided with a 1 inch weather head installed for the radio cable. The radio cables shall be pulled through the conduit, , through the weather head with 3-feet of cable left unterminated and available for termination by the radio system supplier.

7. The Cat 6 communication cable will be terminated to the RJ45 weather tight connectors provided with the radio assembly equipment. Additionally, a #4 green ground wire shall be installed in the conduit, through the weather head and shall be terminated on the radio antenna enclosure on the grounding screw provided with the radio equipment. The radio antenna cables and grounding wire shall be pulled from the control panel enclosure to the weather head, through the termination enclosure and shall not be cut or spliced. The Cat 6 cables will be terminated and tested by the electrical contractor. In addition, a 10 foot grounding rod shall be installed at the base of the antenna and a minimum #2 bare copper wire be terminated on the grounding rod and run up the mast to the radio. Secure the wire with clamps every 10-feet. At the top of the mast, the bare grounding wire shall be bonded to the #4 ground wire.

K. Spare Parts: Provide the following spare parts.
   1. One input/output module for each type provided.
   2. One PLC processor module including memory for each type provided.
   3. One communications module for each type provided.
   4. One power supply for each type provided.

PART 3 - EXECUTION

3.01 WITNESSED TEST

A. General: The PLCs that are not provided by the packaged equipment vendors shall be tested at System Integrator's shop:
   1. Control Panel assembly and Programming of the PLCs shall be by System Integrator. The programs will be loaded to each PLC during the Witnessed Test and the entire system shall be tested by System Integrator and the Engineer.
   2. System Integrator shall coordinate all required technical information regarding PLC hardware.

B. Prior to shipment of the PLCs to the jobsite, perform a Witnessed Test. This test shall demonstrate full compliance of the PLCs with contract requirements. The test shall be performed by System Integrator with the Engineer.

C. Prepare a detailed written witnessed test procedure to be submitted at least two weeks prior to start of the test. The test procedure shall describe testing methods and provide detailed specification of the input data and data sequences to be used in the test. If, in the opinion of the Engineer, a resubmission of the proposed test

procedure is required, the date for the performance of this test shall be six weeks following delivery of the resubmitted test procedure.

D. Perform the witnessed test in accordance with the test procedure and coordinate with the Engineer. Any deviation in performance from that specified in these Specifications shall be corrected prior to shipment. If the deviation in performance is deemed by the Engineer to be substantial and if it is not corrected within the period allowed for the test, a second test shall be performed. No extension of Contract time will be allowed in the event that this second test in necessary.

E. Submit the results of the test in a formal document within two weeks following satisfactory performance of the test. The test results shall document all problems encountered in running the test, corrective action taken, and the detailed results of each phase of the test.

3.02 FIELD TEST

A. After the PLC has been installed at the jobsite, a demonstration of compliance with all functional objectives shall be made under actual or simulated operating conditions, subject to favorable review by the Engineer.

B. Prepare a detailed written witnessed test procedure to be submitted at least two weeks prior to start of the test. The test procedure shall describe testing methods and provide detailed specification of the input data and data sequences to be used in the test. If, in the opinion of the Engineer, a resubmission of the proposed test procedure is required, the date for the performance of this test shall be set at least six weeks following delivery of the resubmitted test procedure.

C. Perform the witnessed test in accordance with the test procedure. Any deviation in performance from that specified in these Specifications shall be corrected prior to shipment. If the deviation in performance is deemed by the Engineer to be substantial and if it is not corrected within the period allowed for the test, then a second test shall be performed. No extension of Contract time will be allowed in the event that this second test in necessary.

D. Submit the results of the test in a formal document within two weeks following satisfactory performance of the test. The test results shall document all problems encountered in running the test, corrective action taken, and the detailed results of each phase of the test.

3.03 TRAINING

A. General: To familiarize the Owner's personnel with PLC operation, training shall be provided as detailed hereunder. The training course shall be conducted under the direction of a Plant Manager who shall design a detailed training plan that complements the experience and skill levels of the Owner's personnel.

B. PLC Operations Training: A minimum one-day course shall be provided for up to six persons by System Integrator. The level of training shall be sufficient to familiarize the personnel with the operation of the PLCs and programming and program storage device. All essential system operating procedures shall be described as

required to enable Owner's personnel to observe the controller operation via the programming device displays.

C. PLC Corrective Maintenance Training: A one-day course shall be conducted for up to six persons on maintenance of modifications to the PLC by System Integrator. Instruction shall be given in the use of hardware diagnostic routines, test equipment and test procedures as required to enable the Owner's personnel to detect and isolate system faults to the circuit board or module level and to implement repairs by replacing failed circuit boards or modules. Step-by-step written procedures shall be provided for identifying hardware faults to the circuit board or module level for all items of digital equipment. All equipment corrective maintenance training activities shall be limited to the use of diagnostic routines with the aid of the programming device.

D. Additional PLC Training: If requested by Owner, a portion of the field instrument training required in Section 17010 may be allocated toward a continuation of either training course above or covering a specific topic. The Owner and System Integrator must agree to the training content prior to commencing any training.

E. Documentation: Upon completion and acceptance of the PLC system, System Integrator shall provide complete documentation for all equipment provided in building the Industrial Control Panels. Any engineer approved modifications/changes to the electrical drawings shall be marked on a record set of drawings and returned to the Engineer for incorporation. Two copies shall be submitted to the Owner and one copy to the Engineer.

END OF SECTION

SECTION 17330-A

PLC PROCESS CONTROL STRATEGIES

LIFT STATION 1B SUBMERSIBLE PUMPS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This Appendix describes the monitoring and control of the Thoroughbred Lift Station submersible pumps.

1.02 PROCESS OVERVIEW

A. Wastewater flows by gravity into Thoroughbred Lift Station Diversion Manhole, which combines and directs the flows to either the Thoroughbred Lift Station Wet Well 1, Wet Well 2, or the emergency storage basin. Two submersible pumps (P-110 and P-120) take suction from the Thoroughbred Lift Station Wet Well 1 and two submersible pumps (P-210 and P-220) take suction from Thoroughbred Lift Station Wet Well 2 and discharge to the Thoroughbred force main.

PART 2 - PRODUCTS

2.01 PROCESS AND INSTRUMENTATION EQUIPMENT

2.01.2 Thoroughbred Lift Station

A. Level switch (LSH-155) that measures the high level in the Diversion Manhole.

B. Position switches (ZSC-151 and ZSC-251) that senses the fully closed position of the wet well sluice gates.

C. Hatch access switches (ZS-184 and ZS-284) that senses the fully closed position of the wet well sluice gates.

D. Four submersible pumps with VFD driven motors (P-110, P-120, P-210 and P-220).

E. Hand/Off/Auto switches for each pump (HS-110, HS-120, HS-210 and HS-220).

F. Position switches (ZSC-9201, ZSC-9202, ZSC-9204 and ZSC-9205) that senses the fully closed position of the check valves.

G. Level switches (LSHH-151 and LSHH-251) that measures the high level in the wet wells.

H. Level switches (LSLL-151 and LSLL-251) that measures the low level in the wet wells.

I. Radar Level transmitters (LIT-153 and LIT-253) that measures the level in wet wells.

J. Pressure transmitter (PIT-250) that measures the pressure of the force main.

K. Flow transmitter (FIT-250) that measures the flow in the force main.

L. Level switch (LSH-154) that measures the high level in the underground Emergency Storage Basin.

M. Intrusion switches (ZS-100 and ZS-102) that senses the fully closed position of the Electrical Room and Generator Room doors.

PART 3 – EXECUTION

3.01 PREPARATION

A. SCADA System and PLC Strategies – General
1. The SCADA system is an existing system that will be modified by the Control System Integrator.
2. Any communication failures between SCADA and the Pump Station PLC shall be logged as a SCADA Alarm.
3. The Pump Station Control System shall be provided:
   a. Manual Control of the Pump Station PLC controlled System from SCADA.
   b. Automatic control of the Pump Station PLC controlled systems, selectable from either SCADA or the local Operator Interface Terminal.

3.02 INSTALLATION

A. Basic Operating Control Strategies
1. General: The following “Control Strategy” descriptions define the key features associated with the lift station. These control strategies provide the system integrator with an overview of the operation parameters that will be expected. The system integrator will develop the PLC programs for each of the PLCs based on the operating strategies described below, and in keeping with the basic function described below.
2. Motor: Where the P&IDs define that a motor load is controlled by a PLC, all of the status and alarm functions shall be displayed on SCADAI. Both a PLC automatic based control strategy and a manual overall control via SCADAI shall be provided for each motor. All setpoints shall be accessible and modifiable via SCADA.
3. Packaged System: Where the P&IDs define that a package system is monitored by the PLC, all of the status, control, and alarm functions noted on the P&ID shall be displayed on SCADA. These package systems include:
   a. Emergency Generator (for Schoolhouse Lift Station only)
4. Pump Station Alarms – Each equipment failure, low-low state, low-state, high-state, high-high state, communication failures, normal power failures, or UPS power failures shall be reportable via SCADA.
5. Pump Station Status and Control – All instrumentation analog values, in actual engineering units shall be accessible from the SCADA.
6. Instrumentation:
   a. Where the P&IDs define that an instrumentation device is monitored by a PLC, all status and alarm functions shall be displayed on SCADA.
   b. All instrumentation having an analog value shall have a PLC based High-High, High, Low, and Low-Low alarms that can be monitored by

SCADA. Each alarm shall have a PLC-based set point that can be adjusted via SCADA. Each alarm shall have a means to be enabled or disabled via SCADA.

c. All instrumentation having an analog value shall be trended historically and shall be available for staff to rend and perform analysis via the Historian an.

B. Control Strategy – Sewage Lift Station, General (Thoroughbred Lift Station)

1. The Lift Station will consist of two duplex alternating pump system using four (4) equally sized submersible pumps (two duty, two standby). No provisions are provided for additional pumps.
2. All pumps should alternate starts.
3. The level transmitter shall start and stop the pumps during normal operations via the local PLC.
4. The radar level transmitter shall operate the pumps via the local Distribution Panel should the level transmitter fail or the local PLC fail. The pumps will start with the HWL and stop with the LWL. A failure alarm shall be issued if the pump fails, the low-low level float is triggered, or the high-high level float is triggered.
5. The PLC shall show flow data including instantaneous, non-resettable total, resettable total, current day, and previous day flows.
6. The pumps may be monitored and controlled locally or remotely through SCADA.
7. The panel enclosures shall have an entry alarm with operator reset.

3.03 PUMP CONTROL STRATEGIES

A. General: The submersible pumps at the lift station may be controlled automatically through the PLC in the Control Panel or manually via the manual control switches located on the Control Panel. Automatic control of the pumps (i.e., start high speed, start low speed, and stop) is based on the respective wet well level set points. The designated standby pump serves as a backup to the lead pump.

B. Refer to Specification 17010 Appendix A and drawings for the information that is monitored and transmitted to the workstations

C. Controls:

1. When the Wet Well Pumps are set for automatic, then Pump 1 and Pump 2 will operate in a duty/standby manner. The PLC Alternator can be set to Automatic Alternation, PumpP-110-Duty/Pump P-120 Standby, or Pump P-120-Duty/Pump P-110-Standby. Pumps P-210 and P-220 in Wet Well 2 will remain in standby unless manually adjusted by the Operator. Pump alternation will occur when the level in the wet well falls to the Duty Pump Off level setpoint.
    i. If the Duty Pump Failure Alarm Occurs or Fails to Start then the PLC alternate will make the Standby Pump the Duty Pump and start the pump.
    b. Provide via SCADA the means to designate “automatic alternation” or ‘no alternation”. If “no alternation” is selected designate which pump is “Duty” and which Pump is “Standby”.

2. Pump Duty/Standby selection is chosen by the operator via a sequence selector switch on the HMI. The selector switch operates as follows.

Switch Position	Duty Pump	Standby Pump
1	1	2
2	2	1

3. Pumps will be started and stopped in accordance with the following.

Level (Ft Elev)	Duty Pump	Standby Pump	Alarm
<147.39	Off	Off	Yes
<146.89	Off	Off	Yes
=<147.89	Off	Off	No
>150.14	On	Off	No
>150.14 (1 minute)	On	On	No
=>151.14	On	On	Yes
=163.00	On	On	Yes

4. If a pump fails to start "X" seconds (initially set to 30 seconds) after it was commanded to start or has an active fault condition, it will be automatically replaced in the start/stop sequence by the standby pump.
5. If a pump is running and its associated check valve position switch indicates the valve is closed for an operator-adjustable period of time (initially set to 2 minutes), the pump will turn off and an alarm will alert the condition through SCADA. The pump shall be stopped regardless of the level in Thoroughbred Lift Station wet well. The pump will then require to be manually started prior to continuation of automatic operation.
6. The following control level set points shall be provided:
   a. High-High Level Set Point
   b. High Level Set Point
   c. Duty Pump Start and Stop Set Points
   d. Standby Pump Start and Stop Set Points
   e. Low Level Set Point
   f. Low-Low Level Set Point
7. Provide at SCADA elapsed runtime displays for each pump
   a. Daily
   b. Total
8. Provide at SCADA, level alarms based on the level switches.
   a. High-High Float Level Alarm
   b. Low-Low Float Level Alarm
9. If the pumps are set to automatic (any one or both), and the level rises to the high level switch, then the second pump within the same wet well set to automatic will be called to run via hardwired motor starter controls regardless of the PLC. The pump will run until the level drops to the low level switch and pump control will be controlled either via the PLC or via the level switches.
10. Lift Pump No. 1
    a. Typical of Lift Pump No. 2
    b. Function: Lift Pump No. 1 is one of two pumps that control the flow out of the Wet Well.

c. Local Control: The pump is equipped with VFD to allow full control of the pump and to minimum pipeline surges.
d. Selector Switch – Hand/Off/Automatic: At the distribution, personnel can select between Hand-Off-Automatic Operation via a selector switch.
    i. When the selector switch is in the Hand Position, the pump will run with local manual control of the pump speed via the VFD controller.
    ii. When the selector switch is set in the Off Position, the pump will not run and is not available for automatic operation, manual operation, or level switch override operation.
    iii. Remote Control: When the Hand/Off/Automatic Selector Switch is in the Automatic Position, the pump operation is controlled by the pump station PLC.
        1. SCADA Selection: From SCADA, pump station PLC control can be placed in either Remote Manual Control or Automatic Control.
        2. Remote Manual Control: When Remote Manual Mode is selected at SCADA, the pump shall be capable of manual control from SCADA. The pump operations are “Start” and “Stop” and the speed setting is entered via the HMI.
        3. Automatic Control: When the Automatic Control Mode is selected at SCADA, the pump operations shall be as described previously within this control strategy under Item 3.03.C.1, Controls.
            a. When both Hand/Off/Automatic Selector Switch for each Pump is set to the “Automatic” position, a “Ready” indicator (located on the HMI screen) will be activated.

D. Alarms
1. Pump Failure to Start:
    a. If the PLC issues a command to start a pump and after a time delay, pump running contact fails to close then a failure to start alarm is issued to SCADA.
    b. Remote Reset to Pump VFD, fails to allow pump start.
    c. Remote Reset to either Pump High Temperature or Pump Moisture High, fails to allow pump to start.
2. Pump VFD Failure: If the pump failure alarm is from the VFD, then an alarm is sent to SCADA.
3. Pump High Temperature: A submersible pump relay will monitor the Pump Windings. If a High Temperature Alarm occurs, the pump will be issued a stop command. The PLC will issue a remote alarm reset to attempt to reset the alarm condition. After three attempts, if the alarm condition doesn’t clear, then a Pump Fail to Start Alarm is issued. Failure of the remote alarm reset to reset the Pump High Temperature Alarm will require onsite inspection and correction of the pump failure alarm.
4. Pump Moisture High: A submersible pump relay will monitor the Pump Casing for moisture or leakage. If a Moisture High Alarm occurs, the pump will be issued a stop command. The PLC will issue a remote alarm reset to attempt to reset the alarm condition. After three attempts, if the alarm condition doesn’t clear, then a Pump Fail to Start Alarm is issued. Failure of the remote alarm

reset to reset the Pump High Temperature Alarm will require on site inspection and correction of the pump failure alarm.

5. Valve Failed to Open: If the check valve close signal does not clear after a set point amount of time after the associated pump has started, a Valve Failed to Open Alarm will be generated. If a Moisture High Alarm occurs, the pump will be issued a stop command. The PLC will issue a remote alarm reset to attempt to reset the alarm condition. After three attempts, if the alarm condition doesn't clear, then a Pump Fail to Start Alarm is issued. Failure of the remote alarm reset to reset the Pump High Temperature Alarm will require on-site inspection and correction of the pump failure alarm.

E. Pump Running Status: The PLC shall provide SCADA with the following information:
   1. Daily Runtime for a 24-hour period
   2. Total Runtime
   3. Average Daily Runtime
   4. Number of Pump Starts issue per day

F. Level Measurement System:
   1. Level Transmitter – LIT 153/-253
      a. Function: Monitor the level in the Wet Well. This level signal is monitored by the Pump Station PLC. This level signal is used in the automatic PLC based control of the Sewage Lift Pumps and alarms:
         i. High-High Level Alarm for Wet Well
         ii. High Level Alarm for Wet Well
         iii. Low Level Alarm for Wet Well.
         iv. Low-Low Level Alarm for Wet Well
         v. Start and Stop Automatic Control of Lead Pump and Lag Pump.
      b. Float Type Level Switches – LSHH 151/251 and LSLL 151/251
         i. Function: The level switches provide alarm status regarding the wet well level as well as backup hardwired control of the Sewage Pumps in the event of either a failure of the PLC or the level transducer.

G. Sewage Pump Station Discharge Flows:
   1. Function: A magnetic flow meter will monitor the discharge flow from the Sewage Pumps. This flow signal is for monitoring purposes only and not involved in the control operations of the Sewage Pumps. This flow signal will provide the following data and alarms that will be available via SCADA:
      a. Discharge Flow
      b. High Discharge Flow Alarm
      c. Low Discharge Flow Alarm

H. Sewage Pump Station Discharge Pressure:
   2. Function: A pressure sensor will monitor the discharge pressure from the Sewage Pump header. This pressure signal is for monitoring purposes only and not involved in the control operations of the Sewage Pumps. This pressure signal will provide the following data and alarms that will be available via SCADA:
      a. Discharge Pressure
      b. High Discharge Pressure Alarm
      c. Low Discharge Pressure Alarm

3.04 GENERATOR CONTROL STRATEGIES

A. General: The pump station is equipped with a stationary generator as well as the means to connect a portable generator. In the event of a utility power outage, the automatic transfer switch will transfer power need to the standby generator and start the stationary generator.

1. When a utility power outage occurs, all pumping operations will be suspended for a fixed time duration to allow the generator to start and for the pumps to come to a complete stop.
    a. Once the generator is running, if the pumps are in automatic, they will operate to meet the current wet well level conditions. If the wet well level is above the Lag Pump Start Level Setpoint, start the lead pump and then the lag pump sequentially to minimize the required starting KVA on the generator.
    b. Once the generator is running, if the pumps are in hand, they will rely on the time delay start relays in the motor starter controls to ensure that they start back up sequentially and not in unison to minimize the required starting KVA on the generator.
    c. If the stationary generator is not available, then the pumps will remain off until a portable generator is brought on sight. Once the generator is connected and running, from SCADA select “Portable Generator Connected”. The PLC will then be allowed to control the pumps either automatically from the PLC or manually using the local Pump Hand-Off-Automatic Selector Switches.
2. Generator Status: The Stationary Generator will start and stop based on a signal from the automatic transfer switch. The PLC will monitor the position of the Automatic Transfer Switch. The PLC will monitor Generator Running and Generator Failure and report the status to SCADA.
3. Day Tank Status: The Stationary Generator will receive fuel from a local Diesel Fuel Day Tank, The PLC will monitor the Fuel Low Alarm and the Fuel Leak Alarm and report the alarms to SCADA.

3.05 INTRUSION SYSTEM STRATIGIES

A. General: The wet wells will be equipped with an intrusion system that will give an alarm to SCADA if unauthorized personnel open the wet well hatch at its respective lifting station. The intrusion system will also allow Rainbow Municipal Water District (RMWD) staff to open the wet well and temporarily disable the intrusion system via an HMI setpoint.

1. The PLC will monitor all intrusion switches located on the doors and hatch lids. When the doors or hatches are opened, the PLC will provide an adjustable time delay (initially 120 seconds). The time delay will allow RWMD staff time to open the Control Panel and activate the Spring Wound Timer. Once the Spring Wound Timer times out, the PLC will re-activate the Intrusion Alarm. If the hatches are still open when the Spring Wound Timer times out or if the Spring Wound Timer is not activated, then the PLC will issue an Intrusion Alarm to SCADA.

3.06 MISCELLANEOUS STRATEGIES

A. The SCADA system shall monitor the various alarm status conditions:
    1. UPS power failure
    2. UPS low battery
    3. Control Power AC Failure
    4. Distribution Power AC Failure

END OF APPENDIX A

SECTION 17510

PANELS

PART 1 - GENERAL

1.01 RELATED WORK SPECIFIED ELSEWHERE

A. Section 16955: Control Devices.

B. Section 17200: Panel Mounted and Miscellaneous Field Instruments.

1.02 DESCRIPTION

A. Provisions: Requirements of Division 1 and Section 17010 form a part of this Section.

B. Work Includes: This Section covers control panels shown on the Electrical or Instrumentation Drawings, or as specified in either Division 16 or 17, and sets minimum standards for all packaged unit panels specified in Divisions 11 to 15, unless modified under those sections.

1.03 REFERENCE STANDARDS

A. National Electrical Manufacturers Association (NEMA):
   1. ICS 1 General Standards for Industrial Controls and Systems
   2. ICS 2 Standards for Industrial Control Devices, Controllers and Assemblies
   3. ICS 4 Terminal Blocks for Industrial Control Equipment and Systems
   4. ICS 6 Enclosures for Industrial Controls and Systems

B. Underwriters Laboratories, Inc. (UL):
   1. UL 508A Industrial Control Equipment

1.04 SUBMITTALS

A. Submit material or equipment data in accordance with the requirements of Section 16010.

B. Shop Drawings: In lieu of shop drawings for detailed PLC control panels, the Contractor shall provide:
   1. Manufacturer’s data sheets for all equipment listed in the Bill of Materials including but not limited to:
   2. All panel pieces and components required to make a complete and functional control panel.
   3. UL Certifications of the fabricator/panel shop to be used for construction of the “industrial control panels”.
   4. Fabricator/panel shop shall provide references from Clients of three previous projects of the magnitude of Longview or larger.
   5. Air supply piping schematics (as required).
   6. Pneumatic signal tubing schematics (as required).

7. Fabrication drawings for peripheral equipment or panels not currently detailed in the drawing set, including a dimensioned outline drawing to scale, showing space for conduits, etc.
8. Details of seismic restraints (refer to Section 01190 for requirements).
9. Details of all panel accessories.
10. Nameplate inscriptions.
11. Connections to external equipment.
12. Wire marking equipment and specifications for wire tagging materials.
13. Panel load calculations.
14. Arrange submissions in a logical manner. Use the device abbreviation identifications and equipment names as shown on the Drawings in order to expedite and facilitate review by the Engineer.
16. Where equipment deviates in any way from that shown on the Drawings, provide a complete record and explanation of such deviations.
17. All proposed equipment substitutions shall be clearly defined in a special section of the submittal called “Substitutions”. All proposed substitutions shall be accompanied by the OEM documentation of what is designed in this specification and drawings as well as the OEM data sheets of the proposed substitution.
18. Any suggested substitutions during the bid process shall not be considered “Engineer Approved”.

C. Spare Parts List: Include a spare parts list showing recommended parts and quantities as well as complete ordering information for replacement components. Provide instruction books for special control devices and special equipment installed in the control panels. Submit these to the Engineer prior to installation of the equipment.

D. Manuals: Provide manuals as specified in Section 17010.

1.05 UL LABEL

A. UL Label:
1. Each assembled control panel and terminal cabinet shall bear the UL label. The UL label shall apply to the enclosure, the specific equipment supplied with the enclosure, and the installation and wiring of the equipment within and on the enclosure. If required for UL labeling, provide ground fault interrupters, isolation transformers, fuses, and any other necessary equipment, even though such equipment is not indicated on the Drawings. The fabricator shall be an approved UL listed manufacturer and meet the requirements as listed in paragraph 1.04, B.3 above.

PART 2 - PRODUCTS

2.01 CONSTRUCTION

A. General:
1. Provide panels as shown on the Drawings. Control Panels shall conform to the requirements of UL 508A – Industrial Control Panels.
2. Panels shall be IP-65/NEMA 4X, type 304 Stainless Steel.

3. Any penetrations in an IP-65 NEMA 4/4X cabinet shall conform to IP-65 requirements to keep the integrity of the IP-65 panel rating (i.e., Panel mounted PC/HMI, Control Stations, process indicators, etc.).
4. The panel itself shall conform to NEMA Standards ICS 1 (General Standards for Industrial Controls and Systems) and ICS 2 (Standards for Industrial Control Devices, Controllers and Assemblies). Control panels measuring 5 feet in height or less shall be supported via uni-strut and wall mounted in areas shown on the Drawings. Dual door control panels shall be designed for floor mounting. All panels shall be wall-mounted or freestanding floor mounted, as shown. Provide sufficient access to the panels.
5. The enclosures shall be stainless steel of adequate strength, when complete, to withstand seismic forces equivalent to those noted in Section 01190. Enclosures shall conform to requirements of NEMA Standard ICS 6 (Enclosures for Industrial Controls and Systems). Panels shall be Hoffman as identified on the Drawing Bill of Material or Engineer approved equal.
6. The enclosures shall have vertically hinged front doors; provide hinge on side of panel that ensures compliance with the 30-inch rule in NEC Paragraph 110-16(a). Freestanding enclosures shall have doors secured by keyed three point latches, except in corrosive locations. Mount the devices through the doors or on recessed plates. Provide nameplates indicated on the Drawings. Each component within the panel shall be securely mounted and arranged for easy servicing, such that all adjustments and component removal can be accomplished without disturbing other components. No fastening devices shall project through the outer surfaces of the cabinet and all components and terminals shall be mounted on mounting pans within the panels.

B. Safety Requirements: The electrical supply to each control panel shall be arranged to be disconnected by a single switch or circuit breaker, except for necessary foreign circuits as required by NEC.

C. Wiring: Factory wire the control panels. Cable all panel wiring by securing to the panel surfaces with plastic cable ties. Permanently identify each wire at each termination by means of a heat shrink numbered sleeve. Number all wires as shown in the detailed drawings. Provide black wire color for ac wiring with white neutral and green ground from panel boards. Provide red wiring for 120 Vac control wiring and blue wiring for DC wiring. Minimum wire size shall be 14 gauge, Type MTW or THHN, 600 volt, stranded copper wire except where prefabricated wire harnesses are used (typically between the PLC I/O card and the I/O terminal wiring in the panel).
   1. Where wiring crosses hinged surfaces, provide an 18-inch "U" shaped hinge loop of extra flexible wires secured at both ends. Provide ring-type lugs for all panel wiring; spade-type lugs are unacceptable. Use ratchet type crimping tools that do not release until proper crimp pressure has been applied.

D. Terminal Blocks: Terminal blocks shall be rated 600 volts for signals greater than 30 V and 300 volts for signals less than 30 V, and shall conform to requirements of NEMA Standard ICS 4 (Terminal Blocks for Industrial Control Equipment and Systems). The terminal block and terminal lug shall be compatible. Provide disconnecting terminals for any circuit within the control panel that can be energized when the branch circuit feeding the control panel, if any, is off. All installed PLC I/O modules shall be wired to panel field terminal blocks. All field wiring shall terminate on field side of the panel field terminal blocks; wiring directly to PLC I/O modules is

not permitted. Provide terminals for all external (field) connections and provide at a minimum, 25 percent spare terminals. Identify each terminal permanently with the numbering scheme shown on the drawings. Terminals shall be Phoenix Contact UK Series, AB 1794, or equal. Note: Alternate IEC wiring systems from Phoenix Contact for high density wiring terminations shall be called out as a substitution and shall require approval prior to procurement.

E. Nameplates: Provide nameplates as shown on the Drawings, and as specified in Section 17010. A "CAUTION" nameplate shall be attached to the outside of access doors warning of foreign voltages inside the panel (see "Safety Requirements").

F. Finish:
   1. After fabrication all external welds shall be ground smooth. The entire unit shall be thoroughly degreased, then filed and sanded. All carbon steel surfaces shall be given a rust-inhibiting treatment or passivator, then one coat of synthetic primer, followed by two coats of synthetic enamel. The average overall finish shall be at least 3 mils in thickness. All damage to the finish during installation shall be touched up at the jobsite as approved.
   2. Exterior panel color shall complement adjacent panels and shall be approved by the Owner. Sharp angled horizontal front edges of panels shall be protected by brushed and coated stainless steel angled strip with concealed fasteners.

G. Size and Supports:
   1. Panels shall be of sufficient size to adequately enclose all instruments designated as "panel-mounted" plus ample interior clearance to allow for installation, general servicing, and maintenance of the instruments. Weight of instruments shall be supported by Unistrut; Famet; Caine; or equal, channel supports. Panel size shall be as indicated on the Drawings or as required to include any approved substituted equipment.
   2. Provide rigid supports for all devices. Supports shall not cause warping or bowing sides or mounting plates.
   3. Should any approved panel equipment substitutions require a larger cabinet than shown on the Drawings, no additional cost shall be incurred by the Owner.

H. Mounting:
   1. Attachment methods shall be detailed on panel fabrication drawing submittals. Heavy panels shall be attached by anchor bolts to the concrete floor. Seismic restraints shall be installed as specified by the manufacturer.
   2. Mounting pans of rigid sheet steel shall be provided for interior components and accessories as required. A steel divider shall separate pneumatic sections from electrical sections. Devices having both electric and pneumatic connections shall be in the pneumatic section and connected to the electric section with waterproof flexible conduit.

I. Arrangement:
   1. The instruments mounted in the panels shall have the nominal size and general arrangement shown. Panel layouts and nameplates shall conform to the approved submittal.
   2. Space shall be provided for instruments indicated as furnished by others to be mounted and wired by the control panel manufacturer. These units shall be shipped to the control panel manufacturer in sufficient time for wiring. Coordination of instrument delivery shall be the responsibility of the Contractor.

The instruments and controls to be located on each panel are shown on the instrumentation drawings, electrical schematics, and/or in the individual Specification.

J. Ventilation:
   1. Ventilation shall be provided to prevent internal panel temperatures from exceeding 140°F.
   2. Louvers shall be provided, when required for cooling, near the bottoms and tops on the rear doors and side of panels. 80-mesh screens shall cover the insides of louvers.
   3. Provide a thermostatically controlled fan in each enclosure when louvers cannot dissipate heat adequately or cause sufficient flow to all panel areas. Ventilation fans shall be low acoustic type suitable for control rooms. Provide removable cleanable or disposable dust filter for each remote site enclosure.
   4. Provide heaters and circulating fans in all outdoor panels to prevent condensation.
   5. Provide air control cooling system for panels requiring less than 1,500 Btu/hr heat dissipation.
   6. Provide air conditioning for IP-65/NEMA 4/4X panels requiring heat removal.

K. Cable Entry Plates:
   1. For top entry panels, a gasketed 10-gauge steel cover plate shall be cut that is suitable for the number of conduits. Cable entry plates are not required for bottom, side, or back conduit entry unless the Contractor must specifically control the position, size, and location of cutouts.
   2. Cable entry plates shall mount to and be fastened along panel stiffeners and framing segments. Tee nut fasteners are preferred.

L. Signal Ground Buses:
   1. Provide each panel with at least one isolated signal ground bus. Provide a bus 1-inch wide by 1/4-inch thick, running from top to bottom. Provide the bus with tapped holes to accommodate ground connections from various devices in the rack. Provide separate ground buses for analog and discrete/digital signals.
   2. Connect all signal shield grounds within the panel to the ground bus(es) with ring-tongue connectors that bolt to the bus(es).

M. Signal Ground Plate: For rack, multiple enclosure, or bay systems provide a separate 1/4-inch-thick isolated copper system ground plate. Mount this plate in a location central to all system components.

N. Panel Lights and Receptacles: Panels shall be internally lighted by fluorescent lamps, provided with guards and a toggle switch located convenient to each access door. One duplex GFI type receptacle shall be provided in each panel section.

2.02 PANEL HARDWARE

A. All doors shall be set flush with hardware required to meet the NEMA rating associated with the environment the panel will be installed in.

B. Supply a minimum of two sets of keys. Doors shall be labeled with "AUTHORIZED PERSONNEL ONLY" in 1-inch letters.

C. Hinges shall be piano type. All hardware and handles shall be stainless steel.

D. Leveling adjustments on each panel section shall be provided on freestanding panels.

E. Status lights, selector switches, and pushbuttons shall be as specified in Section 16955.

F. Provide a copy of the As-Built elementary control diagram(s) and wiring schematics for the control panel, enclosed in plastic and mounted inside the panel.

G. Were noted on the Drawings provide rack-out devices and access plates to make panel access easier and safer. Panel fabricators shall add full extension drawer guides and adjust width of front access plates to assure access to all components and hardware.

I. Floor stand kits shall not exceed 24 inches in height nor cause the panel to exceed 84 inches in overall height.

2.03 CONTROL PANELS AND ELECTRONIC RACKS

A. General:
   1. Steel control panels shall be formed of cold-rolled sheet steel of sufficient thickness and with stiffening as required for fabrication, shipping, erection, and service.
   2. Panels shall be fully enclosed, including top, with no visible seams on the front. Panel front construction shall be minimum 3/16-inch stretcher-leveled, cold-rolled steel with stiffeners as necessary to maintain a flatness of ±1/16-inch of any 2-foot span and ±1/8-inch over any 8-foot span with all equipment installed. All other sections shall be 12 gauge except doors shall be minimum 14 gauge and shall maintain the same specified flatness when closed and latched. When shown on the Drawings, filler panels shall extend to the ceiling.
   3. Cabinets shall be freestanding with adequate internal bracing to support the weight of instruments and wiring. The cabinet design shall be for front access. Doors shall be key locked with a minimum of two sets of keys supplied. Connections to and from the cabinets shall be through conduit through the bottom except when otherwise indicated on the electrical drawings.
   4. Heavy-duty industrial quality racks shall be 19- or 24-inch panel. Framing shall be at least 14-gauge cold rolled steel, and continuously welded, rather than spot welded, at the seams of each intersecting joint.

B. Finish: After fabrication, all external welds shall be ground smooth. The entire unit shall be thoroughly degreased, then filled and sanded. All carbon steel surfaces shall be given a rust-inhibiting treatment or passivator, then one coat of synthetic primer, followed by two coats of synthetic enamel. The average overall finish shall be at least 3 mils in thickness. All damage to the finish during installation shall be touched up at the job site as approved.

C. Exterior panel color shall complement adjacent panels and shall be approved by the Owner. Sharp angled horizontal front edges of panels shall be protected by brushed and coated stainless steel angled strip with concealed fasteners.

2.05 MANUFACTURER

A. Manufacturer of the control panel enclosures shall be Nvent/Hoffman; or approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Installation, testing, calibration, validation, startup, and instruction shall be in accordance with Section 17010.

B. Install each control panel level and plumb, and secure by the favorably reviewed seismic mounting method. Doors shall swing freely and close tightly.

C. Provide a 3-inch-high concrete pad for each field-mounted, freestanding control panel. Provide a 3-1/2-inch-high I-beam kick panel for each control-room mounted, freestanding panel.

D. Carefully repair any damage to the structure, components or finish to the satisfaction of the Engineer. Clean all nameplates.

E. Exercise care at all times after installation of control panels to keep out foreign matter, dust, dirt, debris, or moisture. Use protective sheet metal covers, canvas, heat lamps, etc., as needed to ensure equipment protection.

F. For all metal panels mounted on concrete walls or floors, install 1/8-inch shims, and paint the back sides and bottom of the panels with Mobil Hi-Build Bituminous Coating 35-J-10; Koppers Bitumastic Super Tank Solution; or equal. Film thickness shall be 10-mils minimum.

END OF SECTION

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