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Technical Specifications

SS-20-01 & SS-20-02
AM-WRF Compost and Dewatering Improvements

January 2021

Prepared for

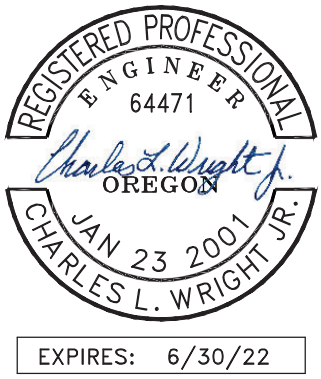
City of Albany
333 Broadalbin Street SW
Albany, Oregon 97321

K/J Project No.1976018*00 and 1976019*00

TECHNICAL SPECIFICATIONS
FOR
SS-20-01 & SS-20-02
AM-WRF COMPOST AND DEWATERING IMPROVEMENTS

CITY OF ALBANY

JANUARY 2021



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JOB NO. 1976018*00 and 1976019*00

CITY OF ALBANY
SS-20-01 & SS-20-02
AM-WRF COMPOST AND DEWATERING IMPROVEMENTS PROJECT

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SECTION 01010

SUMMARY OF WORK

PART 1 - GENERAL

1.01 WORK COVERED BY CONTRACT DOCUMENTS

A. The Class A Biosolids Composting Project includes: construction of a covered aerated static pile type composting system with associated mechanical systems, electrical components, instrumentation and controls; construction of a pipe-on-grade type biofilter, and membrane type buildings; providing a mobile type mixer and associated conveyor; and construction of general site improvements including grading, underground utilities, and paving.

B. The Dewatering Improvements Project includes: demolition of existing belt filter presses, dry type polymer feed system, screw conveyors, heating and ventilation equipment, piping, and associated appurtenances, electrical components and instrumentation; providing rotary screw presses for solids dewatering, liquid polymer type feed equipment, screw conveyors, heating and ventilation equipment, odor control equipment, piping, and associated appurtenances, electrical components and instrumentation into existing buildings; providing temporary solids dewatering facilities; providing new underground electrical conductors; and structural modifications to existing buildings including concrete infill of existing sumps, wall penetrations, equipment supports, metal access platforms, partition walls, and doors.

1.02 WORK UNDER OTHER CONTRACTS

A. PLC and SCADA Programming: The Owner will be responsible for modifications needed to the Owner’s existing programmable logic controller (PLC) and supervisory control and data acquisition (SCADA) system to incorporate equipment associated with the Project. Frequent interaction and coordination with the Owner's PLC/SCADA Programmer (Owner's Programmer) will be required, especially for facility/equipment testing and startup activities. The Contractor shall include Plant Control System startup and testing activities being completed by the Owner’s Programmer in the construction schedule.

1.03 OWNER-FURNISHED AND INSTALLED ITEMS (N.I.C.)

A. Certain items shown or referred to in the Contract Documents are not included in this contract and are marked "Not in Contract" (N.I.C). The Owner will furnish and install N.I.C. items. Owner will make required connections between N.I.C. items and mechanical and electrical services provided under this Contract.

B. The Contractor shall cooperate with the Owner's workers and shall provide access to work areas and space to store tools, material, and equipment. The Owner shall coordinate his work efforts with those of the Contractor and shall adjust his schedule to accommodate the Contractor's schedule.

1.04 OWNER-FURNISHED CONTRACTOR INSTALLED ITEMS (O.F.C.I.)

A. Certain items shown or referred to in the Contract Documents to be furnished by the Owner and installed by the Contractor are referred to as "Owner-Furnished Contractor Installed (O.F.C.I.)." O.F.C.I. items shall be available for the Contractor at the project site.

B. Contractor's installation of O.F.C.I. items shall include attaching or anchoring items, connecting utilities and controls, lubricating and necessary adjustment, startup, testing, and placing items in service. If items are new, the Contractor shall turn over operation and maintenance manuals and equipment warranties to the Owner.

1.05 WORK SEQUENCE

A. General Requirements. The Water Reclamation Facility must remain fully functional during the construction period. The existing facilities are operating under the terms of a National Pollutant Discharge Elimination System (NPDES) permit issued by the State of Oregon that dictates discharge requirements for the facility. Operations of the facility and its ability to meet the conditions of its NPDES permit may not be adversely impacted by the Contractor. A copy of the permit can be provided by the Owner on request of the Contractor.
   1. The Contractor is to employ personnel knowledgeable and experienced in wastewater treatment facility construction including knowledge of treatment processes, facility operations, and chemical systems.
   2. Work Sequence and Constraints described hereinafter are critical events in the work which are presented to underscore the importance of proper sequencing, scheduling, and coordination so that it is integrated with required treatment plant operations. The work sequence and constraints presented do not describe all items affecting the completion of the Work but are intended to describe important events necessary to minimize disruption of the existing facilities and to ensure compliance with permit requirements.
   3. The existing facility where the Contractor's work is to be done will be occupied by the Owner throughout the construction period. The Contractor shall provide all necessary access to the Owner's personnel as required to safely and efficiently operate/maintain the facilities. At all times during the Contract duration, the Contractor is to provide the Owner's personnel and representatives safe and immediate access to all process control equipment. Additionally, the Contractor is to provide for unimpeded access for all delivery vehicles transporting materials, chemicals, and equipment to the facility for the Owner's operations.
   4. 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 facility. Modifications that affect or may affect the operation of the facility shall not be made without first obtaining written permission from the Engineer. Disruptions or interference to one portion of the facility will likely affect other facility processes since they are interrelated and dependent on one another. The Contractor must fully understand any and all possible reductions on facility production and/or water quality as they plan the Work.

5. The Contractor shall note that not all valves and gates that may be used to isolate lines and facilities will completely seal. The Contractor shall allow for leakage in planning its work and may, with the Owner's concurrence, test certain valves and gates before work involving isolation is begun. The Contractor shall provide adequate temporary pumping and piping facilities to properly clear the work areas as necessary of water, chemicals and/or sludge. The Contractor shall clean the work areas as required to perform the work. Shutdown and isolation of existing facilities by closing existing valves/gates and operating electrical control panels, or as specifically provided for in the Contract Documents, will be performed by Owner's personnel.
6. 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.
7. The Contractor is advised that any shutdown of facilities will place a considerable burden on the Owner's staff before, during, and after the shutdown. If through inadequate planning, lack of preparedness, faulty or inefficient workmanship or other causes controllable by the Contractor, delays, excessive time, or additional shutdowns are required that cause the Owner to incur extra cost, said extra cost will be assessed against the Contractor. To minimize impact on plant staff, all outages shall be limited to 4-hour periods, unless otherwise approved. All shutdowns and outages must receive written approval as specified.

B. Construction sequencing will be constrained by existing operating facilities at the Water Reclamation Facility. The following defines the constraints required for facility operations and staff use of the site. Prepare a construction schedule meeting the Contractor's work needs while meeting the following constraints.
1. Solids dewatering is critical to the operation of the Water Reclamation Facility and its ability to meet NPDES discharge requirements. Until temporary dewatering facilities are fully tested and operational, operation of the existing dewatering facilities may not be interrupted for more than 48 hours per occurrence with a maximum frequency of one occurrence per 7-day period.
2. Demolition of the existing belt filter presses, polymer feed system, cake conveyance, or any associated electrical system, piping, or appurtenance that affects the ability of the existing dewatering system to operate at full capacity may not occur until temporary dewatering facilities are provided, tested, and in full time operation by the Owner for a minimum continuous period of 14 days.
3. Temporary dewatering facilities must remain fully functional and available for use by the Owner until the new dewatering system is fully installed, tested, and has successfully completed the 30-day Acceptance Test in accordance with Section 01650.
4. The Owner will be responsible for modifications to the Owner's existing PLC and SCADA system to integrate equipment provided by the Project into the Owner's existing control system. To allow sufficient time for the Owner's Programmer to complete needed software development, facility startup

(Section 01650) may not start sooner than 90 days after the Contractor has received Engineer's favorable review for the following submittals:

a. Liquid Emulsion Polymer System, Section 11240
b. Rotary Screw Press, Section 11340
c. CASP Composting System, Section13501
d. Screw Conveyors, Section 14400
e. Heating, Ventilating, and Air Conditioning, Section 15800
f. Odor Control Equipment, Section 15850
g. Motor Starters, Section 16155
h. Motor Control Centers, Section 16920
i. Variable Frequency Drives, Section 16924
j. Control Devices, Section 16955
k. Programmable Logic Controller, Section 17330
l. Control Panels, Section 17510

5. The Contractor will install the Owner furnished Composting RIO Panel (WW1-016RIO6001). To allow sufficient time for the Owner to procure the panel, the Contractor may not schedule installation of the panel sooner than 90 days after the Contractor has received Engineer's favorable review of the CASP Composting System (Section 13501) submittal. The construction schedule shall show the planned installation date of the panel. The Contractor shall confirm the installation date a minimum of 7 days prior to the scheduled event.
6. The Contractor shall provide the time specified below for the Owner's Programmer to complete startup testing and debugging of the plant PLC control logic and SCADA system during functional testing in accordance with Section 01650. Time periods specified shall be shown on the construction schedule and may not run simultaneously with one another. Contractor shall complete all specified startup steps prior to functional testing prior to commencing Owner's Programmer allotted testing time.
    a. Polymer feed system: 2 working days.
    b. Rotary screw presses: 4 working days.
    c. Screw press and cake conveyors: 3 working days.
    d. Ventilation and odor control: 2 working days.
    e. CASP composting system: 4 working days.

1.06 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.

B. Except for the dewatering facility, the Owner must continue operation of its existing facility during 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.

1.07 DOCUMENTING EXISTING CONDITIONS

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 minimum of 100 digital color photographs and a video showing all areas that may be affected during the Work. Provide two CD/DVD copies of all photos and videos.

1.08 SHUTDOWN OF EXISTING UTILITIES, SERVICES, OR OPERATIONS

A. Obtain the Engineer's written approval at least fourteen (14) days prior to the shutdown of any utility, service, or operation of any existing facility and provide confirmation of the shutdown within 72 hours of the scheduled event. Give required notice and make appropriate arrangements with utility owners and other affected parties prior to shutdown of any utility service. The cost of premium time to perform work requiring utility shutdowns on weekends or outside of normal working hours shall be borne by the Contractor.

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 Contractor shall bear the cost of additional workers and premium time work required to minimize the impact of utility service or operations shutdowns.

1.09 REGULATORY REQUIREMENTS

A. The codes and regulations together with local amendments when applicable adopted by the State and other governmental authorities having jurisdiction shall establish minimum requirements for this project. This project shall comply with the applicable codes listed in the code summary shown on the Drawings (Drawing A-001).

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

C. Standard Construction Specifications covers the Contractor's responsibility to comply with laws and codes applicable to Means and Methods for performing the Work.

D. Before starting work, the Contractor shall carefully study and compare the Contract Documents with each other and with existing site conditions and field measurements. The Contractor shall immediately report any discovered deficiencies including code violations to the Engineer, in writing. The Contractor is not responsible for finding all deficiencies but will be held responsible for

construction required to correct deficiencies or code violations that the Contractor had knowledge of or should reasonably have had knowledge of and did not report to the Engineer in writing.

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.

1.10 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 Standard Construction Specifications. Provisions in referenced standards with regard to measurement and payment shall not apply to this Work unless specifically cited.

1.11 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.

1.12 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"

1.13 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

Abbreviation	Stands for
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
CBM	Certified Ballast Manufacturers
CI	Chlorine Institute
CISPI	Cast Iron Soil Pipe Institute
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
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
HI	Hydraulic Institute
HMI	Hoist Manufacturers Institute
IAPMO	International Association of Plumbing and Mechanical Officials
IBC	International 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

Abbreviation	Stands for
PCA	Portland Cement Association
REA	Rural Electrification Administration
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
UMC	Uniform Mechanical Code
UPC	Uniform Plumbing Code
USDC	U.S. Department of Commerce
UL	UL LLC
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 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. Coordinate construction scheduling with plant and utility shutdowns with requirements and limitations in Section 01010. 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 Division 8. Locate access doors to provide convenient access and to coordinate with finished visual elements.
   5. Coordinate location of fixtures, registers, grills, outlets, switches, panelboards, pull boxes, 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 the 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 the 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 the affected trades and the 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 the 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 treatment facility must remain in operation during construction. Schedule utility interruptions, piping connections, and interruption of existing plant operations as required to permit continued compliance with regulatory requirements and to meet the 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 "One Call" in Oregon, contact 1-800-332-3244 for information at least 48 hours in advance of beginning work. Give the 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.
   1. If the Contractor encounters: (1) subsurface or otherwise concealed physical conditions which differ materially from those indicated in the Contract Documents or (2) unknown physical conditions of an unusual nature, which differ materially from those ordinarily encountered and generally recognized as inherent in work of the character covered by these Contract Documents,

(3) material that the Contractor believes may be hazardous waste as defined by law, the Contractor shall immediately report them to the Engineer.

2. Failure to notify the Engineer of a differing condition prior to performing additional work shall be a waiver by the Contractor of any and all claims arising from the differing conditions.
3. If the Engineer determines that conditions encountered are materially different from those indicated in the Contract Documents or ordinarily encountered in work of the character required and that the differing conditions cause a change in the Contractor's cost or time, it will recommend an equitable adjustment in Contract Price and/or Time.
4. The Contractor's failure to notify the Owner of differing conditions that cause a reduction in the Contractor's cost or time shall not affect the Owner's right to make a Claim for adjustment in Contract Price and/or Time.

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. Reference points provided by the Owner will be verified by a registered land surveyor licensed in the State of Oregon by the Contractor at no additional cost to the Owner.

B. The Contractor will 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 CONFERENCE

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. 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.

B. The Contractor shall submit preconstruction conference submittals required by the Special Provisions.

1.08 PROGRESS MEETINGS

A. The Engineer will conduct weekly 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 rolling three-week and 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 Startup and Controls Integration.
9. Discuss open items on Engineer's "Items of Concern List."
10. Discuss impact of proposed changes on progress Schedule.
11. Other business.

1.09 DAILY LOGS

A. The Contractor shall maintain a daily log containing a record of weather, Contractor's own forces working on Site; Subcontractors working on the Site; number and labor classification of workers or each Subcontractor on Site; materials delivered; major equipment on Site, Work started, completed and accomplished that day; approximate count of all personnel at the Project Site; inspections tests and visitors; accidents, any Work stoppages, delays, shortages or losses; problems encountered and other similar relevant data as the Engineer may reasonably require. The daily log shall be signed by the Contractor's Superintendent, submitted by 4:30 p.m. on the next Working Day to Engineer and shall be made available to others as directed by the Engineer.

1.10 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. Where performance-type specifications are used or where pre-engineered or Contractor-designed systems, elements, equipment or components are called for, 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.

1.11 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 the 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.

1.12 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.

1.13 SAFETY

A. In accordance with generally accepted construction practice, applicable law, and the Standard Construction Specifications, 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.

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 specified.

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.

1.14 EXCAVATION AND TRENCHING; WORK WITHIN CONFINED SPACES

A. Submit specific plans to the Owner showing details of provisions for worker protection from caving ground that conform to Oregon OSHA requirements for excavation and work within confined spaces. 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 orders including applicable Oregon OSHA requirements.

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.

1.15 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.

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.

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.

1.16 TESTING LABORATORY SERVICES AND CERTIFIED LABORATORY REPORTS

A. Provide testing services in accordance with Standard Construction Specifications 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 schedule Special Inspections with the Owner’s selected Special Inspection agency. The Contractor shall provide access for the Special Inspections and notify the Owner a minimum of two (2) working days in advance of when work has been scheduled for Special Inspection.

1.17 DOCUMENTS AT THE SITE AND RECORD DRAWINGS

A. The Contractor shall keep a complete set of Contract Documents including all modifications and all favorably reviewed submittals at the site.

B. The Contractor shall prepare Record Drawings by neatly adding the following information in ink at least once a week to a set of Contract Drawings: (1) references to Contract modifications including Responses to Request For Information, minor changes and Change Orders; (2) as-built work that differs from work shown on the Contract Drawings; and (3) the dimensioned, as-installed location of major underground and concealed utilities, conduits, piping, tanks, facilities, and similar items. Record Drawings shall be made on a clean copy of the Contract Drawings and not used for any other purposes. The Contractor shall make Record Drawings available to the Engineer to verify progress. The

Contractor shall submit and obtain favorable review of the Record Drawings prior to Final Acceptance.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 01140

ENVIRONMENTAL PROTECTION

PART 1 - GENERAL

1.01 SCOPE

A. 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. Develop an Environmental Protection Plan in detail and submit in accordance with Section 01300 to the Engineer in the Product Review 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 sanitary landfill site.
   3. Other proposed disposal sites.
   4. 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.

B. Distribute the favorably reviewed Environmental Protection Plan to all employees and to all subcontractors and their employees.

1.03 MITIGATION OF CONSTRUCTION IMPACTS

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. 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.
      a. Protection: Protect trees that are located near the limits of the Contractor's work areas which may possibly be defaced, bruised, or injured or otherwise damaged by the Contractor's operations. No ropes, cables, or guys shall be fastened to or attached to any existing nearby trees or shrubs for anchorages unless specifically authorized. Where such special emergency use is permitted, the Contractor shall be responsible for any damage resulting from such use.
      b. Trimming: Trim and seal tree limbs overhanging the line of the work and in danger of being damaged by the Contractor's operations in accordance with recognized standards for such work. Remove other tree limbs under the direction of the Engineer, so that the tree will present a balanced appearance.
      c. Treatment of Roots: Do not cut roots unnecessarily during excavating or trenching operations. Expose major roots encountered in the course of excavation and do not sever. Wrap them in burlap as a protective measure while exposed. Neatly trim all other roots larger than 1 inch in diameter that are severed in the course of excavation at the edge of the excavation or trench and paint them with a heavy coat of an approved tree seal.
      d. Repair or Restoration: Repair or replace any trees or other landscape features scarred or damaged by equipment or construction operations as specified below. The repair and/or restoration plan shall be favorably reviewed prior to its initiation.
      e. 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.

3. Water Resources:
   a. Investigate and comply with all applicable Federal, State, and local regulations concerning the discharge (directly or indirectly) of pollutants to the underground and natural waters. 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 Standard Construction Specifications, or directed by the Engineer. 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. The Contractor shall submit an Erosion Prevention and Sediment Control (EPSC) plan and obtain an EPSC permit from the City of Albany, Oregon. The Contractor's Construction Schedule 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 the Contractor has obtained the EPSC permit and the EPSC plan has been accepted. The Owner will not be liable to the Contractor for failure to accept all or any portion of an originally submitted or revised water pollution control plan, nor for any delays to the work due to the Contractor's failure to submit an acceptable water pollution control plan.
   c. 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.
   d. Nothing in the terms of the Contract or in the provisions in this Section shall relieve the Contractor of the responsibility for compliance with applicable statutes relating to prevention or abatement of water pollution.
   e. 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.

f. Chlorinated Water: Take special measures to prevent chlorinated water from entering the ground or surface waters. Dechlorinate chlorinated water prior to discharge.

4. Fish and Wildlife Resources: Perform all work and take such steps required to prevent any interference or disturbance to fish and wildlife. The Contractor will not be permitted to alter water flows or otherwise significantly disturb native habitat adjacent to the project area which are critical to fish and wildlife except as may be indicated or specified.
5. Cultural Resources: The project does not pass through any known archaeological sites. However, it is conceivable that unrecorded archaeological sites could be discovered during the construction. 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.

6. Revegetation of Disturbed Areas:
    a. Tree and Shrubs Replacement: Replace trees and shrubs damaged by the construction or as noted on the Drawings after completion of earthwork in the area. Plant nursery stock of the same species and variety, in 5-gallon cans on a one-for-one basis. Plant in the early fall. If planting is not feasible in early fall, the Engineer will reschedule the tree planting operations.
    b. Planting of Trees and Shrubs:
        1) Selection: Deliver trees and shrubs to the site in the nursery containers, with the nursery tags identifying the species and variety. The trees and shrubs should be selected for shape and symmetrical branching habit, which at maturity will produce strong, full foliated specimens. The specimens shall have grown in the designated size of container for a sufficient length of time for the root system to hold the earth when taken from the container, but not long enough to become rootbound or cause a "hardening off" of the root system. Specimens which are loose in the root ball will be rejected. Remove all rejected specimens from the site and replace with specimens as specified. Specimens shall be sound, healthy, vigorous and free from insects, pests, plant diseases and injuries.
        2) Protection: Specimens which cannot be planted within one day of delivery shall be properly protected and kept moist to prevent drying.
        3) Planting Procedure: Planting hole shall be twice the width of the root ball and at least one and one-half times the height of the root ball. Fill the planting hole with water and let drain away. Mix excavated soil with a planting mix appropriate for the type and condition of the soil and the species of tree or shrub and place the mixed soil in the planting hole to the depth necessary to bring the root ball slightly higher than the surrounding soil. Remove the specimen from the container carefully so that the root ball remains unbroken. Place in planting hole and fill with mixed soil to one-half the height of the root ball, tamp thoroughly, then water. Set specimens at such a level that after settlement the top of the root ball is level with the surrounding finish grade. Add mixed soil to form watering basin, fill basin twice with water immediately after planting. Water plantings as frequently as required to keep the specimens adequately moist until well established. The Contractor will be responsible for maintaining specimens for a minimum of one year after final acceptance or planting, whichever is later.
        4) Staking: Use 2-inch x 2-inch redwood or cedar stakes of length adequate to support each tree. Drive a stake on each side of each specimen outside of the root ball, to a depth of 3 feet. Support tree to stakes using twisted galvanized wire covered with reinforced rubber hose where in contact with the specimen.
        5) Mulching: Fill all watering basins of trees and shrubs with a layer of mulch not less than 2 inches thick.

7. Noise Control: The following noise control procedures shall be employed:
    a. Maximum Noise Levels within 1,000 Feet of any Residence, Business, or Other Populated Area: Noise levels for trenchers, pavers, graders and trucks shall not exceed 90 dBA at 50 feet as measured under the noisiest operating conditions. For all other equipment, noise levels shall not exceed 85 dBA at 50 feet.
    b. Equipment: Jack hammers shall be equipped with exhaust mufflers and steel muffling sleeves. Air compressors should be of a quiet type such as a "whisperized" compressor.
    c. Operations: Keep noisy equipment as far as possible from noise-sensitive site boundaries. Machines should not be left idling. Use electric power in lieu of internal combustion engine power wherever possible. Maintain equipment properly to reduce noise from excessive vibration, faulty mufflers, or other sources. All engines shall have mufflers.
    d. Scheduling: Schedule noisy operations so as to minimize their duration at any given location.
    e. Monitoring: To determine whether the above noise limits are being met and whether noise barriers are needed, the Contractor shall use a portable sound level meter meeting the requirements of American National Standards Institute Specification S1.4 for Type 2 sound level meters. If non-complying noise levels are found, the Contractor shall be responsible for monitoring and correction of excessive noise levels.
8. Dust Control, Air Pollution and Odor Control: Employ measures to prevent the creation of dust, air pollution and odors.
    a. Unpaved areas where vehicles are operated shall be periodically wetted down or given an equivalent form of treatment, to eliminate dust formation.
    b. Store all volatile liquids, including fuels or solvents in closed containers.
    c. No open burning of debris, lumber or other scrap will be permitted.
    d. Properly maintain equipment to reduce gaseous pollutant emissions
9. Construction Storage Areas: Storage of construction equipment and materials shall be limited to the designated Contractor's storage area.
    a. Store and service equipment at the designated Contractor's storage area where oil wastes shall be collected in containers. 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. No dumping of surplus concrete or grout on the site will be permitted.
10. 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. Facilities shall be regularly maintained.
11. 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.

12. Erosion and Sediment Transport Control:
    a. Adhere to the EPSC permit requirements and associated Erosion and Sediment Control Plan specified.
    b. Discharge construction runoff into small drainages at frequent intervals to avoid buildup of large potentially erosive flows.
    c. Prevent runoff from flowing over unprotected slopes.
    d. Keep disturbed areas to the minimum necessary for construction.
    e. Keep runoff away from disturbed areas during construction.
    f. Direct flows over vegetated areas prior to discharge into public storm drainage systems.
    g. Trap sediment before it leaves the site, using such techniques as check dams, sediment ponds, or siltation fences.
    h. Remove and dispose of all project construction-generated siltation that occurs in offsite retention ponds.
    i. Confine construction to the dry season, whenever possible. If construction needs to be scheduled for the wet season, ensure that erosion and sediment transport control measures are ready for implementation prior to the onset of the first major storm of the season.
    j. Stabilize disturbed areas as quickly as possible.
    k. In addition, prior to, during, and after earthmoving or excavation operations, the Contractor shall implement Best Management Practices (BMPs) to reduce potential erosion and sedimentation impacts. These BMPs shall include the following:
        1) A minimum number of access points for construction vehicle entry/egress will be designated to prevent vehicle trackout of sediments, and traffic shall be prohibited over exposed soils during wet weather or when the construction site is saturated or muddy.
        2) Flags, markers, and/or temporary fences shall be installed prior to construction activities to avoid soil disturbance outside of the construction easements.
        3) All material excavated shall be sufficiently watered to prevent excessive amounts of dust. Watering, with complete coverage, shall occur at least twice daily, preferably in the late morning and after work is done for the day.
        4) All earthmoving or excavation activities shall cease during periods of high winds (i.e., greater than 25 mph average over 1 hour).
        5) Any material transported offsite shall be either sufficiently watered or securely covered to prevent excessive amounts of dust.
        6) The area disturbed by earthmoving or excavation operations shall be minimized at all times.
        7) Onsite construction-related vehicle speed shall be limited to 15 mph.
        8) Disturbed areas shall be stabilized as quickly as possible.

9) At a minimum, sandbag dikes, silt fences, straw bales, or equivalent control practices shall be used for all significant sideslope and downslope boundaries on the construction area.
10) At the end of each workday, sediment shall be thoroughly swept or washed from paved areas.

1.04 DISPOSAL OPERATIONS

A. Solid Waste Management:
1. Supply solid waste transfer containers. 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 will not be permitted. Remove any excess concrete to the sanitary landfill.

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. Garbage: Store garbage in covered containers, pick up daily and dispose of in a sanitary landfill.

D. 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.

E. Excavated Materials:
1. 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 offsite in accordance with applicable regulations at the disposal site indicated in the Environmental Protection Plan. No additional compensation will be paid to the Contractor for such disposal. Include all such costs in the lump sum prices bid for the project. 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.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

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.
   2. Conduit, piping, cable trays, raceways, ducts and similar systems.
   3. Tanks and vessels (include contents), including support systems.
   4. All equipment specifically listed in this specification.
   5. 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 7-16, 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 Section 01040.

D. 2019 Oregon Structural Specialty Code.

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 7-16, 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 7-16; 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 7-16 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 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, OR piping of 3-inches nominal pipe size and less (Ip=1.0), OR piping of 1-inch nominal pipe size and less (Ip greater than 1.0).
   3. Electrical conduit less than 2.5 inches trade size OR raceways supported by individual hangers 12 inches or less in length from raceway support point to the bottom of the structural support for the hanger, where the hangers are detailed to avoid bending of the hangers and their connections.
   4. 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, OR ducts suspended by individual hangers 12 inches or less in length from the duct support point to the bottom of the structural support for the hanger, where the hangers are detailed to avoid bending of the hangers and their connections.

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.

2. For fire protection systems, follow NFPA 13 modified as in paragraph 1.b above. Ensure that no seismic interaction occurs with items of other systems.

1.07 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Shop Drawings and Calculations 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. Rotary Screw Press Support Structure
2. Flocculation Tank Support Structure
3. Conveyor Spans
4. Conveyor Supports
5. Amendment Storage Building
6. Composting Building
7. Any other item the Contractor's Engineer designs in accordance with Chapter 15 of ASCE 7-16.

C. Seismic Certification of Equipment

1. Certification is required for the following elements or components:
   a. Rotary Screw Press
   b. Flocculation Tank
   c. Polymer Feed Pumps
   d. Conveyors
   e. Odor Control Unit
   f. HVAC Units
   g. MCC
   h. Composting Control Panels and Transformer
   i. Compost Supply and Exhaust Fans
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 7-16 Section 13.2.5, or
      3) Experience Data meeting ASCE 7-16 Section 13.2.6.

D. Shop Drawings for Anchorage Calculations: Where required in the equipment specifications in Divisions 2 through 17, submit **signed and sealed** structural calculations and detailed drawings from the Contractor's Specialty Engineer.
   1. Polymer Feed Skids
   2. Odor Control Unit
   3. Air Handling Unit (Existing Relocated)
   4. Makeup Air Unit
   5. MCCs
   6. Screw Press Room Exhaust Fan
   7. Screw Press Control Panels
   8. Screw Presses
   9. Flocculation Tanks
   10. Conveyors
   11. Compost Supply Fan
   12. Compost Exhaust Fan
   13. Foul Air Ducting
   14. Composting Air Ducting
   15. Stanchion Mounted Compost Control Panels
   16. 45 KVA Transformer
   17. Composting RIO
   18. Overhead Coiling Door

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.

1.08 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 Oregon State's 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 Section 05090 for additional requirements.

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

END OF SECTION

SECTION 01300

SUBMITTALS

PART 1 - GENERAL

1.01 SUBMITTAL PROCEDURES

A. Accompany each submittal with a Submittal form, attached hereto, which contains 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. Provide submittals in electronic PDF searchable format complete with bookmarks for each submittal section

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. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this Section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

F. Preconstruction Conference Submittals. Submit in accordance with the Special Provisions.

G. The Contractor shall allow 30 days for the Engineer's review of each submittal and 30 days for each resubmittal unless a different period is specified by the Engineer in writing. If the Engineer requests additional information or clarification of a

submittal, the 30 days shall be measured from the date the additional information or clarification is received. If the Contractor requires more than two submittals to obtain the Engineer's Favorable Review, the Contractor shall compensate the Owner for the cost of the Engineer's additional review time. The Contractor shall not perform work for which reviewed submittals are required without obtaining Favorable Review of submittals.

1.02 SCHEDULE OF SUBMITTALS

A. Submit a Schedule of Submittals showing the date by which each submittal 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.

B. The Schedule of Submittals shall be kept current for the Engineer’s information and shall be coordinated with the Contractor's construction schedule which shall allow the specified time for the Engineer's review of submittals and resubmittals.

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. The form of Construction Schedule may be selected by the Contractor but shall meet the minimum requirements of this section.

B. The Contractor's Construction Schedule shall be in the form of a computer-generated network analyses diagram and supporting mathematical analysis using the Critical Path Method (CPM) under concepts and methods outlined in the Associated General Contractor's publication, "The Use of CPM's Construction - A Manual for General Contractors and the Construction Industry."
   1. Draw network diagram to scale using actual calendar dates. Show work subdivided into identifiable activities within each trade such that no activity has a duration longer than five (5) working days. Show order and interdependencies of each activity.
   2. Use actual calendar dates to show planned and actual performance and show:
      a. Preceding and following event numbers.
      b. Activity description.
      c. Estimated duration of activity.
      d. Earliest start date.
      e. Earliest finish date.
      f. Actual start date.
      g. Actual finish date.
      h. Latest start date.
      i. Latest finish date.
      j. Total and free float.
      k. Monetary value of activity, keyed to Schedule of Values.

l. Percentage of activity completed.
m. Dates for preparation and delivery of submittals.
n. Dates for delivery of materials or equipment requiring long lead time procurement.
o. Dates of Substantial and Final Completion.
p. Other information required by the Engineer.

B. If the Construction Schedule does not reflect the CPM format requirements, the specified work, or the Contract Time, it will be returned to the Contractor for modification.

C. The Contractor shall submit to the Engineer an updated Construction Schedule with each Application for Payment (other than the final Application for Payment), revised to indicate the portion of the Work executed, all progress slippages, corrective actions taken, or slippage carry-over, for all anticipated delays of difficulties, and all other information required to accurately present the actual status of the progress of the Work as of the date of the Application for Payment. If the Contractor does not submit an updated Construction Schedule with an Application for Payment, Owner shall withhold payment, in whole or in part.

D. The Contractor shall perform the Work in accordance with the most recent Construction Schedule and schedule of Submittals. The Contractor shall monitor the progress of the Work and conformance with the requirements of the Construction Schedule and shall promptly advise the Engineer of any delays or potential delays.

E. Accelerated Work if Required to Meet Schedule: If the Contractor's performance falls behind schedule, the Contractor shall propose a plan to correct the delay, including overtime and/or additional labor to accelerate the work as required to get back on schedule at no additional cost to the Owner. Accelerated work shall include air or express delivery of materials and equipment, increasing the number of workers, working overtime, working Saturdays, Sundays, and holidays and working additional shifts. The Contractor shall pay the Owner for any extra cost of inspection made necessary by accelerated work required under this provision. Give Engineer three (3) days prior notice of construction that will take place outside of normal work hours or work days.

F. In no event shall any construction schedule update constitute an adjustment in the Contract Time, any deadline, or the Contract Price unless any such adjustment is agreed to by the Owner and authorized pursuant to Change Order.

G. The Contractor may, at its option, complete the Work in a shorter period than the Contract Time but the Contractor may not make a claim for extended overhead or other charges for: (1) delays that extended completion beyond the date planned by the Contractor but not beyond the Contract Time, and (2) delays contemplated by the Contractor and the Owner. All float in the schedule shall first be for the benefit of the Owner, the Engineer, the Design Engineer and then for the benefit of the Contractor.

H. Give Engineer three (3) days prior notice of normal work days on which construction will not take place or of scheduled construction that will not take place. Compensate Owner for extra inspection cost resulting from failure to give notice.

I. Daily logs shall be prepared and submitted per Section 01040.

1.05 SCHEDULE OF VALUES

A. Submit a Schedule of Values, in a form acceptable to the Engineer, allocating the Contract Price to various trades, types of work, pieces of equipment, and major tasks to assist the Engineer in evaluating the percentage completion for each part of the Work. The Contractor's overhead and profit shall be uniformly pro-rated over all items in the Schedule of Values. The Schedule of Values shall represent the actual cost of each segment of the work and shall not allocate higher costs, overhead, or profit to work items scheduled for early completion. If the Engineer objects to the allocation of cost or the level of detail provided, the Contractor shall revise and resubmit the Schedule of Values.

B. Energy Trust Incentive Items. The following items shall be shown as separate line items within the Schedule of Values:
   1. Makeup Air Unit. Provide cost for Makeup Air Unit (WW1-015AHU0001) system broken down into the following items: demolition, ductwork and accessories, Makeup Air Unit (WW1-015AHU0001), Screw Press Room Exhaust Fan (WW1-015FAN0001) and Polymer Pump Room Exhaust Fan (WW1-015FAN0005).
   2. VFD for Odor Control System (WW1-015ORT1211).

1.06 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 in the Technical Specifications (Divisions 2 through 17).

B. The Contractor shall make all 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 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. Where items are specified with a description followed by a maker's name and trade name or model number, the item shall be provided with all of the custom modifications, special features, accessories, and options described even though such things may not normally be included by the maker or provider as part of the model specified. Where there is a conflict between the written description of an item and maker's trade name and/or model number, the written description shall take precedence.

F. Requirements for Contractor Designed Items: Verify that items meet the requirements in the paragraph titled "Performance Specifications and Contractor Designed Items" in Section 01040.

G. The Contractor and appropriate Subcontractor shall review, stamp, date, and sign submittals before sending them to the Engineer. By making such a submittal, the Contractor makes the following warranty and shall include that warranty statement on its letter of transmittal.

"The Contractor warrants:

1. Work or items submitted are complete, accurate and meet the requirements of the Contract Documents, or else any deviations are identified and described in a separate letter accompanying the submittal form.
2. Work or items submitted have been coordinated with and meet the requirements of other submittals, field conditions and the Work as a whole and quantities and dimensions are correct.
3. Proposed Equivalent items (if allowed by the Contract Documents) are at least equal in quality, utility and appearance to the first specified item, or else any deviations are identified in a separate letter accompanying the submittal form.
4. Adjustments to other work required to accommodate Proposed Equivalent items (if allowed by the Contract Documents) have been delineated on the submittal and will be made at the Contractor's expense.
5. This submittal includes all items needed for a particular specification section or assembly for which submittals are required.

6. And represents that all material, equipment, hardware, software and firmware product provided to the Project will perform without error, loss of data or loss of functionality arising from any failure to process, calculate, compare or sequence date data accurately."

H. Submittals that contain deviations from the requirements of the Contract Documents shall be accompanied by a separate letter explaining the deviations. See the Standard Construction Specifications. 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.

I. Engineer's Review Procedure and Meaning:
   1. The Engineer will stamp and mark each 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. No further submittal activity is required by the Contractor.

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

J. 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.

K. 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.

L. Intent and Limitation on Engineer's Review:

1. 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.
2. The Engineer's review of the Contractor's submittals is done solely for the Engineer's and Owner's benefit. The Engineer has no duty to the Contractor or any of its subcontractors or suppliers for the accuracy, completeness, or adequacy of the Engineer's review of its submittals.
3. The Engineer's review of submittals is for compliance with the design intent and requirements of the Contract Documents and is based solely on information provided by the Contractor and on the Contractor's warranty that the work or items submitted meet the requirements of the Contract Documents, and the Work as a whole. If later information reveals that work or items submitted or furnished do not meet the requirements of the Contract Documents or the Work as a whole, the Engineer's Favorable Review shall be void and the items or work shall be considered Defective. The Engineer's Favorable Review shall not include an examination of methods or means of construction or required safety precautions. The Engineer's Favorable Review: (1) shall not include a review of quantities or dimensions, (2) shall not relieve the Contractor from responsibility for errors or omissions in submittals, (3) shall not relieve the Contractor from responsibility for complying with the requirements of the Contract Documents, (4) shall not constitute a Change Order, and (5) shall not constitute final acceptance of a product, item or portion of the Work.
4. The Engineer's Favorable Review of submittals shall not relieve the Contractor from responsibility for deviations from the requirements of the Contract Documents unless the deviations are specifically called to the Engineer's

attention in a separate letter accompanying the submittal form, and the Engineer favorably reviews the specific deviations in writing.

5. The Engineer's Favorable Review of a re-submittal does not include a review of changes made by the Contractor to a previous submittal that were not requested by the Engineer unless the Contractor specifically calls the Engineer's attention to the non-requested changes, in a separate letter accompanying the resubmittal form.
6. Where performance type specifications are used or where pre-engineered or Contractor designed systems, elements, equipment or components are called for, the Owner, the Design Engineer and the Engineer shall have the right to rely on the Contractor's design. Favorable Review of the Contractor's design submittal shall be limited to acknowledgment that the design was prepared with the intent of meeting the specified performance criteria, but the Engineer's review shall not constitute a review of the design itself, of the designer's calculations, or of the effectiveness of the design in actually satisfying the specified criteria.

1.07 PROPOSED EQUIVALENTS (SUBSTITUTIONS)

A. 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.

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

C. Time of Submittal:
   1. Proposed Equivalents (Substitutions) shall be submitted within thirty-five (35) days of the Contract date. The Engineer may agree to a later submittal date if requested in writing within thirty-five (35) days of the Contract date. The request shall identify the item; give the Specification reference, and proposed manufacturer and model number of the item that will be submitted and the proposed submittal date.
   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.

D. Content of submittals shall be the same as that required for Product Data, Shop Drawings and Samples submitted 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.

E. The Engineer's review of Proposed Equivalent items is based solely on information provided by the Contractor and on the Contractor's warranty that the proposed item is at least equal in quality, utility, function and appearance to the first specified item. Favorable Review of a Proposed Equivalent item has the same meaning and is subject to the same limitations that apply to the Favorable Review of Product Data and Shop Drawings described in this Section.

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.

1.08 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.
5. Provide 2-dimensional and/or 3-dimensional graphical representations of the overall equipment and of individual elements of the equipment in electronic (PDF, JPEG or other format) suitable for use in an electronic O&M manual.

C. Submit at least sixty (60) days prior to Facility Startup and Training specified in Section 01650.

D. When standard manufacturer's literature is used highlight or mark all copies to show specific items and options provided and cross out all that do not apply.

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 a minimum of two site photographs from different directions and a minimum of 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)

END OF SECTION

From: Company Name
Mailing Address
City, ST Zip
Name

Page: 1 of 2
Submittal Date: _____
K/J Job No.: _____
Project Name: _____

Specification Section: _____ **Prior Submittal:** _____

SUBMITTAL

A. Certification of Completeness and Accuracy

We certify that we have reviewed this submittal in detail and that the submittal is:

1. Complete and accurate and in complete compliance with the Contract Documents.
2. Compliant with the requirements of "Material and Equipment" in Section 01040, especially the subparagraph titled "Compatibility of Equipment and Material".
3. Compliant with the paragraph titled "Performance Specifications and Contractor Designed Items" in Section 01040.
4. Without any deviations from the Contract Drawings, except the following (describe deviation) which have the following advantages and disadvantages:

Delete or replace this text with your response. Space is limited; attach additional sheets if necessary.

Signed by _____ Title: _____ Date: _____

Signed by Contractor: _____ Title: _____ Date: _____

Response Date: _____ **K/J Job No.:** _____

Specification Section: _____ **Project Name:** _____

Page: 2 of 2

Response

Item	K/J Action	Refer to Comment	Manufacturer or Supplier	Title of Submittal / Drawing

A. The action(s) noted above have been taken on the enclosed document(s).

NET = No Exceptions Taken
MCN-N = Make Corrections Noted, No Resubmittal Required
MCN-R = Make Corrections Noted, Partial Resubmittal Required
A&R = Amend and Resubmit
NR = Not Reviewed
RR = Rejected, Resubmit
RA = Receipt Acknowledged

Comment(s):

Delete or replace this text with your response. Space is limited; attach additional sheets if necessary.

B. Corrections or comments made on the shop drawings during this review do not relieve the Contractor from compliance with the requirements of the Drawings and Specifications. This check is only for review of general conformance with the design concept of the project and general compliance with the information given in the Contract Documents. The Contractor is responsible for: confirming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating its work with that of all other trades, and performing its work in a safe and satisfactory manner.

_____
Responder: type name here - sign above

Distribution	Submittal	Encl.	Response
Owner			
Engineer			
Contractor			
File			

From: Company Name
Mailing Address
City, ST Zip
Name

Page: 1 of 3
Submission Date: _____
K/J Job No.: _____
Project Name: _____

Specification Section: _____ **Prior Submittal:** _____

PROPOSED EQUIVALENT

A. When the first specified item is followed by a second maker's name and "or equal," the Contractor may submit Proposed Equivalent items for the Engineer's review. Proposed Equivalent 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 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.

B. This request shall include adequate technical information to fully describe the function and quality of the item. Submittals of Proposed Equivalent items that are not made within 35 days of the Contract date will be rejected unless the Engineer has agreed in writing to a later submittal date and the Contractor agrees to comply with all conditions of the Engineer for the late submittal. If the Contractor's second attempt to obtain Favorable Review of a Proposed Equivalent item is unsuccessful, the Contractor shall submit the first specified item.

C. Inclusion of a maker's name and/or model number after a specification description is not a representation that the maker will furnish an item meeting the Contract requirements at bid time or at time of need. It is the Contractor's sole responsibility to furnish items meeting the Contract requirements.

D. The Engineer's review of Proposed Equivalent items is based solely on information provided by the Contractor and on the Contractor's warranty that the proposed item is equal in quality, utility, function and appearance to the first specified item. Favorable Review of a Proposed Equivalent item has the same meaning and is subject to the same limitations that apply to the Favorable Review of Product Data and Shop Drawings described in the Contract Documents.

E. Submit with proposal:

1. Description of item being proposed including the Manufacturer's model number.
2. Manufacturer's representation that item is equal to or superior to specified item in all respects.
3. Manufacturer's product data.
4. Information about several recent similar installations, including project name, owner's name, address, telephone number, and name of knowledgeable person to contact for information on performance of the product.
5. Whether a reduction in the Contract Price is being proposed and, if so, how much.
6. Any differences between the product specified and the Proposed Equivalent, including the warranty.

Submission Date:
Project Name:
Specification Section:
Page 2 of 3

F. Certification of Equivalency, Completeness and Accuracy:

We certify that we have reviewed this request in detail and that the item proposed is:

1. Equal to or superior to the specified item
2. Complete and accurate and in complete compliance with the Contract Documents,
3. Compliant with the requirements of "Material and Equipment" in Section 01040, especially the subparagraph titled "Compatibility of Equipment and Material",
4. Compliant with the paragraph titled "Performance Specifications and Contractor Designed Work" in Section 01040,
5. Without any deviations from the Contract Documents, except the following (describe deviation) which have the following advantages and disadvantages:

Delete or replace this text with your response. Space is limited; attach additional sheets if necessary.

We further represent and warrant to be solely responsible for any extra cost or expense necessary to make the proposed item or service fully equivalent to and compatible with the Contract Documents and meet or exceed the design intent.

If we use the Proposed Equivalent, we agree to comply with all additional requirements imposed upon us by the Engineer and Owner.

Signed by Subcontractor: _____ Title: _____ Date: _____

Signed by Contractor: _____ Title: _____ Date: _____

Response Date: _____ **K/J Job No.:** _____

Specification Section: _____ **Project Name:** _____

Page: 3 of 3

RESPONSE

Item	K/J Action	Refer to Comment	Manufacturer or Supplier	Title of Submittal / Drawing / Information

A. The action(s) noted above have been taken on the enclosed document(s).

NET = No Exceptions Taken A&R = Amend and Resubmit NR = Not Reviewed
MCN = Make Corrections Noted RR = Rejected, Resubmit

Comment(s):

Delete or replace this text with your response. Space is limited; attach additional sheets if necessary.

B. Corrections or comments made on the submittal during this review does not relieve the Contractor from compliance with the requirements of the Drawings and Specifications. This check is only for review of general conformance with the design concept of the project and general compliance with the information given in the Contract Documents. The Contractor is responsible for: confirming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating its work with that of all other trades, and performing its work in a safe and satisfactory manner.

_____
Responder: type name here & sign above

Distribution	Proposed Equivalent	Encl.	Response
Owner			
Engineer			
Contractor			
File			

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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, and Engineer'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.

C. Temporary Heat: Contractor may use Owner's existing heating system in the Dewatering Building to the extent possible in completing the Work. However, Contractor shall provide supplemental temporary heating equipment as required to maintain conditions necessary for construction operations. Contractor shall provide temporary heating and ventilation for the temporary biosolids dewatering system specified in this Section.

   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 existing 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.

D. 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. Temporary lighting meeting the requirements for finish work shall be provided for the temporary biosolids dewatering system specified in this Section.

E. 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 BIOSOLIDS DEWATERING

A. General: Provide temporary biosolids dewatering facilities to dewater waste activated sludge (WAS) pumped from the aerobic digesters by the existing Aerobic Digester Transfer Pump. The temporary biosolids dewatering facilities shall be provided for the time duration specified in Section 01010 ~~01500~~ and shall be suitable for 24-hour continuous operation. Solids dewatering is critical to the operation of the Water Reclamation Facility and its ability to meet NPDES discharge requirements. Penalties imposed on the Owner resulting from permit violations caused by interruption of the temporary biosolids dewatering system shall be borne in full by the Contractor, including legal fees and other expenses to the Owner resulting directly or indirectly from the permit violation.

B. Design Requirements: Temporary biosolids dewatering facilities shall meet the following design and performance requirements:

Item	Value
WAS concentration, percent solids	0.8 to 1.2
Dewatering capacity, dry lbs/hour	1,200
Dewatered solids concentration (minimum), percent solids	14
Solids capture (minimum), percent	95

C. Biosolid Production: Estimated wastewater solids projections are as shown on the Drawings.

D. Temporary Biosolids Dewatering Plan: Submit a Temporary Biosolids Dewatering Plan 90 days before the temporary dewatering equipment is delivered. The plan must be favorably reviewed a minimum of 30 days before the temporary dewatering equipment is delivered. The plan shall include 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. Detailed drawings, layouts, and descriptions of all equipment required for the temporary biosolids dewatering system.
   3. Information on proposed connection points.
   4. Schedule for equipment delivery, setup, training, and demobilization.
   5. Information including safety data sheets for proposed polymer.
   6. Name and contact information of supplier-authorized local resources available for on-call repairs in the case of dewatering equipment failure or outages.

E. Qualifications: Equipment furnished for the temporary biosolids dewatering facilities shall be by a single supplier who has been regularly engaged in furnishing, operating, training, and maintaining dewatering facilities for municipal wastewater solids for at least 10 years.

F. Equipment Supplier: Temporary biosolids dewatering facilities shall be as provided by Aspen Rentals, or equal.

G. Equipment: A complete and functional temporary biosolids dewatering system shall be provided that at a minimum includes the following:
   1. Trailer mounted belt filter press.
   2. Automated liquid emulsion polymer feed system.
   3. Stacking conveyor to convey dewatered biosolids into 30-yard rolloff bins. Discharge shall be at an adjustable height of at least 8 feet above ground, minimum. (Rolloff bins provided by Owner.)
   4. Sludge feed pump.
   5. Wash-water pump.
   6. Electrical equipment, controls, and alarms.
   7. All interconnecting piping, instruments, miscellaneous equipment, and materials including liquid emulsion polymer needed for a complete a functional dewatering system.

H. Enclosure: Fully enclose the temporary biosolids dewatering facilities to provide weather and freeze protection. Shelter size shall be sufficient to fully enclose all equipment with adequate space for maintenance and operation. Rolloff bins will be located outside the enclosure. The enclosure shall be provided with lighting meeting the requirements of this Section, heated and ventilated (6 air changes per hour).

I. Spares: Provide all maintenance and materials needed to keep the temporary biosolids dewatering system ready for full time operation. Spare parts shall be maintained onsite to reduce potential downtime. At a minimum, spares shall include the following:
   1. 1 set belts (upper and lower)
   2. 1 belt drive motor
   3. 1 sludge feed pump motor
   4. 1 wash-water pump motor
   5. 1 set sludge pump seals
   6. 1 set wash-water pump seals
   7. 1 set polymer feed pump hose

J. Utilities: Provide all required pumping equipment, piping, electrical and control connections between the wastewater treatment plant facilities and the temporary biosolids dewatering equipment, including but not limited to, digested sludge, filtrate, spray water, power, and controls. The existing Aerobic Digester Transfer Pump may be used to pump WAS to the temporary biosolids dewatering system. The pump is automatically controlled based on system pressure. Contractor shall connect to the Aerobic Digester Transfer Pump piping system downstream of the existing pressure transmitter to allow continued use of the existing pump control system. See the Drawings for utility connection locations. Power requirement for temporary dewatering facilities shall not exceed those that may be provided via a temporary 100 A, 480 VAC, 3 phase circuit.

K. Alarms: The temporary dewatering system shall be provided with the following 120V discrete alarm outputs that will be integrated by the Owner into the Owner's existing control system for remote alarm indication. The Contractor shall provide temporary wiring from the temporary dewatering system to the location shown on the Drawings.
   1. Belt tension limit switch

2. Low air/hydraulic pressure
3. Equipment emergency stop
4. Belt drive VFD fault
5. Sludge feed pump VFD fault

L. Operation: The Owner will provide labor needed to operate the temporary dewatering system as required for biosolids dewatering. The equipment supplier shall provide the Owner's staff with a minimum of 2 days of training in operation of dewatering system equipment prior to initial startup of the temporary dewatering system.

M. Maintenance and materials. The Contractor shall provide all maintenance, supplies and materials (including liquid emulsion polymer) needed for continuous operation of the temporary dewatering system. In the event of equipment failure, the equipment supplier shall have a repair technician on site within 24 hours of the failure. The temporary dewatering system shall not be out of service due to equipment failure for more than 72 hours in any 4-week period. Should equipment failure cause the system to be out of service for more than the specified time, the Contractor shall within 24 hours provide equivalent means of solids dewatering or shall commence hauling liquid wastewater solids for remote disposal at no additional cost to the Owner. Remote disposal shall be in accordance with all applicable regulatory requirements. Liquid solids hauling shall be done at a rate equal to actual solids production to prevent the accumulation of solids within the Owner's treatment facilities.

1.03 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.

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.

1.04 BARRICADES, FENCES AND ENCLOSURES

A. See Section 01040.

B. Barricades: Provide temporary guardrails, ladders, stairs, guards, and barricades to protect persons in accordance with applicable regulations, including Oregon OSHA.

C. Fences: Existing fences enclose the present facilities site. The fences are for the protection and security of the present operating facilities. The Contractor may not remove fencing without Engineer approval. If fence removal is approved, Contractor shall provide equivalent temporary protection and security and shall 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.

1.05 PROTECTION OF INSTALLED WORK

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

B. Protect finished floors, stairs, and other surfaces from traffic, dirt, wear, damage, or movement of heavy objects, by covering surfaces with non-staining heavy-duty reinforced moisture-resistant Kraft building paper with joints continuously taped with waterproof tape OR ½-inch-thick CDX plywood with all joints continuously taped with 2-inch-wide duct tape.

C. 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.

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

1.06 SECURITY

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

1.07 ACCESS ROADS, PARKING AND STAGING AREAS

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

B. Parking: Construct temporary gravel surfaced parking areas for construction personnel within the Contractor's staging area shown on the Drawings.

C. Staging Area: Staging areas shall be located as shown on the Drawings. At the Contractor’s expense, temporary improvements (fencing, gravel base, etc.) may be made within the area designated. The Contractor is responsible for all clearing, grading, and other operations required to develop the lot into a useable area. The site shall be returned to original or better condition and approved by Engineer prior to completion of the Work.

1.08 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.

1.09 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. Provide a meeting room suitable for twelve (12) people for conducting the regular construction progress meetings.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

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 14 days prior to starting each system or piece of equipment.

C. Coordination:
   1. Schedule and conduct a facility startup coordination meeting with Engineer, subcontractors, and Owner's PLC/SCADA Programmer (Owner's Programmer) a minimum of 60 days prior to starting the initial startup sequence described in this Section. The Contractor's startup plan and schedule will be presented at this meeting.
   2. Contractor's construction schedule shall specifically show time required in Section 01010 for Owner's Programmer to debug and test the plant PLC control logic and SCADA system interface
   3. During the startup period, coordinate the operation of the facility with Engineer, subcontractors, Owner's operators, and manufacturer's representatives. Provide regular updates of construction schedule and startup activities to the Owner's Programmer.

D. Furnish test equipment, measuring devices, and supplies required to conduct tests.

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

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

G. Provide initial supply of chemicals (full tank volume of each) for startup and testing of the facility. The Owner will provide subsequent chemical supplies.

H. Submit Operation and Maintenance Manuals and Parts Lists specified in Section 01300 at least 60 days prior to startup of new equipment/facilities or the first training session, whichever is earliest. Favorably reviewed Operations and Maintenance (O&M) Manuals are required 21 days before the startup of new equipment/facilities.

1.02 SUBMITTALS

A. Startup Plan, Forms, and Schedule: Prepare a facility startup plan and schedule.
   1. The plan shall include test methods and procedures and sample forms for recording test data.
   2. Plan and schedule shall be submitted a minimum of 60 days prior to starting the initial startup and operation of facilities sequence described in this Section.
   3. Favorably reviewed startup plan and schedule are required 21 days before starting the initial startup and operation of facilities sequence described in this Section.

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. 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.
   2. Successfully complete testing of electrical work required prior to energizing of the electrical system in accordance with Division 16 requirements.
   3. After completion of Step 2, successfully complete electrical testing required after energizing of the electrical system in accordance with Division 16 requirements.
   4. Ring out and test signal wiring in accordance with Division 17 requirements.
   5. Complete calibration of instruments in accordance with Division 17 requirements.
   6. Satisfactorily complete system verification of instrumentation work in accordance with Division 17 requirements.
   7. After completion of Steps 1 and 3, perform a rotational test of equipment and correct backward rotating drives.
   8. After completion of Steps 5 and 6, 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 7, perform instrumentation and control testing and adjustments as related to the equipment being tested.
   10. Concurrent with Step 7, perform adjustments of the electrical work as related to the equipment being tested.
   11. Complete the Functional Testing specified for the equipment. Provide time required by Section 01010 and shown in the construction schedule for the Owner's Programmer to debug and test the plant PLC control logic and SCADA system interface. Provide personnel to assist Owner’s Programmer

in operation of equipment and adjustments of this system debugging and testing. All SCADA controls, interlocks, alarms, etc. including signals from other parts of the facility shall be tested. Provide simulation of inputs if needed during this step.

12. Repeat Steps 1 through 10 as required for other equipment items and systems until all process components and utility systems are ready for new system(s) 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 new system(s) operation is to occur so that the Owner may order chemicals and make other arrangements for full-time operation. This notification shall have an accuracy of plus or minus 7 days. Notify the Owner and Engineer again, exactly 7 days before total facility operation is to begin.
15. 7-day Operational Test. Upon completion of the above steps, the new system(s) shall be filled with service fluid, started up and operated by the Contractor on a full-time basis for 7 consecutive days. All process units shall be brought to full operating conditions. If continuous process operation is interrupted for a period of 4 consecutive hours or more due to a failure of the equipment or work provided by the Contractor, then the counting of the 7-day period shall be restarted at day one.
16. 30-day Acceptance Test: Upon successful completion of all the above steps and all specified training of the Owner's operations and maintenance staff, the new system(s) shall be operated on a complete full-time basis with the Owner providing operating personnel and chemicals. For 5 consecutive days beginning with the first day of the 30-day period, the Contractor shall have at the plant 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 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 days. The Contractor shall provide additional training as needed to the Owner's 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 adjust 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. If continuous process operation is interrupted for a period of 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 shall be restarted at day one if these periods have not reached satisfactory completion.
17. After successful completion of the 30-day Acceptance period, the Owner will take over maintenance duties as well as operation and will begin to provide and pay for lubricants.

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 the 30-day initial operation period.
   1. Affidavits shall contain the following specific wording:
      "The *insert 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. Demonstrate the operation, maintenance and safety procedures for all systems and equipment to personnel designated by the Owner.

B. 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

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 means the Work has progressed to the point that the following items are met:
   1. The Work is ready for beneficial use and occupancy by the Owner for the intended purpose,
   2. All fire and life safety work has been completed, inspected and accepted,
   3. All mechanical and process systems and equipment are complete, have been put in automatic operation, and the 30-day Acceptance Test has been successfully completed in accordance with Section 01650,
   4. The total value of uncompleted work is less than one-half of one percent of the Contract Price,
   5. Temporary facilities and controls have been removed,

6. Completing the Work will not significantly interfere with the Owner's convenience, use or cost of operation.

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. The Contractor shall complete or correct the items on the Punch List until, in the Contractor’s opinion, the Work is Substantially Complete. The Contractor shall then deliver the Punch List to the Engineer and 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. 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. If the Engineer determines the Work is not Substantially Complete, the Contractor shall continue the Work and call for a second Semifinal Inspection when the Work is ready. When the Engineer finds the Work is Substantially Complete, he/she will prepare a Final Punch List and a notice of Substantial Completion, 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. If the Contractor does not achieve Substantial Completion on the second attempt, the Contractor shall reimburse the Owner the cost of the Engineer’s services for additional inspections.

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 and has made all required final submittals, the Contractor shall give the Engineer written notice that the Work is ready for Final Inspection and shall submit a final Application for Payment. The Engineer shall then make a Final Inspection. If the Engineer finds the Work is not fully complete, the Engineer shall notify the Contractor of items still requiring completion or correction. The Contractor shall immediately correct these deficiencies and call for a reinspection. When the Engineer finds to the best of the Engineer’s knowledge, information and belief, and on the basis of the Engineer’s observations and inspections, the Work is acceptable and fully complete in accordance with the Contract Documents, the Engineer will recommend that the Owner issue a Notice of Final Completion, make Final Payment and Accept the Work in accordance with the terms and conditions of the Contract Documents.

B. Final Submittals include:
   1. Record Drawings
   2. Extra Materials
   3. Special Guarantees
   4. Maintenance Contracts
   5. Insurance Certificate showing required continuation of coverage beyond Final Payment.

6. Release of Liens.
7. Waiver of Claims by Contractor.
8. And any other submittals required by the Contract Documents and not previously received.

C. The Owner will make Final Payment to the Contractor per Standard Construction Specifications.

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 on the building or 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 GUARANTEES

A. The Standard Construction Specifications covers the Contractor's responsibility to remedy defects due to faulty workmanship and materials, which appear within the period specified in the Standard Construction Specifications. Within 7 days of receipt of written notice from the Owner, the Contractor shall correct or replace work found Defective within the specified warranty period. If the Contractor fails to correct Defective Work within 7 days of receiving notice to do so, the Owner may correct the Work and recover the cost of correction from the Contractor in accordance with the Standard Construction Specifications regarding the Owner’s right to do work.

B. Guarantees for more than that required in the Standard Construction Specifications 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 7 days 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 in accordance with the Standard Construction Specifications regarding the Owner's right to do work.

Signed _____
(Subcontractor or Supplier)

Company_____

Address_____

Telephone Number_____

Countersigned_____
(Contractor)

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

1.08 TWELVE-MONTH INSPECTION

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

1.09 MAINTENANCE CONTRACTS

A. The Contractor shall deliver original signed copies of prepaid contracts for maintenance of equipment or systems in accordance with detailed requirements contained in Technical Specifications sections.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

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SECTION 2050

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 renovation and construction operations.
         1) Protect the environment, both onsite and offsite, during renovation and construction operations.
         2) Prevent environmental pollution and damage.
         3) Maximize source reduction, reuse, and recycling of solid waste.
   7. If the presence of a hazardous material is suspected, have material tested. If material is identified as hazardous, retain qualified and licensed specialist to remove and dispose of it legally.
   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.

1.04 QUALITY ASSURANCE

A. Maximize use of source reduction and recycling procedures.

1.05 SUBMITTALS

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

B. Submit copies of all executed permits.

C. Solid Waste Management Plan: Prepare and submit a Solid Waste Management Plan within 30 days of the date of the Agreement. The plan shall include, but not be 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.

D. 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. With each Application for Payment, submit updated documentation for solid waste disposal and diversion.

2. With each Application for Payment, submit manifests, weight tickets, receipts, and invoices specifically identifying the Project and waste material.

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. Carpet.
      b. Resilient Flooring.
   13. Insulation.
   14. Ceiling Tiles
   15. Others as appropriate

C. Recycling/Reuse: Maximize recycling and reuse of materials.

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.

3.02 REMOVAL OF CONSTRUCTION IN AREAS TO RECEIVE NEW WORK

A. In areas intended to receive new work and/or finishes, remove all unwanted non-structural partitions, furred walls, chases, suspended or furred ceilings, doors, windows and finishes.

B. Remove all unwanted mechanical and electrical work (whether shown or not) that is not wanted and is not needed to serve other areas that is in, on, or concealed behind work being removed. Cap off or terminate all mechanical or electrical work in accordance with the requirements of Divisions 15 and 16.

C. Protect mechanical and electrical work that serves other areas. Relocate concealed mechanical and electrical work that is required to preserve service to other areas.

D. Remove structural work 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.

E. 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 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.

B. 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 designated location on the jobsite.

C. 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. Use debris chutes with covered tops emptying into covered containers.

B. Use rubber tired covered buggies with rubber bumpers to transport debris through occupied sections of buildings.

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

D. 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 02300

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. ASTM International (ASTM):
   1. ASTM D698 Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft3).

B. American Association of State Highway and Transportation Officials (AASHTO):
   1. AASHTO M288-17 Geotechnical Strength Property Requirements.
   2. AASHTO T99 Standard Method of Test for Moisture–Density Relation of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) Drop.

C. Oregon Department of Transportation (ODOT), Standard Specifications (Standard Specifications)

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): Describe sheeting, shoring, and bracing materials and installation required to protect excavations and adjacent structures and property; include structural calculations for over 20 foot cuts to support plan.
   2. Potholing Report.
   3. Product Data: Submit gradation reports for bedding materials and import backfill materials. Submit product data for geotextile fabric indicating fabric and installation procedure.
   4. 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 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 Owner will hire a third-party Geotechnical Engineer to provide the following quality control measures:
      a. Review and test materials proposed for use.
      b. Observe foundations, site grading and borrow operations.
      c. Observe placement and compaction of fill.
      d. Test soils during placement of fill.
   2. Contractor shall excavate holes for in-place soil sampling. Contractor shall be responsible for costs of additional inspection and re-testing resulting from non-compliance.

C. Testing Methods:
   1. Testing shall conform to the requirements of the ODOT Standard Specifications.
   2. Field testing procedures shall be in accordance with the ODOT Manual of Field Test Procedures (MFTP).
   3. Non-field testing procedures shall be in accordance with the ODOT Non-field Tested Materials Acceptance Guide (NTMAG).
   4. References to these two documents can be found in the ODOT Standard Specifications Sections 00165.30 and 00165.35, respectively.

D. Definitions:
   1. Relative Compaction: In-place density divided by the maximum dry density laboratory compaction expressed as percentage.
   2. Rock Excavation: Excavation of solid ledge rock that, in the opinion of the Engineer, requires for its removal drilling and blasting, wedging, sledging, barring or breaking up with power-operated tools. The term "Rock Excavation" indicates a method of removal and not a geological formation.

E. Qualifications: Prepare excavation protection plan (for over 20 foot cuts) under direct supervision of Professional Engineer experienced in design of this Work and licensed in the State of Oregon.

1.05 EXPLOSIVES

A. Do not use explosives unless specifically authorized, in writing, by the Engineer.

1.06 SUBSURFACE INVESTIGATIONS

A. Geotechnical investigations for design purposes were not done specifically for this project. However, investigations for design purposes were made for the biosolids composting project by Foundation Engineering in a report dated July 16, 2020.

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.

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.

1.07 REFERENCE SPECIFICATIONS

A. Whenever the words "Standard Specifications" are referred to, the reference is to the Oregon Department of Transportation (ODOT) Standard Specifications (latest edition).

1.08 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, and OR-OSHA requirements.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Crushed Rock: 1"-0 or ¾"-0 Shoulder Aggregate, ODOT Standard Specifications 02640.

B. Pipe Zone Materials: 1”-0 or ¾”-0 Dense Graded Aggregate, ODOT Standard Specification 02630.

C. Select Fill: 1 or ¾-inch minus, clean (i.e., less than 5% passing the #200 U. S. Sieve), well-graded, crushed gravel or rock.

D. Granular Site Fill: +- 3-inch minus, clean (i.e., less than 5% passing the #200 U. S. Sieve), well graded, crushed gravel or rock, or approved rounded gravel. Granular site fill may be used to raise site grades.

E. Sand: Clean, free draining, well-graded sand as follows:

Sieve Size	Percent Passing
3/8 inch	100
No. 4	70 to 100
No. 8	36 to 93
No. 16	20 to 80
No. 30	8 to 65
No. 50	2 to 30
No. 100	1 to 10
No. 200	0 to 5

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

G. 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.

H. Aggregate Base: ¾-inch minus clean (i.e., less than 5% passing the #200 U. S. Sieve), well graded, crushed gravel or rock.

I. Separation Geotextile: AASHTO M 288-17 geotextile for separation having Mean Average Roll Value (MARV) strength properties meeting the requirements of an AASHTO M 288-17 Class 2, woven geotextile.

J. Warning Tape: 3-inch-wide, inert, fade-resistant plastic film resistant to acids, alkalis, and other components likely to be encountered in soil. The tape shall be colored the same as the field color specified in Section 10400, imprinted with "CAUTION _____ BELOW", with fluid name in the blank. 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 structure or other material or feature to be placed.
   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.

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 Section 01040 and the Standard Construction Specifications. 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 may be 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 OR-OSHA when working anywhere on this project.

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.

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

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 Standard Construction Specifications.

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. 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 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.

C. The trench shall not be backfilled until the Engineer reviews the pipe and bedding installation.

D. Take care not to over excavate. 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. Backfill and compact over excavations with bedding material. There shall be no additional payment to the Contractor for over excavations not directed by the Engineer. Remove unsatisfactory material encountered below the grades shown as directed by the Engineer and replace with bedding material. Payment for removal and replacement of such unsatisfactory material directed by the Engineer shall be made in accordance with the provisions of the Standard Construction Specifications.

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 in an undisturbed condition. If the Contractor overexcavates or disturbs the foundation surfaces, 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 overexcavation.

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 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.

3.07 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. Geotextile fabric shall be installed for overexcavations as directed by the Engineer.

C. Bedding material shall not be placed until the Engineer reviews the bottom of the trench.

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

E. 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.

F. 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.

G. 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.

3.08 STRUCTURAL BACKFILL

A. Place a layer of Select Fill, in maximum 8-inch lifts and compacted to 95% in accordance with the requirements listed above, under structures to the lines, grades and minimum thicknesses shown on the Drawings.

B. Backfill Adjacent to Structures:
   1. Backfill shall be as shown on the Drawings.
   2. Do not place backfill against structures until the concrete has been patched and cured.
   3. 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.
   4. Place backfill in uniform, level layers, not exceeding 8 inches thick measured before compaction. Bring backfill up uniformly on all sides of the structure, and on both sides of buried walls.

3.09 ROCK SUBGRADE UNDER STRUCTURES

A. Select Fill shall be used under equipment pads and where shown on the Drawings.

B. Select Fill shall be placed as a 6-inch layer, unless otherwise shown on the Drawings, compacted to 95% relative compaction.

3.10 COMPACTION

A. Add water to the backfill material or dry the material as necessary to obtain moisture content within 2% 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. Compaction of embankment and backfill materials by flooding, ponding or jetting is not permitted.

E. When densities of compacted materials do not meet the requirements, remove and/or recompact the material until the requirements are met. 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.

F. Compact all fill in loose lifts not exceeding 12 inches. Thinner lifts of 8 inches or less will be required if light or hand-operated equipment is used.

G. Material Requirements:
   1. Pipe Bedding Material: Compact to a minimum of 95 percent relative compaction in accordance with ASTM D698, unless otherwise specified or shown on the Drawings.
   2. Pipe Zone Material: Compact by hand methods under the haunches of the pipe and in areas not accessible to mechanical tampers unless otherwise specified or shown on the Drawings.
   3. Select Fill: Compact to a minimum of 95 percent relative compaction in accordance with ASTM D698, unless otherwise specified or shown on the Drawings.
   4. Granular Site Fill: Compact to a minimum of 95 percent relative compaction in accordance with ASTM D698, unless otherwise specified or shown on the Drawings.
   5. Sand: Sand where shown for electrical conduit bedding and backfill shall be compacted by vibrating, tamping, or a combination thereof, to a minimum of 95 percent relative compaction in accordance with ASTM D698.
   6. Landscape Fill: Compact to a minimum 85 percent of maximum density, in accordance with AASHTO T-99 unless otherwise specified or shown on the Drawings.
   7. Aggregate Base: Compact to a minimum of 95 percent relative compaction in accordance with ASTM D698, unless otherwise specified or shown on the Drawings.

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 FINISH GRADING

A. Except where shown otherwise in the Drawings, restore the finish grade to the original contours and to the original drainage patterns. Grade surfaces to drain away from structures. The finished surfaces shall be smooth and compacted.

3.12 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.

END OF SECTION

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SECTION 02920

HYDROSEEDING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Provide all labor, materials, and equipment necessary to furnish and place hydroseeding as required for erosion control during and after construction to form to the requirements of the SWPPP, the project post-construction BMPs, these Specifications, and as directed by the Engineer. Hydroseed uses a mixture of tackifier, fiber, seed, fertilizer, and water to stabilize disturbed soil areas, including but not limited to areas to be graded, areas immediately surrounding excavation or new work, areas used for Contractor's access, and Contractor's laydown areas.

1.02 REFERENCES

This section contains references to the following documents. They are a part of this section 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 this section shall prevail.

Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no 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.

A. Technical Association of the Pulp and Paper Industry.

1.03 SUBMITTALS

A. The following information shall be submitted in accordance with Section 01300:
   1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed

written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. 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 with no further consideration.

B. Submit the following under the Product category.
   1. Submit a signed certification from each source of supply for each material indicating that the material meets the Specification requirements.

1.04 QUALITY CONTROL

A. Retain and submit record of hydroseed applications including:
   1. Compliance with specified rates.
   2. Application area.
   3. Application time.
   4. Quantity.

PART 2 - PRODUCTS

2.01 HYDROSEEDING MIXTURE

A. Seeding Mixture:
   1. Erosion Control Seed Mix: Minimum 85% germination. Percent purity and percent germination are given by the manufacturer and shall be submitted to the Engineer by the Contractor upon delivery.
      The seed mix shall be as follows:
      a. Blando Brome - 20 lbs/acre.
      b. Annual Rye Grass - 10 lbs/acre.
      c. Inoculated Clover - 20 lbs/acre
      d. Fertilizer: Commercial 16-20-0 fertilizer. Apply at a rate of 300 lbs/acre.
   2. Soil Stabilizing Agent: A mixture of 100 percent organic, water soluble alginic acids derived from cold water kelps.
   3. Fiber:
      a. Green colored, fibrous, wood cellulose mulch containing no other growth or germination inhibiting factors and manufactured in such a manner that after addition and agitation in slurry tanks with fertilizer, seed, water, and other approved additives, the fibers in the material will become uniformly suspended to form a homogeneous slurry; and that when hydraulically sprayed on the ground, the material will form a blotter-like ground cover impregnated uniformly with seed; and which after application, will allow the absorption of moisture and allow the rainfall to percolate to the underlying soil.

b. Cellulose shall be certified to indicate that laboratory and field testing of the product has been accomplished and that it meets all of the foregoing requirements based on testing. Weight specifications of this material from suppliers and for all application shall refer only to air dry weight of the fiber material.
c. Absolute air dry weight is based on the normal standards of the Technical Association of the Pulp and Paper Industry for wood cellulose and is considered equivalent to 10% moisture. Each package of the cellulose fiber shall be marked by the manufacturer to show the air dry weight content.
d. Apply at a rate of 1,500 lbs/acre.

4. Water: Clean, potable. Add to slurry mixture in sufficient amount to spread uniformly the required quantity of hydromulch solids.

PART 3 - EXECUTION

3.01 HYDROSEEDING

A. Preparation of Slopes:
1. Dress and grade the slopes to provide a uniform surface and slope. Do not compact the surface. Roughen slopes by running equipment perpendicular to direction of the slope.
2. Thoroughly water the slopes for 1 week prior to seeding. Take care not to cause erosion or otherwise damage the slope profile and integrity.

B. Hydroseeding Installation:
1. Use hydroseeding equipment to apply hydroseed. Slurry shall be applied with a commercial hydroseeder having a built-in agitation system with capacity to continuously agitate, suspend, and homogeneously mix slurry.
2. Contractor shall plan the layout of slurry hose to reduce potential damage to existing vegetation. Due diligence shall be practiced to preserve the newly hydroseeded areas. Areas farthest from the pump vehicle shall be hydroseeded first and areas nearest the pump vehicle will be hydroseeded last. The slurry hose shall be retracted accordingly to minimize trampling and disturbance of newly hydroseeded areas.
3. Apply hydroseed at rates indicated.
4. Do not apply hydroseed if:
   a. Water is standing on or moving across the soil surface.
   b. Soil is frozen.
   c. Air temperature is below 40º F during the tackifier curing period unless allowed by the tackifier manufacturer and approved by the Engineer.
5. In applying hydroseed, care shall be taken to provide even and uniform coverage. Overspray and other residue or trash from the hydroseeding operations shall be cleaned and removed from the site on the same day of application.

C. Preliminary Inspection: Notify the Engineer 48 hours in advance of all seeding inspection and favorable review of the completed work shall begin the plant establishment period.

D. Plant Establishment Maintenance:
   1. General plant maintenance shall immediately follow seeding and continue until seeded areas are 85% germinated and covered with acceptable stands of vegetation.
   2. Protect areas against all damage, including erosion and trespass, and provide proper safeguards. Maintain and keep in good repair all temporary barriers erected to prevent trespass. Check all barriers and temporary fencing daily, and make immediate repairs or replacements.
   3. Reapply hydroseed within 24 hours of discovering visible erosion, unless the Engineer approves a longer period.
   4. Hydroseed disturbed or displaced by your vehicles, equipment, or operations shall be reapplied at your expense.
   5. Cleanup, repair, removal, disposal, or replacement due to improper installation or your negligence are not included in the cost for performing maintenance.
   6. Irrigate if necessary to maintain minimum moisture depth in soil of 6 inches to insure vigorous growth.
   7. Continue maintenance for at least 45 days or until the vegetation is established.

E. Final Inspection and Acceptance: Final inspection will be conducted upon completion of maintenance replacements, and corrective work. Five (5) days' notice shall be given. If project improvements, corrective work, and maintenance have not been performed as specified and to the satisfaction of the Engineer, maintenance shall continue at Contractor's expense until such time as work has been successfully completed.

F. Guarantee and Replacement:
   1. Guarantee all planting to be in a healthy, thriving condition until the end of the maintenance period or beyond that time until active growth is evident and for 1 year from date of acceptance.
   2. Replace all seeded areas not in vigorous condition as soon as directed by Engineer. Repair any erosion in areas where grass does not become established. Seed mixture used for replacement must be of the same kind and quantity as specified in this Section.

END OF SECTION

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.

C. Standard Specifications for Public Works Construction or “GREENBOOK.”

D. NSF/ANSI 61 – Drinking Water System Components – Health Effects.

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 where the structures are being constructed.
   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 where the structures are being constructed. Include formwork removal procedure and

magnitude of construction loads permitted during reshoring or backshoring on shop drawings.

D. Samples:
   1. Form ties.
   2. Submit two 12-inch square samples of the proposed form liner.

1.04 QUALITY ASSURANCE

A. Contractor Qualifications: See Section 03300.

B. Construction Standard: Applicable requirements of the ACI 301.

C. 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 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 where the work will be done.
   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.
      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 ¾-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 ¾-inch chamfer unless otherwise noted on the Drawings.
   2. Circular columns shall be formed with steel, fiberglass reinforced plastic, or seamless cardboard column forms. 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 1½ inches to the finished concrete surface.

B. Form Ties for Water Containment Structures:
   1. Provide form ties that have no metal or other material within 1½ 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 1½ 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 ¾ 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 any 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 ¾ inch 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 release agent 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 except where 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, and in no case less than required in paragraph H below.

B. Remove top forms on sloping surfaces of concrete as soon as removal will not allow concrete to sag. Perform needed repairs or treatments 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 full design strength noted for the mix design.

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 Sections 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.

END OF SECTION

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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 D1171 Standard Test Method for Rubber Deterioration-Surface Ozone Cracking Outdoors or Chamber (Triangular Specimens)
   7. ASTM D1751 Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction. (Nonextruding and Resilient Bituminous Types)
   8. ASTM D1752 Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
   9. ASTM E96 Water Vapor Transmission of Materials

C. U.S. Army Corps of Engineers (COE) Specifications:
   1. COE CRD-C-572 Polyvinylchloride Waterstops

D. 2019 Oregon Structural Specialty Code.

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, and NSF 61 approval for products in contact with potable water.
   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 is 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, and Inserts: Store in accordance with the 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 EPOXY BONDING SYSTEM

A. General: Moisture-insensitive, solvent-free, two-component epoxy resin, ASTM C881:
1. Provide Type I for bonding hardened concrete to hardened concrete; Type II for bonding freshly mixed concrete to hardened concrete; and Type III as a binder in epoxy mortar or concrete, or for use in bonding skid-resistant materials to hardened concrete.
2. Provide Grade 1 or 2 for horizontal surfaces and Grade 3 for vertical surfaces.
3. Provide Class A if placement temperature is below 40°F, but not less than allowed by the manufacturer; Class B if placement temperature is between 40 and 60°F; or Class C if placement temperature is above 60°F, but not more than allowed by the manufacturer.

4. NSF/ANSI Standard 61 approved for potable water contact.
5. Provide: Sikadur Epoxy adhesives manufactured by the Sika Chemical Corporation; Concresive compounds manufactured by Master Builders, Inc; or equal.

B. For bonding new to pre-existing concrete, provide Sikadur 32 Hi-Mod (Sikadur 32 Hi-Mod LPL is not allowed for use in contact with potable water) by Sika Chemical Corporation; Concresive Liquid LPL by Master Builders; or equal.

2.03 PREFORMED JOINT FILLER

A. Structures Retaining Water or Earth: ASTM D1752 Type III or equal. Neoprene sponge 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 the Drawings.

C. Structures Resisting Ozone: ASTM D1056, Type 2, Class C, Grade 5, Suffix C1. Supply premolded product, Durafoam P192HD; equivalent product by Armacell; or equal.

D. Separation 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% for 70 hours at 68ºF and subsequently recovering at least 20% of its original thickness in the first ½ 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.

2.04 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.

2.05 JOINT SEALANTS

A. General: ASTM C920, polyurethane, 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. Water Exposure: NSF 61 approved products; Sikaflex-1a, by Sika Corp.; Select Seal U-227 reservoir grade by Select Products Corp.; or equal.

E. Exterior Exposure: Sikaflex-2c, by Sika Corp.; Select Seal U-200 by Select Products Corp.; or equal.

F. Prepare surfaces and provide primer and sealants in strict accordance with the manufacturer's recommendations.

G. Backing Rod: Extruded, closed cell, polyethylene foam rod, compatible with sealant. Provide 5/8-inch-diameter rod for ½-inch joint, 1¼-inch rod for 1-inch joint.

2.06 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 ¼ 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
   3. Waterstop Types:
      a. Serrated (Ribbed) Flat: Vinylex R6-38; Greenstreak Style 679.
      b. Retrofit (Includes construction joints or expansion joints where new concrete will be placed adjacent to existing concrete.): Vinylex Ret638; Greenstreak Style 609. Provide additional components including epoxy gel, 16-gauge Grade 304 stainless steel batten bars with holes 6 inches on center, and stainless steel ¼-inch by 2¼-inch concrete anchor bolts.
   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 inch on center, ½ inch 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.

B. Hydrophilic Rubber Waterstop: Includes construction joints where new concrete will be placed adjacent to existing concrete.
   1. Material: Hydrophilic rubber strip with installation adhesive as recommended by the waterstop manufacturer and capable of withstanding a minimum of 150-foot hydrostatic head.

2. Provide Adeka Ultraseal MC-2010M waterstop and P-201 adhesive, manufactured by Asahi Denka Kogyo KK and distributed by OCM, Inc.; or Swellseal 2010 waterstop and Swellseal Gun Grade manufactured by De Neef Conchem Inc.; or Hydrotite CJ-1020-2K waterstop and HydroSwell Swelling Paste by Greenstreak; or equal.

2.07 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 calendar 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 calendar days after the first concrete placement at the joint.
   3. During placement of the new concrete, ensure there are no interruptions to the 14 calendar day curing time and 14 calendar 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 50 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 50 feet apart.
7. 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 to leave saturated surface dry condition.
11. 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.
12. 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 preformed joint filler, securely fastened to the existing concrete as directed by the manufacturer.
3. 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.
4. 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 Joints 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 the 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 shall 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. For retrofit waterstops between new and existing concrete, prepare existing concrete by grinding away irregularities. Clean concrete to ensure good epoxy bond. Apply continuous bed of epoxy to concrete. Embed retrofit waterstop in uncured epoxy. Mechanically fasten waterstop to concrete using stainless steel batten bars and anchor bolts staggered 6 inches on center maximum. Use batten bars on top and bottom. Tool continuous layer of epoxy over batten bars and bolts to protection from corrosion. Use expansion joint filler at moving joints to minimize shear stress (expansion joint filler should be large enough to allow waterstop centerbulb to remain completely unembedded in concrete). Expansion material should cover retrofit hardware reaching all the way to waterstop ribs. Allow retrofit waterstop system to cure for 24 hours before placing new concrete. Follow all manufacturer's preparation and installation instructions.

G. Hydrophylic Rubber Waterstop: At splices, butt ends of profile together and glue with manufacturer suggested adhesive. Locate between reinforcement curtains and maintain concrete cover as required by the manufacturer. Fasten to concrete with continuous adhesive paste. Allow time for adhesive to cure, prior to concreting. Keep the materials dry until concreting. Follow the manufacturer's specifications.

H. Compressible Joint Filler: Install compressible joint filler in conformance with the manufacturer's recommendations; including surface preparation, adhesive installation, heat welding, and set time.

I. Smooth Dowels: Install smooth dowels used at movement joints at right angles to the surface of the joint. Align dowels and secure to prevent displacement during concrete placing. Install expansion caps and apply bond breaker at one end of the dowel as indicated on the Project Drawings.

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: Materials, fabrication, placement, and tolerances of reinforcement and reinforcement accessories.

1.02 REFERENCES

A. ASTM International (ASTM) Standard Specifications:
   1. ASTM A82: Steel wire, plain, for concrete reinforcement.
   2. ASTM A143: Practice for safeguarding against embrittlement of hot-dip galvanized structural steel products and procedure for detecting embrittlement.
   3. ASTM A185: Steel welded wire fabric, plain, for concrete reinforcement.
   4. ASTM A496: Steel wire, deformed, for concrete reinforcement.
   5. ASTM A497: Steel welded wire fabric, deformed, for concrete reinforcement.
   6. ASTM A 572: High-strength low-alloy columbium-vanadium structural steel.
   7. ASTM A615: Deformed and plain billet - steel bars for concrete reinforcement.
   8. ASTM A706: Low-alloy steel deformed bars for concrete reinforcement.
   9. ASTM A767: Zinc-coated (galvanized) steel bars for concrete reinforcement.
   10. ASTM A780: Repair of damaged and uncoated areas of hot-dip galvanized coatings.
   11. ASTM A820: Steel fibers for fiber-reinforced concrete.
   12. ASTM A955: Deformed and plain stainless steel bars for concrete reinforcement.
   13. ASTM A970: Headed steel bars for concrete reinforcement.
   14. ASTM A996: Rail-steel and axle-steel deformed bars for concrete reinforcement.
   15. ASTM E329: Agencies engaged in the testing and/or inspection of materials used in construction.

B. American Concrete Institute (ACI):
   1. Details and Detailing of Concrete Reinforcement (ACI 315).
   2. Building Code Requirements for Reinforced Concrete (ACI 318).

C. Concrete Reinforcing Steel Institute (CRSI): Manual of Standard Practice (CRSI Manual).

D. International Code Council (ICC): Evaluation Reports (ICC Reports).

E. American Welding Society (AWS): 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 supports including 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 5 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 WELDED WIRE REINFORCEMENT

A. Plain Welded Wire: ASTM A185; sheets with welded intersections spaced not farther apart than 12 inches in the direction of principal reinforcement.

2.03 TIE WIRE

A. Annealed steel, 16-gauge minimum.

2.04 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 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.

2.05 JOINT SLIP DOWEL SYSTEM

A. Provide Greenstreak two component Speed Dowel System to accept slip dowels of the size shown on the Drawings. The Speed Dowel System is comprised of a reusable base and plastic sleeve. Both pieces shall be manufactured from polypropylene plastic. Do not place concrete directly over the Speed Dowel System.

2.06 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 ½ 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.

C. Do not use aluminum or stainless steel supports or accessories.

2.07 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 by the Engineer, 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 the Drawings.
   3. Provide same dowel size and spacing as the reinforcing to which they are spliced, unless noted otherwise.

2.08 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 the Drawings. 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 on the Drawings. Base the equivalent diameter of the bundle on a single bar of a diameter derived from the equivalent total area.
   4. Reinforcement supports: CRSI Manual, Chapter 3. Unless noted otherwise on the 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 1½ inches. At splices, bundle and wire together bars to accomplish this.
   7. Welded wire reinforcement: Install necessary supports and chairs to hold in place during concrete pours. Straighten reinforcement to lay in flat plane and bend reinforcement to fit work. Tie every other wire at laps. For slabs on soil, extend welded wire reinforcement to within 2 inches of the concrete edge. Lap edges and ends of welded wire reinforcement sheets a minimum of 12 inches. Do not extend welded wire reinforcement through contraction

joints. Support welded wire reinforcement during placing of concrete to ensure required positioning in the slab. Do not place welded wire reinforcement on grade and subsequently raise into position in concrete.

8. Column dowels: Furnish and use templates for placement of column dowels.
9. Welding of reinforcing: Proceed after continuous inspection has been authorized. Welding procedure: Satisfy AWS D1.4.
10. 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 1½ inches of expansion. Use an acceptable bond breaker on the dowel on one side of the movement joint.
11. Reinforcement termination: Where reinforcement does not extend through a joint, terminate 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 by the Engineer and only under continuous inspection. Notify the Engineer at least 48 hours in advance of any procedure involving welding.

E. Coordinate access and notify special inspector 48 hours in advance of any concrete placement so that special inspection and testing may be performed in accordance with the Special Inspection and Testing Schedule.

END OF SECTION

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 C171 Sheet Materials for Curing Concrete
17. ASTM C172 Sampling Freshly Mixed Concrete

18. ASTM C173 Air Content of Freshly Mixed Concrete by the Volumetric Method
19. ASTM C192 Making and Curing Concrete Test Specimens in the Laboratory
20. ASTM C227 Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)
21. ASTM C231 Air Content of Freshly Mixed Concrete by the Pressure Method
22. ASTM C260 Air-Entraining Admixtures for Concrete
23. ASTM C289 Potential Alkali-Silica Reactivity of Aggregates (Chemical Method)
24. ASTM C309 Liquid Membrane-Forming Compounds for Curing Concrete
25. ASTM C494 Chemical Admixtures for Concrete
26. ASTM C595 Blended Hydraulic Cements
27. ASTM C618 Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
28. ASTM C827 Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixtures
29. ASTM C869 Foaming Agents Used in Making Preformed Foam for Cellular Concrete
30. ASTM C881 Epoxy-Resin-Base Bonding Systems for Concrete
31. ASTM C920 Elastomeric Joint Sealants
32. ASTM C989 Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
33. ASTM C1064 Temperature of Freshly Mixed Hydraulic-Cement Concrete
34. ASTM C1077 Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
35. ASTM C1107 Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
36. ASTM C1240 Use of Silica Fume as a Mineral Admixture in Hydraulic-Cement Concrete, Mortar, and Grout
37. ASTM C1293 Determination of Length Change of Concrete Due to Alkali-Silica Reaction
38. ASTM C1602 Mixing Water Used in the Production of Hydraulic Cement Concrete
39. ASTM D882 Tensile Properties of Thin Plastic Sheeting
40. ASTM D1056 Flexible Cellular Materials - Sponge or Expanded Rubber
41. ASTM D1752 Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
42. ASTM D2419 Sand Equivalent Value of Soils and Fine Aggregate
43. ASTM E96 Water Vapor Transmission of Materials

C. International Building Code (IBC) 2018 Edition and the 2019 Oregon Structural Specialty Code.

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. Samples: Submit any item of Product Data not fully assembled by a single manufacturer.

D. 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. Construction Standard: Applicable quality requirements of the IBC, ACI 301, ACI 318, and ACI 350.

B. 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

C. Concrete Mix Designs: By an independent commercial testing 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.

D. Concrete Mix Test Results: Submit in accordance with requirements of paragraph 2.05.F.

E. Concrete Tests, as Placed: Performed by the Owner's Testing Agency:
   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: Obtain at least one composite sample for each 100 yd^3, or a fraction thereof, of each concrete mixture placed in any 1 day.
5. Concrete samples: In accordance with ASTM C172. Provide all material required.
6. Compressive strength: A set of five standard 6-inch x 12-inch concrete cylinders shall be cast for each test set for concrete greater than 2,500 psi. Alternately a set of seven 4-inch x 8-inch cylinders may be cast at testing agency's discretion.
    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 one cylinder at age of 7 days, two at 28 days, and hold two for additional testing at 56 days, if required (Test three cylinders at each of 28 and 56-day intervals if 4 inch cylinders are used).
    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 ¼ yd^3 of concrete.
9. Temperature: 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 7 days of test completion.

F. 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 the uniformity or for selecting areas to be cored; however, only core tests will be permitted for verifying the concrete strength in place.
   3. 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.
   4. 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: ASTM C150, Type II. 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:
      a. ASTM C33:
         1) 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.
         2) 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.
         3) Provide free from organic materials, waste products, clay balls, shale, and mica and thoroughly washed before use.
      b. 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.
      c. 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.

d. Provide aggregates that do not deleteriously react with the alkalies in the cement in accordance with ASTM C227 or ASTM C1293.
e. Grading: ASTM C136. Submit results of sieve analysis on combined aggregates.
f. Reactivity: ASTM C1293. Non-reactive.

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: ASTM C142: 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 1 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: ASTM D2419. 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	
	1½-Inch Gradation	1-Inch Gradation
2-inch	100	--
1½-inch	90-100	100
1-inch	50-96	90-100
3/4-inch	45-80	55-100
3/8-inch	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 or AASHTO T26 are available. Water for washing aggregates, for mixing concrete, for patching grout and for curing shall be free from oil and contain no 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; Daravair by GCP Applied Technologies; or equal.

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 GCP Applied Technologies; 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 GCP Applied Technologies; Glenium 3030 NS by BASF; Eucon 1037 by Euclid; or equal.

G. Corrosion Inhibition and Permeability Reduction (Silica Fume): ASTM C1240. Force 10,000D (dry) by GCP Applied Technologies; Rheomac 222+ by Master Builders; or equal.

H. Controlled Low Strength Material (CLSM) Admixture: See ASTM C869. DaraFill by GCP Applied Technologies; MasterCell by BASF; or equal.

I. 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.

J. 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.

K. Admixtures containing calcium chloride or any chloride ions are prohibited.

L. 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 301 Section 4.2.3.
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 301 Section 4.2.3. 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 301 Section 4.2.3.
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 301 Section 4.2.3.
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 *f'cr*. 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. 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.
7. Prepare mix designs for concrete placement by the batch process and/or by pumping, as required, and state the process on the design submittal.
8. 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.
9. Do not exceed the water-cementitious material ratios. Vary the water-reducing admixtures to accomplish an increase in slump or workability time.
10. Proportion cementitious materials, aggregates, and water by weight.
11. 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.

12. Do not use chlorides in any concrete mix.
13. 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.
14. Resubmit mix design for review for each class of concrete when modification of the mix design is required by ACI 301 Section 4.2.3. 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:

Mix Design Requirements	B	E
Specified 28-Day Compressive Strength (lb/in2) f'c	4,500	2,500
Combined Aggregate Gradation (in)	1	1
Air Content at Point of Placement (%)	4-1/2	2
Maximum Water-Cementitious Material Ratio	0.42	0.55
Minimum Cementitious Material Content (lb/yd3)	590	510
Cement Type	II	II

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. If used, 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 03150, 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 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 ±1½%.
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 ECOLOGY-BLOCK UNITS

General: Modular concrete blocks manufactured from concrete with a minimum compressive strength of 3000 psi. Full blocks shall be 2’x2’x6’ in nominal exterior dimension. Half blocks 2’x2’x3’. Blocks shall have an integrally cast, 3-inch tongue-and-groove, or similar, interlocking system on the top and bottom faces to prevent sliding and come equipped with a cast-in lifting eye on the top face for handling. Manufacturers: Oldcastle Infrastructure or equal.

2.09 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 containing 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 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 the Engineer where modifications are necessary 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 feet 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.

D. Time Limit: Place all concrete in its final position in slab or forms within 1½ 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 80°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 3 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 onsite 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 Sections 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 Sections 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 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 1½ 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 two 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.

3.06 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 7 days 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.

3.07 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: 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. International Building Code (IBC) 2018 Edition and the 2019 Oregon Structural Specialty Code.

1.03 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Shop Drawings: Program and method of production, transportation, placement, protection, materials, curing, and temperature monitoring of concrete during hot weather.

C. Quality Assurance: 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. Construction Standard: Applicable requirements of the OSSC, 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/ft2/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 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 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/yd3 when tested per ASTM C156.

3.04 CONCRETE FINISHES

A. General: Refer to Section 03350.

B. Apply an evaporation retarder during the finishing operation following the manufacturer's recommendation.

3.05 FIELD QUALITY CONTROL

A. Protection and Monitoring:
   1. Monitor site conditions (air temperature, humidity, wind speed, and 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 2 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.

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 additional 6-inch-diameters by 12-inch cylinders to be cured under field conditions in accordance with ASTM C31.
2. Test two cylinders for compressive strength, in accordance with ASTM C39, at 28 days. Hold two cylinders as back-ups.

END OF SECTION

SECTION 03306

COLD WEATHER CONCRETING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: 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. International Building Code (IBC) 2018 Edition and 2019 Oregon Structural Specialty Code.

1.03 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Product Data: Material proposed for use as insulation during protection period.

C. Shop Drawings: 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: Submit a copy of the concrete temperature logs to the Engineer. 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.

Table 3.03A – Protection Period Requirements

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-hour 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 not 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 or as noted elsewhere in Division 3, whichever is longer.

B. The 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 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.

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 additional 6-inch-diameter by 12-inch cylinders to be cured under field conditions in accordance with ASTM C31.
2. Test two cylinders for compressive strength, in accordance with ASTM C39, at 28 days. Hold two 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) 2018 Edition and the 2019 Oregon Structural Specialty Code.

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. Construction Standard: Applicable requirements of the OSSC, ACI 301, ACI 318, and ACI 350.

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 80°F in a moist condition and without external loadings for 14 days after placement, and comply with requirements of Sections 03305 and 03306.
   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 Material 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 gallon 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 gallon 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 on Grade and Footings (not used to contain water): Wet Cure or Sheet Material Cure.
   2. 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.

3. 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: Whenever the surrounding air temperature is below 40°F:
1. See Section 03306.

H. Hot Weather Requirements: Provide additional cooling to concrete when temperatures rise above 80°F, or low humidity, wind, and temperature combine to cause high surface evaporation, over 0.2 lb/sq. ft./hour:
1. See Section 03305.

3.02 CONCRETE FINISHES

A. Refer to Section 03350.

3.03 FIELD QUALITY CONTROL

A. 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.

3.04 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 days for interior spaces using water and a stiff brush.

END OF SECTION

SECTION 03350

CONCRETE FINISHES (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. “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 International 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.
   5. Provide NSF 61 Certified compound for surfaces in contact with potable water.

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 not less than 0.60 for level surfaces and 0.80 for

surfaces sloped 1:20 or greater. Measure friction coefficients in accordance with ASTM C1028

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 Chapters 10, and 11.
5. Slope interior floor surfaces containing floor drains to drain water to the drains. Review elevations shown on the 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 hairbrush.

3.02 FINISHING FORMED SURFACES

A. General:
   1. After form removal, give each formed surface one or more of the finishes specified on the 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 1½ inch wide or ¼ inch deep.
      b. Remove projections greater than ½ 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 ¾ inch wide or ¼ inch deep.
      b. Remove projections greater than ¼ 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 ½ inch wide or ¼ 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.

3.03 SCHEDULE OF CONCRETE FINISHES

A.	**SLABS**		**LOCATION OF FINISH**
1.	Scratch Finish	3.01B	N/A
2.	Float Finish	3.01C	Applies to slab surfaces indicated to receive a “Float Finish” including the Composting Building slabs and walkways, Amendment Storage Building slabs, Conveyor apron slab, and all exterior equipment slabs.
3.	Trowel Finish	3.01D	Applies to surface indicated to receive a “Trowel Finish” including the interior electrical equipment pads and Dewatering Building sump infill concrete.
4.	Broom Finish	3.01E	N/A
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.	**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. Including Composting Building and Amendment Storage Building piers (buried). 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. Including Composting Building back wall, Composting Building piers, and Amendment Storage Building piers (above grade). Compost slab trench walls.

END OF SECTION

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. Masonry grout is covered in Section 04200.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. ASTM C531 Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical Resistant Mortars, Grouts and Monolithic Surfacings and Polymer Concretes.
   2. ASTM C827 Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixtures.
   3. ASTM 1107 Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).
   4. ASTM 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. Submit in accordance with Section 01300.

B. Product Data: Submit product data for all grout products specified in Part 2 of this Section. 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 Material Safety Data Sheet (MSDS),
   8. Type and brand of the cement,
   9. Gradation of the fine aggregate, and
   10. Proposed admixtures and the proposed mix of the grout for non-packaged mixes.
   11. 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.

12. 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.

C. Samples: Field samples for color control if a color match is required.

D. Quality Control:
   1. Laboratory Test Reports: Submit laboratory test data as required under Section 03300 for concrete to be used as concrete grout.
   2. Qualifications: Submit documentation that grout manufacturer has at least 3 years' experience in the production and use of the proposed grouts which they will supply

1.04 QUALITY CONTROL

A. Qualifications: Grout manufacturer shall have a minimum of 3 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 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 equal.

B. Non-shrink Epoxy Grout: Non-shrink epoxy-based grout shall be a pre-proportioned, three-component, 100% 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 equal.

C. Cement Grout: 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 shall 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: Potable water, free from injurious amounts of oil, acid, alkali, organic matter, or other deleterious substances.

F. Grout for Grouting of Masonry: See Specification Section 04200.

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 Owner's 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 City 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 Owner's 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 Owner's 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°F 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°F 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 Owner’s Representative.

B. Avoid mixing by hand. Mixing in a mortar mixer (with moving blades) is required if recommended 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 shall 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 Owner’s 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°F 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 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.

END OF SECTION

SECTION 03935

REPAIR OF DEFECTIVE CONCRETE

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: 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.

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 for removal.
   2. When crack repair is required, submit the proposed materials and manufacturer's method of repair.

C. Shop Drawings:
   1. Repair Plan: After defects are identified and investigated, prepare and submit a repair plan that includes 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:
   1. Certification that the materials meet the requirements of this Section and have the manufacturer's current printed literature on the specified product.
   2. Certification that materials to be applied to concrete surfaces in contact with potable water or water to be treated for potable use shall be approved by NSF/ANSI 61 – Drinking Water System Components – Health Effects for use in contact with potable water after 30 days.

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. Provide materials to be applied to concrete surfaces in contact with potable water certified by NSF 61 for use in contact with potable water.

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 non-shrink 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 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 BONDING AGENT

A. See Section 03150.

2.04 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 inch 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 equal.

2.05 NON-SHRINK GROUT AND NON-SHRINK EPOXY GROUT

A. See Section 03600.

2.06 STRUCTURAL CRACK REPAIR EPOXY ADHESIVE

A. Two-component, solvent-free, moisture insensitive epoxy resin material suitable for crack grouting by injection or gravity feed. Formulate for the specific size of opening or crack being repaired.

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 applications thinner than allowed by Hi-mod LV: Sikadur 35 Hi-Mod LV LPL by Sika Corporation, Lyndhurst, NJ; SCB Concresive 1360 by BASF, Shakopee, MN; or approved equal.

D. For potable-water applications: epoxy coatings used to cover crack repairs must be approved by both NSF and FDA for use in contact with potable water.

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, noncorroding 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 ¼ inch where existing reinforcing is exposed due to sawcutting/core drilling and no new material is to be placed on the cut surface.

C. Sawcut 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 in accordance with repair notes above.

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 ¼-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 1½-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 Methods 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 0.010 inches and cracks 1/32-inch or wider in other surfaces. Repair leaking cracks.

B. 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.

C. 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.

D. For structural nonmoving cracks that require structural bonding of cracked surfaces, use epoxy adhesive injection materials and methods.

E. 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

F. Complete crack repairs before conducting the hydrostatic leakage test.

3.06 CONCRETE FINISHING

A. Refer to Section 03350.

3.07 FIELD QUALITY CONTROL

A. Concrete Curing:
   1. See Section 03330.
   2. Record procedures and equipment that is available for controlling concrete temperature during hot and cold weather conditions.
   3. Record 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 04200

CONCRETE UNIT MASONRY

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Construction requirements for the materials and workmanship used to construct reinforced masonry structures.

1.02 REFERENCES

A. ASTM International (ASTM):
1. A615 Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
2. C33 Specification for Concrete Aggregates
3. C90 Specification for Loadbearing Concrete Masonry Units
4. C94 Specification for Ready-Mixed Concrete
5. C140 Test Methods for Sampling and Testing Concrete Masonry Units and Related Units
6. C143 Test Method for Slump of Hydraulic Cement Concrete
7. C144 Specification for Aggregate for Masonry Mortar
8. C150 Specification for Portland Cement
9. C207 Specification for Hydrated Lime for Masonry Purposes
10. C270 Specification for Mortar for Unit Masonry
11. C331 Specification for Lightweight Aggregates for Concrete Masonry Units
12. C341 Test Method for Length Change of Drilled or Sawed Specimens of Hydraulic-Cement Mortar and Concrete
13. C404 Specification for Aggregates for Masonry Grout
14. C426 Test Method for Drying Shrinkage of Concrete Masonry Units
15. C476 Specification for Grout for Masonry
16. C780 Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry
17. C1019 Test Method for Sampling and Testing Grout
18. C1059 Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete
19. C1314 Standard Test Method for Compressive Strength of Masonry Prisms
20. C1586 Standard Guide for Quality Assurance of Mortars

B. Building Code Requirements for Masonry Structures (TMS 402-16).

C. Specification for Masonry Structures (TMS 602-16).

D. 2019 Oregon Structural Specialty Code.

1.03 DEFINITIONS

A. f’g: Specified 28-day compressive strength of grout.

B. f’m: Specified 28-day compressive strength of concrete masonry assembly.

C. Lift: The height of grout that is placed in a single, continuous operation before consolidation.

D. Pour: The total height of masonry that is grouted prior to erection of additional masonry. A pour may consist of one, two, or three lifts.

E. Exterior Units: Concrete masonry units placed with exterior exposed surfaces.

F. Interior Units: Concrete masonry units placed with no exterior surfaces.

G. Interior Face: Any surface of concrete masonry units that is on the inside of structures and not exposed to weather.

H. Exterior Face: Any surface of concrete masonry units that is exposed to weather or buried.

I. Running bond: The placement of masonry units such that head joints in successive courses are horizontally offset at least one-quarter the unit length.

J. Stack bond: The placement of masonry units such that head joints in successive courses are aligned.

1.04 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Contractor experience.

C. Product Data:
   1. CMU blocks including testing in accordance with ASTM C140.
   2. Ties, fasteners, and accessories.
   3. Preformed control joint filler.

D. Grout and Mortar:
   1. Grout mix design indicating types and proportions of materials in accordance with ASTM C476.
   2. Aggregates for grout and mortar.
   3. Cementitious materials.
   4. Admixtures proposed for use in grout.
   5. Grout mix test results in accordance with ASTM C1019.
   6. Mortar mix design indicating types and proportions of materials in accordance with ASTM C270.

E. 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.

F. Hot weather procedures for work above 90ºF.

G. Cold weather procedures for work below 40ºF.

H. Samples:
   1. Masonry unit proposed for use on the Work.
   2. Submit color charts and one complete physical color pallet of the mortar manufacturer’s standard colors for color selection by the Owner.
   3. Physical samples of colors and textures chosen by the Owner. The Owner will use the physical samples to select the colors for the Quality Control sample.

I. Quality Assurance/Control Submittals
   1. Test Reports: Test reports in accordance with ASTM C140, C780, and C1019.
   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. Contractor Experience: Field supervisors responsible for construction shall have a minimum of 3 years' experience in similar work, and at least three previous projects of similar type.

B. Verification of f'm of concrete masonry shall be achieved by the Unit Strength Method in accordance with TMS 602. Prior to construction, submit test results on three units in accordance with ASTM C140. Test results must comply with TMS 602 Table 2. Submit product data or test results for grout and mortar showing compliance with this Section and TMS 602 Table SC-7.

C. Masonry construction shall be subject to inspection by the Owner's Representative. The Contractor shall make construction accessible and exposed for inspection of the cells and for the size and placement of reinforcement, anchors, or other imbedded items.

D. Inspection shall be in accordance with TMS 602, Level 2.

1.06 DELIVERY, STORAGE AND HANDLING

A. Acceptance at Site: Remove chipped, cracked, and otherwise defective units from Site.

B. 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 masonry placement progresses.

1.08 PROJECT/SITE CONDITIONS

A. Environmental Requirements: Comply with requirements of TMS 602 as noted below:
   1. Cold Weather Requirements: per TMS 602.
   2. Hot Weather Requirements: per TMS 602.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Willamette Graystone; Air Vol Block; Orco Block Company; Basalite Concrete Products; Mutual Materials; or equal.

2.02 MATERIALS

A. Hollow Load Bearing Concrete Masonry Units per ASTM C90:
   1. Block minimum compressive strength: 1900 psi, as specified on the Drawings.
   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 weighs between 85 and 105 pounds per cubic foot when measured in accordance with ASTM C140.
   5. Typical Masonry Units: 4x8x16 and 8x8x16 nominal blocks to match existing alternating course pattern.
      a. Exterior unit color: to match existing.
      b. Interior unit color: to match existing; see Section 09900 for interior paint finish.
      c. Exterior surfaces: alternating split and smooth-faced courses to match existing.
      d. Interior surfaces: smooth to match existing.
   6. Except as required otherwise, provide double open-end, bond beam units ("DOE-BB") to complete walls unless noted otherwise on the Drawings. Provide bond beam, lintel, half, pilaster, wall, cap masonry units, and other special shapes and sizes required. Use lintel masonry unit where underside of lintel will be exposed.
   7. All block shall be produced with an integral water repellent admixture.
      a. WR Grace Dry-Block.
      b. Eucon Blocktite.
      c. Or equal.
   8. Special Units: Provide required special units. Where special units are not available from the supplier, cut available units and fabricate required special shapes.

B. Water: Potable and free of alkalies.

C. Grout:
   1. Proportion per ASTM C476 for Coarse Grout. Compressive strength of grout (f'g) shall not be less than f'm, as defined on the Drawings.
   2. Slump: Between 8 and 11 inches achieved without plasticizers or water reducers.
   3. Admixtures: Not permitted unless approved by the Engineer prior to construction.

D. Cementitious Materials for Grout:
   1. Cement: Portland cement, ASTM C150, Type II. Masonry cement is not permitted.
   2. Fly Ash: ASTM C618, Class F. Not to exceed 20% of combined weight of cementitious materials.
   3. Hydrated Lime: ASTM C207, Type S.

E. Aggregate for Grout: ASTM C404 for Coarse Grout.

F. Mortar: ASTM 270, Type S, either by property or proportion in accordance with TMS 602 Tables SC-1 and SC-2.

G. Aggregate for Mortar: ASTM C144. Not more than 2% by weight of deleterious substances permitted.

H. Cleaning Materials: Sure Klean 600 Detergent, by ProSoCo, Inc. or equal. Efflorescence Control System (ECS), by ProSoCo, Inc. or equal.

I. Expansion Joint Filler: Sponge rubber complying with ASTM D1752 Type 1.

J. Reinforcing Steel: ASTM A615, Grade 60.

PART 3 - EXECUTION

3.01 PREPARATION

A. Surface Preparation:
   1. Coordinate the number, size, length, and location of reinforcing dowels between concrete 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 masonry 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. Lap splices may be non-contact laps, provided spliced bars are in same cell.

D. Tie at intersections using 16-gauge annealed wire.

E. Provide ½-inch minimum clear distance between masonry and reinforcing.

3.03 CONSTRUCTION

A. General:
   1. Lay masonry unit in running bond, except where otherwise shown on Architectural Drawings.
   2. Lay masonry units so the vertical cells line up and are not obstructed by excess mortar.
   3. Fully bed webs and cross walls forming such cells in mortar to prevent leakage of grout.
   4. Grout all cells.
   5. Brace masonry during construction to assure stability.
   6. Cold weather construction per TMS 602, article 1.8C.

7. Hot weather construction per TMS 602, article 1.8D.

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. Create cleanouts by cutting off entire face shell of CMU block. Replace face shell after inspection and cleaning.
   4. Remove mortar fins and any foreign matter from the grout space.
   5. Cleanouts may be eliminated if grout pour height is reduced to a maximum of 5 feet 4 inches.
   6. Brace cleanout closures as required to resist grout pressure.

C. Mixing Mortar
   1. Mix ingredients in a paddle type (plastic) mixer for at least 3 minutes.
   2. 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 Site.

D. 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. Initial bed joint shall not exceed 1¼ inches.
   3. Set units with joints straight and uniform in width in accordance with TMS 602 and quality control sample.
   4. 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.
   5. Remove mortar fins that project more than 3/8 inch into the grout cell.
   6. If a unit is repositioned after placing, it shall be completely removed, cleaned, and reset in fresh mortar.
   7. Set lintels, capping units, and bearing plates in a full bed of mortar.
   8. Locate control joints as shown on the Drawings.

E. Mixing Grout: Plant batch grout by weight and mix in transit in accordance with ASTM C94 or ASTM C476. Any grout that is unused within 1½ hours after initial mixing shall be removed from the Site.

F. Grouting:
   1. Limit maximum height of grout lift to 5-feet 4-inch, and maximum height of grout pour to 12-feet 8-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. Consolidate grout by mechanical vibration unless self-consolidating grout is specifically approved by the Engineer.
   5. For multiple lifts in a single pour, consolidation of the succeeding grout lift and the reconsolidation of the previous grout lift may be done in the same operation.
   6. Reconsolidate each lift after initial water loss and settlement has occurred.

7. 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.
8. Form grout key between pours by terminating the grout a minimum of 1½ inches below the mortar joint.
9. Discontinue placement of grout within 90 minutes after the addition of water.

G. Interface with Other Work
1. Embedded items shall be secured in place prior to grouting.
2. Provide a minimum of ½-inch grout around headed studs and bolts in masonry.
3. At openings for ducts, pipes, and conduit, cut to half or full unit dimensions.

H. Site Tolerances:
1. 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.
2. Other masonry unit and reinforcing tolerances shall be within the tolerances specified in TMS 602, except where the Drawings specify more restrictive tolerances.

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 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.

3.06 PROTECTION

A. During construction, protect masonry cells from debris or mortar dropping that will be detrimental to the final masonry grouted wall.

B. 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 walls and pilasters with polyethylene sheeting.

C. 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.

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SECTION 05090

STRUCTURAL METAL FASTENERS AND CONCRETE ANCHORS

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.

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, 2014.

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 B695 Coatings of Zinc Mechanically Deposited on Iron and Steel
   10. ASTM E8 Test Methods for Tension Testing of Metallic Materials
   11. ASTM F436 Hardened Steel Washers
   12. ASTM F844 Washers, Steel, Plain (Flat), Unhardened for General Use
   13. ASTM F959 Compressible-Washer-Type Direct Tension Indicator for Use with Structural Fasteners
   14. ASTM F1554 Anchors Bolts, Steel, 36, 55, and 105-ksi Yield Strength
   15. ASTM F1941 Electrodeposited Coatings on Mechanical Fasteners
   16. ASTM F2329 Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

F. International Code Council (ICC) Evaluation Service Reports
   1. AC 01 Acceptance Criteria for Expansion Anchors in Masonry Elements
   2. AC 58 Acceptance Criteria for Adhesive Anchors in Masonry Elements
   3. AC 60 Acceptance Criteria for Anchors in Unreinforced Masonry Elements
   4. AC 106 Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry Elements
   5. AC 193 Acceptance Criteria for Mechanical Anchors in Concrete Elements
   6. AC 308 Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements

G. Federal Specifications A-A-1922A Type 2 only, A-A01923A Type 4 only and A-A-55614 for Expansion and Shield-Type Anchors.

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 evaluation reports or equivalent IAPMO evaluation reports for all anchors submitted, demonstrating compliance with 2018 IBC requirements and applicable ICC acceptance criteria.

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 proof loads for anchors.
   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. Installer Training: Conduct a thorough training with the manufacturer or the manufacturer’s representative for the Contractor on the project. Training to consist of a review of the complete installation process for drilled-in anchors, to include but not limited to:
      a. Hole drilling procedure
      b. Hole preparation & cleaning technique
      c. Adhesive injection technique & dispenser training/maintenance
      d. Rebar dowel preparation and installation
      e. Proof loading/torqueing

B. Codes and Standards:
   1. Bolting:
      a. General: AISC Specifications.

C. Tests and Inspections:
   1. General: The Owner shall provide Special Inspections, defined by IBC Chapter 17.
   2. Installation inspection of anchors installed in hardened concrete: Special Inspection shall be either periodic or continuous as required by the ICC-ES or IAPMO evaluation report for the anchor or as required by the Design or Specialty Engineer. Special Inspector shall visually inspect anchor layout, including: required substrate thickness, anchor location, embedment, spacing, and edge distance, and observe hole cleaning procedures, the equipment to be used for adhesive anchor installation, the presence of moisture and temperature of the substrate and presence of moisture in the anchor hole.

D. Additional Tests: Contractor shall provide and pay for all necessary additional tests and Special Inspections 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.

E. Store anchors in accordance with manufacturer’s recommendations.

PART 2 - PRODUCTS

2.01 METAL FASTENERS, ANCHORS, AND FASTENING HARDWARE.

A. General
   1. For anchors, provide anchor embedment depth, edge distance, and spacing as shown on the Drawings, favorably reviewed anchorage design submittals and Shop Drawings.
   2. Provide named mechanical anchors and anchor adhesives where noted on Drawings. Otherwise, submit supporting documentation and applicable connection and anchorage design calculations for the proposed product, in accordance with paragraph 1.03, to demonstrate that the proposed product is a direct replacement for the named product. The connection and anchorage design calculations shall be signed and stamped by a Civil or Structural Engineer licensed in the State where the project is located.
   3. All reinforcing steel indicated to be embedded in hardened concrete shall be embedded using post-installed injectable adhesive anchoring systems.

B. Materials and Finishes:
   1. Hot Dip Galvanizing: Steel hardware, nuts, bolts, washers, anchors, and threaded rods: ASTM F2329 or ASTM A153.
   2. Stainless Steel: ANSI 316.
   3. Size galvanized and plated nuts to accommodate galvanized and plated threads.
   4. Repair Materials: Gal-Viz by Harris Products Group; ReGalv by Rotometals, Inc.; or equal.
   5. Exterior, exposed, buried, submerged, corrosive process, and other conditions not classified as dry interior spaces: metal fasteners, anchors, and fastening hardware shall be ANSI 316 stainless steel, unless otherwise noted.
   6. Dry interior spaces: steel fasteners, anchors, and fastening hardware shall be hot-dip galvanized, unless otherwise noted.

C. Nuts:
   1. Carbon Steel:
      a. For Non-High Strength Bolts, Headed Anchor Bolts, and Threaded Anchor Rods: ASTM A563 Grade A Hex or Heavy Hex.
      b. For High Strength Bolts, Headed Anchor Bolts, and Threaded Anchor Rods: ASTM A563 Grade DH Heavy Hex.
      c. Dimensional requirements: ASME B18.2.2.
   2. Stainless Steel:
      a. ASTM F594 Alloy Group 2 (ANSI 316) CW1 & CW2.
      b. Dimensional requirements: ASME B18.2.2.

D. Washers:
   1. Carbon Steel:
      a. For Non-High Strength Bolts, Headed Anchor Bolts, and Threaded Anchor Rods: ASTM F844 Round Flat Washer.
      b. For High Strength Bolts, Headed Anchor Bolts, and Threaded Anchor Rods: ASTM F436, Type 1 Circular Washer.
      c. High Strength Direct Tension Indicators: ASTM F959.
      d. Split lock washers.
      e. Dimensional requirements: ASME B18.21.1.
   2. Stainless Steel:
      a. ANSI 316 washers meeting the requirements of ASME B18.21.1.

E. Threaded Anchor Rods:
   1. Straight, fully threaded.
   2. Carbon Steel:
      a. Non-High Strength: ASTM F1554, Grade 36.
      b. High Strength: ASTM F1554 Grade 55 or ASTM A193 B7.
   3. Stainless Steel:
      a. ASTM A193 Grade B8M (ANSI 316) Class 2, or ASTM F593 Alloy Group 2 (ANSI 316) CW1 & CW2.

F. Structural Bolting:
   1. Bolts:
      a. Carbon Steel:
         1) Non-High Strength: ASTM A307 Grade A Hex Head.
         2) High Strength: ASTM F3125 Grade A325 Type 1 Heavy Hex Head.
         3) Dimensional requirements: ASME B18.2.1.

b. Stainless Steel:
1) Bolts: ASTM F593 Alloy Group 2 (ANSI 316) CW1 & CW2.
2) Dimensional requirements: ASME B18.2.1.
2. Nuts: See paragraph 2.01.C.
3. Washers: See paragraph 2.01.D.

G. Cast-in-Place Anchors:
1. Headed Anchor Bolts:
a. Carbon Steel:
1) Non-High Strength: ASTM F1554 Grade 36.
2) High Strength: ASTM F1554 Grade 55.
b. Stainless Steel: ASTM F593 Alloy Group 2 (ANSI 316) CW1 & CW2.
2. Threaded Anchor Rods:
a. See paragraph 2.01.E.
b. At anchored end, provide double nuts with washer in between.
1) For Carbon Steel Non-High Strength threaded anchor rods 1¾ inch diameter or greater, provide ASTM A563 Grade A Heavy Hex nuts, and ASTM F436, Type 1 Circular Washer.
3. Welded Headed Studs:
a. Carbon Steel: AWS D1.1, Grade B, $f_{ut} \geq 60$ ksi, $f_y \geq 50$ ksi.
b. Stainless Steel: AWS D1.6, ASTM A276 or A493, $f_u \geq 70$ ksi, $f_y \geq 35$ksi.
4. Nuts: See paragraph 2.01.C.
5. Washers: See paragraph 2.01.D.
6. Provide minimum embedment shown on the Drawings, or a minimum of eight bolt diameters.

H. Post-Installed Mechanical Anchoring Systems:
1. General:
a. For mechanical anchors in concrete, submit ICC-ES or IAPMO evaluation report stating that the anchors are approved per ICC AC193 for use in cracked concrete to resist seismic loads.
b. For mechanical expansion anchors in CMU, submit ICC-ES or IAPMO evaluation report stating that the anchors are approved per ICC AC01 for use in masonry elements to resist seismic loads.
2. <u>Mechanical Undercut Anchoring Systems:</u>
a. Required for overhead applications.
b. Anchor: Undercut anchor shall be of an undercut style with brazed tungsten carbides on the embedded end that perform the self-undercutting process.
1) Carbon Steel Bolt and Sleeve:
a) Bolt: ISO 898, Class 8.8, SAE Grade 5, or ASTM A193 B7.
b) Sleeve: AISI 1045.
c) Nuts: ASTM A563 Grade A and meeting the dimensional requirements of ANSI B18.2.2.
d) Washers: SAE 1005-1033 or AISI 1040 and meeting the dimensional requirements of ANSI B18.2.2 Type A Plain.
e) Products: Hilti HDA-T; DeWalt Atomic+ Undercut (ASTM A193 B7); or equal.
2) Stainless Steel Bolt and Sleeve:
a) Bolt: AISI 316 or 316Ti.
b) Sleeve: AISI 316 or 316Ti.

c) Products: Hilti HDA-TR SS 316; DeWalt Atomic+ High Strength SS 316 Undercut; or equal.

3. Mechanical Expansion Anchoring Systems:
   a. Anchor: Expansion anchor shall be pre-assembled 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 shall 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) Products: Hilti Kwik Bolt TZ CS; Simpson Strong-Bolt 2 Carbon Steel; DeWalt Power-Stud+ SD1 and SD2; or equal.
   c. Stainless Steel Anchors:
      1) Anchor Body and Wedges: ASTM A276 or ASTM A493 with chemical composition of AISI 316
      2) Nuts: ASTM F594 with chemical composition of AISI 316.
      3) Washers: ASTM A240 with chemical composition of AISI 316.
      4) Products: Hilti Kwik Bolt TZ SS 316; Simpson Strong-Bolt 2 316 SS; DeWalt Power-Stud+ SD6 316 SS; or equal.

I. Post-Installed Injectable Adhesive Anchoring Systems in Concrete or fully-grouted Masonry construction:
   1. General:
      a. For application in contact with potable water provide NSF/ANSI STD 61 certified product.
      b. Submit ICC-ES or IAPMO evaluation report stating that the anchors are approved per ICC AC308 for use in cracked concrete to resist seismic loads.
      c. Submit ICC-ES or IAPMO evaluation report stating that the anchors are approved per ICC AC58 for use in masonry elements to resist seismic loads.
   2. High Strength Epoxy Injectable Adhesive:
      a. Adhesive: A two-component high-solids 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. Products: Hilti HIT-HY 200, HIT-RE 500 V3 (NSF 61); Simpson SET-3G (NSF 61 216 in^2/1000gal); or equal.
   3. Threaded Anchor Rods:
      a. See paragraph 2.01.E.
      b. Chamfered edge of top end for ease of starting nut. Provide 45-degree chisel or cut point on embedded end.
   4. Reinforcing Bars:
      a. See Section 03200.
      b. Provide 45-degree chisel or cut point on embedded end.

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 of ASTM F1554 Grade 36 except as noted on Drawings.

E. Insulating products for dissimilar materials:
   1. Galvanic Insulating Washers. NEMA LI 1 Glass Reinforced Epoxy G-10.
   2. Galvanic Insulating Sleeves. 1/32 inch thick, Mylar or Glass Reinforced Epoxy G-10.

F. All metal fasteners not specified elsewhere.

2.03 NON-SHRINK GROUT

A. See Section 03600.

B. 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.

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.
         2) Provide plate washer for long-slotted holes as noted on Drawings.
         3) Provide washers under the turned element for bolts installed with the Calibrated Wrench Pretensioning method.
         4) Provide washers for bolts installed with the Direct-Tension-Indicator Pretensioning method.
   2. 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.

3. Where metal is fastened to concrete, make the connections by cast-in-place anchors or post-installed anchors as noted on Drawings.
4. Post-installed anchors may not be substituted for cast-in-place anchors without Engineer's approval. For post-installed anchors proposed as a substitute, submit a Request for Deviation. Submit product data, evaluation reports, and anchorage calculations demonstrating equivalence, signed and stamped by a Civil or Structural Engineer licensed in the State in which the project is located, in accordance with Engineer's response to the Request for Deviation.
5. 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.
6. Provide leveling nuts on anchor bolts, below base plates, and adjust prior to grouting.
7. 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 Engineer's approval.

B. Post-Installed Mechanical Anchoring Systems:
1. Install mechanical anchors in accordance with the ICC-ES or IAPMO evaluation report for the specific anchor.
2. Mechanical anchors may not be substituted for cast-in-place anchors or post-installed adhesive anchors without Engineer's approval. For mechanical anchors proposed as a substitute, submit a Request for Deviation. Submit product data, evaluation reports, and anchorage calculations demonstrating equivalence, signed and stamped by a Civil or Structural Engineer licensed in the State in which the project is located, in accordance with Engineer's response to the Request for Deviation.
3. 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 Engineer's approval.

C. Post-Installed Adhesive Anchoring Systems:
1. Install adhesive anchors in accordance with the ICC-ES or IAPMO evaluation report for the specific anchor.
2. Adhesive anchors <u>are not allowed</u> in overhead applications unless specially approved for the application by the Engineer.
3. Adhesive anchors may not be substituted for cast-in-place anchors or post-installed mechanical anchors without Engineer's approval. For adhesive anchors proposed as a substitute, submit a Request for Deviation. Submit product data, evaluation reports, and anchorage calculations demonstrating equivalence, signed and stamped by a Civil or Structural Engineer licensed in the State in which the project is located, in accordance with Engineer's response to the Request for Deviation.
4. 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 Engineer's approval.

D. Repair and Modification of Connections and Anchorages: The Contractor shall pay for all necessary work and material, redesign work by the Engineer, and all additional tests and Special Inspections made on welds, bolts, and anchors required to repair or replace faulty work performed during the original fabrication and during erection.

E. Repair of Galvanized Coating: Repair surfaces damaged by cutting or welding by the method of heated zinc alloys in accordance with ASTM A780.

3.02 FIELD QUALITY CONTROL

A. Post-Installed Mechanical and Adhesive Anchoring Systems:
   1. Anchoring systems shall be installed in accordance with the ICC-ES or IAPMO evaluation report for the specific anchor. All anchors shall be tested and inspected 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 abandoned and filled with non-shrink grout. Notify the Engineer. Do not drill additional holes near abandoned drilled holes without the Engineer's approval.
   6. 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 Engineer's approval.

B. Erection Sequence: Verify each stage is completed before proceeding to the next.

C. Tolerances: AISC Standard Practice.

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 and Concrete Anchors
   2. Section 05500: Metal Fabrications (Miscellaneous Metal)
   3. Section 09900: Painting
   4. 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 360-05 Specification for Structural Steel Buildings
   2. ANSI/AISC 341-05 Seismic Provisions for Structural Steel Buildings Including Supplement No.1

C. Research Council on Structural Connections:
   1. RCSC Specification for Structural Joints Using ASTM A325 or A490 Bolts, 2014

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 A500	Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
9.	ASTM A653	Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
10.	ASTM A992	Specification for Steel for Structural Shapes for Use in Building Framing
11.	ASTM B633	Electrodeposited Coatings of Zinc on Iron and Steel
12.	ASTM C827	Test Method for Early Volume Change of Cementitious Mixtures
13.	ASTM C1107	Packaged Dry, Hydraulic-Cement Grout (Non-shrink)
14.	ASTM E8	Test Methods for Tension Testing of Metallic Materials
15.	ASTM E165	Practice for Liquid Penetrant Inspection
16.	ASTM E709	Practice for Magnetic Particle Examination
17.	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. Federal Emergency Management Agency (FEMA):
   1. FEMA 350 Recommended Seismic Design Criteria for New Steel Moment-Frame Buildings, July 2000

J. International Code Council (ICC)

K. Oregon Structural Specialty Code (OSSC) 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. Shop and Erection Drawings:
   1. Structural framing.
   2. Designation of the members and connections that are part of the seismic load resisting system (SLRS).
   3. Connection material specifications.
   4. Locations of demand critical shop welds.
   5. Locations and dimensions of protected zones.
   6. Gusset and base plates drawn to scale.
   7. Welding requirements as specified in AWS D1.1 Appendix W, Sections W2.2 and W2.3.
   8. Locations of pretensioned bolts.
   9. 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 341 Appendix Q.

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 IBC 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 341 Appendix W.
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 316.

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.
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. See Section 03600.

2.08 MISCELLANEOUS ITEMS

A. Furnish all items required to complete the project, but not specified herein, not specified in Section 05500.

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. Review monorail supports and splices with the hoist manufacturer.
8. 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 09900. Provide finish paint coats as specified in Section 09900.

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.

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 cementitious 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 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 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 alloys in accordance with ASTM A780. 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. 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

SECTION 05500

METAL FABRICATIONS (MISCELLANEOUS METAL)

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. All metal fabrications and other miscellaneous metal items together with related accessory items and fasteners, including:
      a. Aluminum stair treads and nosings.
      b. Chain closures.
      c. Gratings.
      d. Grating support angles.
      e. Floor plates.
      f. Floor plate support angles
      g. Steel angle corner guards.
      h. Steel fascias, angles, and trim exposed as part of the finished structure.
      i. All other metal fabrications and miscellaneous metal not covered under other sections.

1.02 REFERENCES

A. American National Standards Institute:
   1. B18.23.1 Beveled Washers

B. ASTM International (ASTM):
   1. A36 Specification for Carbon Structural Steel
   2. A53 Specification for Pipe, Steel, Black and Hot-Dipped Zinc-Coated Welded and Seamless
   3. A123 Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
   4. A153 Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   5. A283 Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
   6. A307 Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
   7. A500 Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
   8. A501 Specifications for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
   9. A653 Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Gavannealed) by the Hot-Dip Process
   10. A786 Specification for Hot-Rolled Carbon, Low-Alloy, High-Strength Low-Alloy and Alloy Steel Floor Plates
   11. A793 Specification for Rolled Floor Plate, Stainless Steel

12. B632 Specification for Aluminum-Alloy Rolled Tread Plate
13. C595 Specification for Blended Hydraulic Cement
14. C1107 Specification for Packaged Dry, Hydraulic-Cement Grout (Non-Shrink)
15. F844 Specification for Washers, Steel, Plain (Flat), Unhardened for General Use
16. F2329 Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

C. Publications of the National Association of Architectural Metal Manufacturers (NAAMM):
   1. "Metal Product Outline; Division 5 Metal"
   2. "Metal Stair Manual"
   3. "Metal Finishes Manual"
   4. "Pipe Railing Manual"
   5. "Metal Bar Grating Manual"

D. The Society for Protective Coatings (SSPC), Volume 2. Standards for Surface Preparation are specified by SSPC followed by SP and a number indicating the specified type of surface preparation.

E. International Building Code (IBC)

F. International Code Council (ICC).

1.03 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Product Data: Fully describe every product proposed for use.

C. Shop Drawings:
   1. Show dimensions, finishes, joining, attachments, inserts, and relationship of work to adjoining construction.
   2. Indicate all shop and erection details including cuts, copes, connections, holes, threaded fasteners, and welds. Indicate welds using AWS "Welding Symbols."
   3. Show field measured dimensions of this and adjacent work and location of inserts on fabrication drawings.
   4. Submit a full floor plan layout and details for all gratings and grating support frames.
   5. Submit a full floor plan layout and details for all floor plates and floor plate support frames.

1.04 QUALITY ASSURANCE

A. Contractor’s Qualifications:
   1. Welding procedures, welders, and welding operations shall be qualified for the type of work required in accordance with AWS Standard Qualification Procedures.

2. Apply fusion epoxy coating by a specialty contractor regularly engaged in the application of fusion epoxy coatings for industrial corrosion protection applications. Application of decorative epoxy coatings to ornamental iron work is not considered an acceptable qualification.

B. Regulatory Requirements: Comply with the following codes and reference standards unless higher standards are specified, shown or required by applicable codes:
   1. "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings," American Institute of Steel Construction (AISC), latest edition.
   2. Structural Welding Code of the American Welding Society, AWS D1.1, latest edition.
   3. International Building Code (IBC), adopted edition, especially Paragraphs 1013, Guardrails, Paragraph 1012, Handrails and Paragraph 1009, Stairs.
   4. Stair, guardrail and accessibility design requirements in IBC, OSHA, OR OAR Divisions 2 and 3 (Administrative Rules) and the Federal Americans with Disabilities Act (ADA).

1.05 DELIVERY, STORAGE AND HANDLING

A. Deliver anchorage devices that will be embedded in the work of other trades in sufficient time to permit their timely installation. Provide proper setting drawings, templates, and directions for installation.

B. Store materials above ground on platforms, skids, or other supports. Store all fasteners and welding electrodes in a weathertight and dry location until ready for use. Store packaged materials in their original labeled containers.

PART 2 - PRODUCTS

2.01 MATERIALS, GENERAL

A. Standard Structural Steel Shapes, Bars and Plates: ASTM A36.

B. Architectural and Miscellaneous Steel Items: ASTM A283, Grade A.

C. Steel Tubing: ASTM A500, (cold formed) Grade A, or ASTM A501 (hot formed), welded or seamless.

D. Steel Pipe: Seamless, conforming to ASTM A53, Type E or S, Grade B.

E. Aluminum: ASTM B483, Alloy 6061-T6 or 6063-T5 or T6.

F. Bolts and Nuts: ASTM A307, Grade A.

G. Plain Washers: ASTM F844.

H. Beveled Washers: ANSI B18.23.1.

I. Weld Type Bends and Fittings for Pipe Guardrails, Handrails and Stair Rails: R&B Wagner, Inc.; J.G. Braun; or equal.
   1. Provide manufactured preformed side outlet (3-way) elbows, radius elbows, bends, tees, crosses, and other fittings of flush design for welded assembly.

2. Provide elbows with a 1-inch inside radius.
3. Provide three-way elbows with a 1/8-inch inside radius.
4. Provide inside alignment sleeves.

J. Concrete Inserts for Guardrail Posts: 16-gauge galvanized steel sleeves, or foam polystyrene inserts ½ inch larger than post diameter x 6 inches (150 mm) deep with removable slip-on plastic covers.

K. Anchorages to Concrete and Masonry:
1. Refer to Section 05090 for anchors carrying shear or tension loads 400 lbs. or more.
2. Provide cast-in-place, expansion, or bonded anchorages with minimum size 3/8-inch-diameter, 3-inch embedment.
3. Provide a satisfactory evaluation report by ICC.
4. Do not load the anchorage in excess of half the ICC values without inspection by Engineer.
5. Material: Stainless steel or as noted on the Drawings.
6. Do not use for loads in tension or withdrawal or for loads subject to vibration.

L. Drive-Anchors: One-piece deformed spring steel anchor: RAWL-Drives, Buildex, or equal. ¼ inch minimum diameter. Drive anchors shall be long enough so that all of the deformed portion plus ½ inch will be embedded in the concrete or masonry. Use for loads less than 200 pounds.

M. Non-Shrink Grout: See Section 03600, 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.

N. Handrail Wall Brackets for Steel Railing: ¼-inch formed steel drilled for screw attachment to pipe rail and expansion bolt anchor to wall, Wagner H-B-1 Type 1-H; Blumcraft wall bracket; or equal.

O. Safety Stair Nosings: Nosing base to be extruded aluminum Type 6063-T5 filled with resilient epoxy binder (13%) combined with a filler that contains at least 60% aluminum oxide abrasive. Provide a minimum coefficient of friction of 0.50. Furnish in two contrasting colors having a difference in light reflectivity of at least 70% to meet CCR Title 24 and ADA requirements for the visually impaired.
1. Concrete Stairs: Nosing base to be extruded aluminum Type 6063-T5 filled with resilient epoxy binder (13%) combined with a filler that contains at least 60% aluminum oxide abrasive. Top surface 3 inches wide; ¼ inch thick. American Safety Tread #9511 for concrete filled pan stairs and #3511 for poured concrete stairs; equivalent products by Wooster; or equal.
2. Metal Stairs: Product meeting requirements above from stair tread manufacturer.

2.02 GALVANIZING

A. Hot-dip galvanize all exterior ferrous metal work and all noted interior ferrous metal work.

B. Hot-dip galvanize all sheet steel, plain or shaped in accordance with ASTM A653, G-90 Commercial Grade.

C. Hot-dip galvanize all products fabricated from rolled, pressed and forged steel shapes, plates, bars, and strip 1/8 inch thick or heavier, in accordance with ASTM A123.

D. Hot-dip galvanize all steel hardware, nuts, bolts, washers, anchors, and threaded rods in accordance with ASTM A153 or F2329. Size thread clearance to allow for galvanized coating; rerun threads after galvanizing, if required, to assure a smooth fit.

2.03 GALVANIZING REPAIR

A. Repair damaged galvanizing by the method of heated zinc alloys in accordance with ASTM A780. Repair materials: ReGalv by Rotometals, Inc., San Francisco, CA; or equal. Specifier knows of no equal.

2.04 FUSION EPOXY COATING

A. Fusion Epoxy Coating:
   1. Apply fusion epoxy coating to items so noted.
   2. Grind all surface irregularities smooth. Round all sharp corners; no sharp corners will be acceptable. Remove all weld spatter prior to sandblasting. Grind welds smooth; grind fillet welds to a uniform radius.
   3. Sandblast all surfaces to a near-white metal finish in accordance with SSPC-SP 10 prior to heating and coating applications.
   4. Use fresh epoxy resins. Submit the hot plate gel time test information to verify that epoxy resins are fresh and suitable for this application.
   5. Apply epoxy powder by the fluidized bed method, in strict accordance with the manufacturer's specifications. Provide a cured coating thickness of at least 12 mils.
   6. Preheated and post heat cure all fabricated items coated with fusion epoxy in accordance with the manufacturer's specifications.
   7. Provide a coating that is uniform, pinhole free, and free from excessive roughness. Test all coatings with a low voltage sponge holiday detector at the protective coating applicator's shop. Only ship coated objects to the project site that are free of holidays and pinholes.
   8. Protect fusion coatings on fabricated work from damage. All pinholes shall be marked and repaired if, in the opinion of the Engineer, the surface is repairable. Unrepairable surfaces shall be cleaned, recoated and then cured in accordance with the manufacturer's recommendations, and retested.
   9. Retest fusion coatings for holidays and pinholes after they have been delivered to the project site.
   10. Make field touchup of the coating as recommended by the manufacturer, to a minimum dry mil thickness of 12 mils.

2.05 SHOP PRIMING

A. Refer to Section 09900 for surface preparation, pretreatment, primers, and application techniques.

B. Apply one shop coat of rust inhibiting primer in accordance with Section 09900 to all steel fabrications not scheduled to be galvanized.
   1. Apply two coats of primer to surfaces not in contact but inaccessible after assembly.

2.06 ISOLATION COATINGS

A. Coat aluminum in contact with other metals in accordance with Section 05100.

B. Coat aluminum in contact with concrete, masonry, or plaster in accordance with Section 05100, Tnemec 46-465 or equal, with a total thickness of system DFT = 8.0 mils, minimum.

C. Provide neoprene or phenolic washers and isolation bolt sleeves or insulating compound at all stainless steel fasteners to aluminum interfaces. Isolation washers shall be capped under a stainless steel washer. Insulating compounds shall be Tef-Gel by Ultra Safety Systems Company; Lanocote by Forespar; or equal.

2.07 FABRICATIONS

A. Aluminum Stairs with Grating Treads:
   1. Stringers and Connectors: Fabricate from structural aluminum shapes.
   2. Treads:
      a. Aluminum bar grating, welded rectangular design, 1½ inch x 3/16-inch bearing bars spaced 1-3/16-inch on centers with ½-inch x 3/16-inch cross bars spaced 4 inches on centers.
      b. Safety nosings: Provide a 2-inch-minimum width angle or channel nosing with a colored abrasive surface meeting the slip-resistance and visually impaired requirements specified under paragraph 2.01 of this Section. Mebac by IKG Industries; equivalent product by Safety Metal Company; or equal.
   3. Intermediate Landings:
      a. Aluminum bar, welded rectangular design gratings with bars as shown on the Drawings and complying with the paragraph headed "Gratings" in this Section.
      b. Safety nosings: Provide a safety nosing meeting the requirements for nosings on grating treads for grating landings and checker plate landings; meet the requirements of paragraph 2.01 for concrete landings.
   4. For interior stairs, the top and bottom nosings shall have a 70% contrast with adjacent surfaces; for exterior stairs, all nosings shall have a 70% contrast with adjacent surfaces.
   5. Guardrails for metal stairs: See Section 05724.

B. Chain Closure: Provide chain closures and related fittings made from 5/16-inch Type 316 stainless steel, with oblong links. Provide three chains 4 inches longer than the anchorage spacing for each guarded area. Mount chains as shown. Provide each chain with boat type snap hooks at each end. Provide eye bolts with 3/8-inch-shank diameter and with 7/8-inch eye for attachment of chains at each anchorage. Provide fittings of the same material and finish as the chain.

C. Grating and Floor Plate Support Frames:
   1. Material: As noted on the Drawings.
   2. Provide grating support angles for all gratings and floor plates. Fabricate grating support angles in complete, closed frames that will lie completely flat in a true plane. Install support frames so they will support the grating and floor plates with even, uniform, non-rattling bearing. Set frames so that the surface of the grating and floor plates are flush with the adjacent floor or surface.
   3. Design and fabricate support frames as required to prevent twisting due to any large ratio of length to width. Restrict the length of each closed section of long narrow support frames to 10 feet maximum.

D. Grating:
   1. General Grating Requirements: Provide gratings that comply with requirements in the NAAMM Metal Bar Grating Manual.
      a. Field measure installed grating frames before fabricating gratings.
      b. Provide grating panels that are absolutely flat, correctly sized, and fabricated to lie in their frames with uniform, non-rattling bearing on all supporting surfaces.
      c. Fabricate with top surface of all bars flush. Install grating flush with adjacent concrete or other walking surfaces.
      d. Provide punch serrated non-slip upper surface on grating in wet areas and areas noted to have a nonslip surface.
      e. Band: Ends of all fixed and removable grating section. Weld banding bars of the same thickness and the same depth as the main bearing bars to the ends of all bearing and cross bars. Weld the banding bars flush with the bearing bars at each panel corner and grind the weld smooth and flush. Round all edges and corners to 1/8-inch radius.
      f. Band all shop and field cutouts and openings. Weld the banding bars to all cut bearing and cross bars.
      g. Leave "split" openings in the gratings when required for the passage of pipes, valve stems, or other devices.
      h. Provide "fixed" grating for all operating grating platforms. Bolt “fixed” grating to support members with saddle clips and stud bolts welded to support members.
      i. Where required for access or where noted, provide removable grating sections sized to limit the weight of any one section to 90 pounds.
      j. Bolt removable sections in place by the same method used for fixed grating. Mark removable sections by painting the banding bars red after fabrication.
   2. Aluminum grating:
      a. Manufacturer: Grating Pacific; Ohio Gratings; or equal.
      b. Aluminum alloy 6063-T6 rectangular bar gratings with a serrated top surface, pressure locked, 1-3/16 x 4-inch bar spacing unless noted otherwise.
      c. Furnish gratings with bar sizes and intermediate supports sized as shown rated for 150 pounds per square-foot superimposed load with a grating deflection not to exceed ¼ inch.
      d. Anchor aluminum grating in place with stainless steel bolts and saddle clips.

E. Floor Plates:
   1. Raised-pattern, galvanized steel, floor plates, ASTM A36.
   2. Galvanized steel 1/4-inch-thick checker plate with stiffeners sized and spaced as shown on the Drawings.
   3. Bolt floor plates to support members with 3/8-inch-diameter countersunk fasteners at 12 inches on center.
   4. Limit the weight of any one section to 200 pounds.

2.08 ATTACHMENTS

A. Metal Anchors: Provide metal anchors and fasteners required to secure all frames and other items rigidly in place and detailed for installation into concrete forms prior to placing concrete.

B. Anchor Bolts and Anchorages to Concrete and Masonry: In accordance with Specification Section 05090.

PART 3 - EXECUTION

3.01 ERECTION TOLERANCES

A. Conform to straight plumb and horizontal lines which also form a true flat plane to within 1/8 inch in 2 feet and ¼ inch in 10 feet and 1/2 maximum overall.

B. Curved surfaces shall conform to a true arc of a circle to within 1/8 inch in 12 inches and ¼ inch maximum overall.

3.02 INSTALLATION GENERAL

A. Fabricate and pre-fit metal work in the shop, in transportable components ready for field erection.

B. Make proper allowance for expansion and contraction of the metals and of the materials to which they are fastened.

C. Where metal is fastened to concrete, make the connection by means of sleeves and fastenings embedded in concrete or by expansion shield anchor bolts or wedge anchor bolts. Wood plugs, plastic plugs, or powder driven studs are not acceptable.

D. Construct steel work in accordance with AISC Standard practices to withstand the forces normally applied and in compliance with IBC and OSHA requirements.

E. Grind welds smooth on all metal work exposed to view. Provide work that has:
   1. Surfaces that are flat, straight, square, plumb, and level.
   2. Smooth curves, free of flat spots, and of uniform radius or, if intended to be of changing radius, follow a flowing fair curve.
   3. Make transitions between curved and straight portions of work at tangent points to achieve smooth and free flowing lines and surfaces without flat spots or abrupt changes in direction.

F. Provide 1/8-inch radius corners and edges on all exposed work.

G. Perform all welding in accordance with AWS Code D1.1. Employ methods and techniques to achieve strength and good appearance.

H. Field Assembly: Set members to lines and elevations indicated. Align and adjust members before making permanent connections.

I. Galvanized Metal Repair: Repair damaged galvanized metal by the heated substrate method as specified in paragraph 2.03.

J. Touch-up Painting (Ferrous Metals): After field assembly, clean all bare metal and all abrasions to shop coat, and spot paint with same primer used in the shop.

3.03 GUARDRAILS AND HANDRAILS

A. Provide workmanship of the highest quality performed by mechanics skilled in executing high quality architectural metal work.

B. Set shop fabricated guardrail sections into position and align the top rail so that it is true to specified tolerances. Do field joining neatly and inconspicuously.

C. Install horizontal sections of guardrail with the top rail exactly horizontal. Vary the height of the rail as required to accommodate sloping deck surfaces. Maintain code required minimum and maximum rail heights.

D. Support guardrails with temporary braces and shoring to maintain true alignment until all final connections and grouting are completed.

3.04 STAIRS AND PLATFORMS

A. Furnish anchor bolts and other connectors required for connection to concrete or other materials.

B. Set structural members to lines and elevations shown. Align and adjust members before making permanent connections.

C. Where stairs land on sloping floors, the height of the first riser at the center of the stair shall be equal to the height of all other risers.

3.05 METAL STAIR NOSINGS

A. Provide safety stair nosings in accordance with paragraph 2.01 at all concrete stairs and landings. Make nosings the full length of each tread less 2 inches at each end. Protect exposed surfaces of safety nosings during construction and leave the surfaces clean and free of concrete and staining.

B. For interior stairs, provide a top and bottom nosing that contrast with adjoining surfaces and nosings on intermediate treads. For exterior stairs, provide nosings on all treads that contrast with surrounding surfaces. Adequate contrast is defined as a 70% difference in light reflectivity.

3.06 GRATINGS AND FLOOR PLATES

A. Install support frames so that gratings and floor plates have continuous support and so gratings and floor plates will sit in their frames without rattling or rocking in any direction including across diagonal corners.

3.07 MISCELLANEOUS

A. Furnish the following for field installation:
   1. Custom fabricated steel connectors for wood beams and other rough carpentry work.
   2. Door frames made of structural steel shapes for installation in the concrete pour. Provide all anchors and connectors.
   3. Miscellaneous metal work not specified in other Sections.

3.08 REPAIRS

A. Repair or replace all defective work including:
   1. Unsightly welds.
   2. Discontinuous welds.
   3. Uneven connections.
   4. Variations exceeding specified tolerances.
   5. Kinks, bends.
   6. Other defects affecting the quality, strength, utility. and appearance of the work.

3.09 CLEANING

A. Wash thoroughly using clean water and detergent.

B. Do not use acid solutions, steel wool, or other abrasives.

C. Remove stubborn grease stains with mineral spirits.

END OF SECTION

SECTION 05724

ALUMINUM COMPONENT RAILING SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Guardrails, stair rails, handrails, toeboards, and related work employing a stock manufactured aluminum Component Railing System.
   2. Related custom manufactured items.
   3. Work in this Section requires the highest level of workmanship, skill and care and may require specialized manufacturing equipment and techniques.

1.02 REFERENCES

A. Aluminum Association:
   1. AA ASD-2013 Aluminum Standards and Data

B. ASTM International (ASTM):
   1. B241 Standard Specification for Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube
   2. B244 Standard Test Method for Measurement of Thickness of Anodic Coatings on Aluminum and Other Nonconductive Coatings on Nonmagnetic Basis Metals with Eddy-Current Instruments
   3. B429 Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube
   4. B483 Standard Specification for Aluminum and Aluminum-Alloy Drawn Tube and Drawn Pipe for General Purpose Applications
   5. C595 Specification for Blended Hydraulic Cements

C. American Welding Society (AWS)
   1. B2.1 Specification for Welding Procedure and Performance Qualification
   2. WHB Welding Handbook – Materials and Applications

D. National Association of Architectural Metal Manufacturers (NAAMM)
   1. AMP 500 Metal Finishes Manual
   2. AMP 521 Pipe Railings Systems Manual

1.03 SUBMITTALS

A. Product Data: Fully describe all products proposed for use.

B. Shop Drawings:
   1. Show dimensions, materials, alloys, finishes, joining, attachments, field splices, control joints, inserts, and relationships of work to adjoining construction. Show sections where guardrail will be removable on all plans.
   2. Indicate all shop and erection details including cuts, copes, connections, slip joints, holes, threaded fasteners and welds. Indicate welds using AWS “Welding Symbols.”

3. Show field measured dimensions of this and adjacent work and field measured locations of cans and inserts.
4. Provide setting drawings, templates and directions for installation.

C. Samples: Provide 6” x 6” section of railing showing the intersection of a post and top rail. Grind, sand and finish all welds. Apply the specified finish and Anodic coating.

1.04 QUALITY ASSURANCE

A. Qualifications:
1. The fabricator and installer must be a State Licensed Specialty Contractor regularly engaged in custom fabrication and installation of fully welded and anodized architectural aluminum railings.
2. Provide minimum three (3) project references of nearby installations of similar size and scope.
3. Welding procedures, welders, and welding operations shall be qualified for the type of work required in accordance with AWS B2.1 and its associated AWS Standard Welding Procedure Specifications (SWPS).

B. Comply with the following Regulatory Requirements:
1. Oregon Structural Specialty Code (OSSC), adopted edition.
2. Stair/Handrail, Guardrail and/or Ladder/Stile design requirements of Oregon OSHA.

C. Comply with the current editions of the following trade association and reference standards:
1. “Pipe Railing Systems Manual,” the National Association of Architectural Metal Manufacturers (NAAMM).
2. “Metal Finishes Manual,” NAAMM.
3. “Welding Handbook – Materials and Applications” American Welding Society.

1.05 DELIVERY, STORAGE AND HANDLING

A. Provide inserts, sleeves, and anchorage devices in time to be incorporated in other work. Provide setting drawings, templates, and directions for installation.

B. Store materials above ground on platforms, skids or other supports, and in a manner to avoid damage. Stacking shall be done in a way which will prevent bending. Store all fasteners and welding electrodes in a dry, weathertight place, away from uncured concrete and masonry. Store packaged materials in their original containers.

PART 2 - PRODUCTS

2.01 MATERIALS, CLASS I

A. Provide an aluminum Component Railing System manufactured and installed under the responsibility of a single specialist firm.

B. Furnish a system that employs fittings that are internally welded to vertical members. See paragraph 2.01.E.4 of this Section. Mechanical attachment of fittings to vertical members is not acceptable.

C. Manufacturer/Installer and Product Line Class I (NOTE: CLASS II NOT ACCEPTABLE FOR THIS PROJECT): C-V Pipe Rail C4300 by Crane Veyor Corporation (CVC); “Series 500” modified to meet these specifications and manufactured by Superior Aluminum Products, Inc.; Golden Railings, Rocky Mountain Railings; or equal.

D. All railing shall be Class I railing, Class II manufacturers’ railing systems will not be reviewed unless the system is fully compliant with Class I above.

E. Part numbers listed in this Specification Section are Crane Veyor Part Numbers and are used to describe the quality and function of the item required.

F. Posts, Rails, Connectors, Toeboards, and Related Items for Component Railing System:
   1. 1-½-inch Aluminum Pipe: Schedule 40, 1.90-inch outside diameter, Alloy 6063 in T6 temper handrail grade, or 6063-T1 or T52 handrail grade where required for bending. Use 6063-T832 where a clear anodized finish is required.
   2. Aluminum Reinforcing Sleeve: Aluminum drawn tube, 6063-T832, 1.6-inch diameter x 0.125-inch thickness. Outside diameter to be a tight fit inside the aluminum pipe.
   3. Aluminum Reinforcing Bar: Solid aluminum bar, 6061-T6, outside diameter to be a tight fit inside the aluminum pipe.
   4. Component Railing System Connectors:
      a. Drawn, forged or fabricated aluminum Alloy 6063-T5, T6, or T832.
      b. Coped to fit tightly at joint to post, rails or other members and shall have a stub or sleeve of reduced diameter to fit snugly inside the connecting member.
      c. Provide an internal bulkhead just inside the point where the connectors are coped to fit the post or connecting member.
      d. Mechanical attachment of connector to post is NOT ACCEPTABLE.
      e. At intermediate railing posts use a “T” top rail connector and saddle intermediate rail connectors CVC #C4350, or equal.
      f. At end railing post, join the top rail to the post with a pipe bend or radius elbow. Miters or “T” connectors with end cap are unacceptable. CVC #C4355 or equal.
      g. At inside and outside corners:
         1) Use two posts located close to the corner in each direction such that clear space between posts does not exceed maximum spacing allowed between horizontal rails. Bend top rail at corners or use a welded radius elbow.
         2) Where shown or required use a custom fabricated single corner post with a side outlet elbow (3-way elbow) as a top of post fitting. Attach top rails to posts with “T” top rail connector; attach intermediate rails to posts with saddle connectors.
      h. Provide 4 inches high extruded aluminum with “F” shaped flanges along the top and bottom edge: CVC #C43880; or equal. At interior and exterior corners, use special corner connectors #C43900 and at splices use #C43890.

G. Use a stainless steel base plate for bolt attachment to steel channel stair stringers. Weld a stainless steel tube to a 3/8-inch-thick stainless steel base plate sized to fit inside the aluminum pipe rail post #C43230(s).

H. Socket for Removable Posts: Stainless steel post socket with closed bottom. #C43300.

I. Aluminum Bars and Plates: 6063-T6 alloy, 35,000 psi yield, 21,000 psi allowable.

J. Grout: Hydraulic quick-setting cement, nonshrinking, unaffected by water after setting and conforming to ASTM C595. Super Por-Rock or equal.

K. Bolts, nuts, washers and screws in contact with aluminum: Stainless Steel, AISI Type 304, with hex head bolts and nuts.

2.02 ALUMINUM ANODIZING

A. After fabrication and finishing give all aluminum railings a medium chemical etch and an Architectural Class I anodic coating, at least 0.7 mils thick, clear AA-C11-A41. Comply with the “Standards for Anodized Architectural Aluminum,” published by the Aluminum Association and referred to in NAAMM “Metal Finishes Manual.” Measure thickness in accordance with ASTM B244.

B. Where aluminum is in contact with concrete, grout, plaster or other metals, apply a coating of aluminum pigmented bituminous paint or epoxy paint to the aluminum after anodizing to act as an isolation barrier.

2.03 FABRICATION OF ALUMINUM HANDRAILS, GUARDRAILS, AND STAIR RAILS

A. Make joints with special connectors designed for concealing shop welding to posts and flush slip on epoxy bonding of horizontal railing members in the field. Accurately cope connectors for a smooth hairline fit. Joints shall be weld joints on the inside of the connector so that welds are not visible from the outside. Bolts, screws, pop-rivets or other exposed fasteners are not acceptable. Remove all sharp edges with fine abrasive.

B. Fabricate custom components that cannot be assembled with fittings using aluminum pipe and welding type fittings. Fully weld all joints all around using Alloy 5356 filler wire, grind smooth and finish with progressively finer grits of abrasive ending with 180 grit.
   1. Avoid posts at inside or outside corners. Locate a post close enough to the corner in each direction such that clear space between posts does not exceed maximum spacing allowed between horizontal rails. From the corner with tight radius pipe bends or manufactured welding type elbows. Miters not permitted.
   2. At wall returns, at intersections of top rails with posts at the end of a run, and at other changes in direction, either custom bend the pipe rail or use manufactured formed or bent pipe ells having a minimum 2-inch-inside radius. Make custom bends on a roll type hydraulic tubing bender. Provide bends that are free of buckles, puckers or deformed surfaces.
   3. At all cross and tee intersections, accurately cope members for a tight fit and internally plug weld as described above.

4. Cap ends of pipes except wall returns with manufactured bulb end caps. Return wall rails to within 1/8 inch of the wall.
5. Posts: Schedule 40 pipe internally reinforced at the bottom with a 20-inch-long tight fitting solid aluminum bar bonded to the inside of the post with structural epoxy. Space posts no further apart than 6 feet regardless of spacing shown on Drawing.
6. Where posts are bolted to the top edge of stair stringers or at similar situations where a flanged connection is required, fabricate the flange from a ¼-inch-thick stainless steel plate. Round corners to a ¼-inch radius and ease all exposed edges to a 1/16-inch radius. Weld a stainless steel sleeve to the plate. Size the sleeve to be a snug fit inside of the aluminum pipe post. Slide the post over the stainless steel sleeve and bond with epoxy.
7. Where chains and snap rings are required, provide a continuous aluminum reinforcing sleeve inside of the aluminum post. Provide 1-inch-diameter 304 stainless steel eye bolts, a 304 stainless steel chain with 13 welded 3/16-inch-diameter wire links per foot, and chrome plated brass snap fasteners. Locate the eyes of the eye bolts on the outside of the post away from the walking side of the rail and not facing the opening that the chain closes.
8. Provide expansion joints consisting of a 6-inch-long solid aluminum sleeve sized to slip inside the members and bonded on one side of the joint only to allow for the thermal movement. Allow a minimum of ¼-inch space for expansion in each 24-foot section. Allow more space if required to accommodate anticipated temperature changes. Locate expansion joints within 6 inches of a post. Ease exposed edges of pipe rail to a 1/16-inch radius.
9. Provide 3/16-inch-diameter holes in inconspicuous locations to vent interior of members.

C. Anodizing:
1. Anodize all parts after the exposed welding is complete in accordance with paragraph 2.03 of this Section. Internally welded connectors may be attached to posts after anodizing.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

A. Shop weld all connectors and fittings to vertical post assemblies. Field cut horizontal railing members and epoxy bond to connectors on post assemblies.

B. Install work to a straight line or flat plane to within 1/8-inch in 6 feet and to within 1/4-inch total deviation. Install curved surfaces conforming to a true arc of a circle to within 1/16-inch.

C. Equally space posts in any run and not more than 6 feet on center. Space posts in parallel rows so they are in alignment.

D. Make proper allowance for expansion and contraction of the metals and of the materials to which they are fastened.

E. Set posts 6 inches deep in sleeves cast in concrete [or in holes core-drilled in concrete] using waterproof, nonshrinking grout.

F. Construct work to withstand the forces required by OSHA.

G. Round and grind smooth all exposed corners and edges.

H. Perform all welding in accordance with AWS manual “Welding Aluminum.” Employ methods and techniques to achieve the full strength of the members joined and architectural appearance.

I. Field Assembly: Set members to lines and elevations indicated. Align and adjust members before making any permanent connections.

3.02 GUARDRAILS AND HANDRAILS

A. Provide work of the highest quality performed by mechanics skilled in executing high quality architectural metal work.

B. Set shop fabricated guardrail sections into position and align the top rail so that it is true to specified tolerances. Do field joining with structural epoxy adhesive. Mix and apply adhesive in accordance with manufacturer’s instructions.

C. Support guardrails with temporary braces and shoring to maintain true alignment until all final connections and grouting are completed. Build surface of grout up at post, ¼-inch higher than surrounding surfaces to direct water away from post.

D. Attach toeboards to posts using two self-tapping, stainless steel machine screws minimum at each connection. Use special toeboard connectors at corners and special splice plates at end joints.

E. Coat surfaces of aluminum in contact with concrete, grout, plaster or dissimilar metals with specified coating material.

3.03 REPAIRS

A. Replace all defective work including:
   1. Unsightly welds.
   2. Discontinuous welds.
   3. Uneven connections, surfaces, finishes or coatings.
   4. Variations exceeding specified tolerances.
   5. Kinks, bends, tool marks, grinding marks.
   6. Other defects affecting the quality, strength, utility and appearance of the work.

3.04 CLEANING

A. Wash thoroughly using clean water and detergent.

B. Do not use acid solutions, steel wool or other abrasives.

C. Remove stubborn grease stains with mineral spirits.

END OF SECTION

SECTION 06100

ROUGH CARPENTRY

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Rough carpentry.
   2. Stock manufactured framing hardware and fasteners.
   3. Blocking, backing, grounds, inserts and similar supports for work provided under other sections.
   4. Furring required to supporting finishes to conceal work provided under other sections.

1.02 REFERENCES

A. The American Institute of Timber Construction "Standard Specification for Glued Laminated Timber," AITC 117 and ANSI/AITC 190.1.

B. American Plywood Association (APA) "Plywood Design Specifications."

C. International Code Council (ICC) Service Reports or National Evaluation Report (NER).

D. U.S. Department of Commerce Voluntary Product Standard PS 56-73 with Amendments.

E. National Design Specification for Wood Construction.

F. American Wood Preservers Association: (AWPA) "Preservative Treatment by the Pressure Processes and Quality Control Standards," C-190, C2-90, C3-90, C4 90, C14 90, C15-91, C16-91, C22-91, C23-84, C24-86, C28-90, and M4-90.

G. ASTM International (ASTM).

1.03 SUBMITTALS

A. Product Data: Fully describe all items proposed for use.

B. Shop Drawings: For stock and custom manufactured items:
   1. Show shop and erection details required for fabrication and installation of Glued Laminated structural units and I-Beam Joists. Include location, type, size, and extent of all connections and fastenings; camber; material grades; and combination. Indicate deviations from the design specified herein.
   2. For Glued Laminated members and I-Beam Joists: Submit glue type, lamination type and grading report and reports of physical tests of random samples of production units.

1.04 QUALITY ASSURANCE

A. Qualifications: Glued Laminations of Structural Units: Manufacturer to be a current licensee of the American Institute of Timber Construction and all products to be marked with the AITC Quality Control Mark.

B. Regulatory and Specified Requirements:
   1. Conform to applicable portions of the adopted edition of the International Building Code Standards and the Oregon Structural Specialty Code, including adopted amendments, especially Chapter 23 unless higher standards are specified or shown.
   2. Lumber Grading Rules and Wood Species: Conform to applicable IBC Standards, Product Standard PS 20-70 and "Standard Grading and Dressing" Rule No. 17 (1993) of the West Coast Lumber Inspection Bureau (WCLIB).
   3. Plywood: Conform to requirements of U.S. Product Standard PS 1-95 and be manufactured by members of the American Plywood Association (APA).
   4. Grade Marks:
      a. Identify all lumber and plywood by official grade mark or provide inspection certificates from appropriate grading and inspecting agencies.
      b. Do not place grade mark on exposed faces.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Immediately upon delivery to job site, place materials in area protected from weather.

B. Protect all lumber stored on site from rain and excessive sun, stack lumber above the ground on sleepers blocked up to create a plane surface, and stack lumber in neat piles and in such fashion as to prevent twisting and warping. Use "stickers" to bind subsequent layers and provide uniform air circulation.

C. Glued Laminated Members:
   1. Protect Members from weather and damage during transportation, erection, and construction.
   2. Store material at site off the ground and protect from weather and moisture by adequate wrapping of load and individual members.
   3. Wrap Members individually with light colored covering; maintain wrapping on members until building is closed in or until finish is applied.
   4. Slit wrapping open to allow moisture to escape, but take care to avoid damaging and staining by weather and sun.
   5. Use nonmarring slings for loading, unloading, and handling of units to prevent damage to surfaces and wrapping.

1.06 PROJECT CONDITIONS

A. Install work under environmental conditions recommended by applicable trade associations, standards and manufacturers or material providers' recommendations.

1.07 SEQUENCE SCHEDULING, COOPERATION, AND COORDINATION

A. This Contractor and other contractors whose work makes it necessary for them to cooperate shall plan a sequence of operations for coordination of their work that will be satisfactory to all concerned. Any differences or disputes concerning such coordination, interferences, or extent of the work shall be decided by the Engineer and his decision shall be final.

B. Before work is commenced, verify lines and levels shown on plans and report any discrepancies required to the Engineer. Have adjustments made prior to proceeding with the work.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Framing and Structural Materials:
   1. Maximum moisture content: 19% and grade stamped S-Dry.
   2. Specified lumber dimensions are nominal. All lumber shall be dressed S4S to WCLIB paragraph 250 sizes.

Item	Species and Grade	Grading Rules
Sills and Top Plates	Pressure treated Douglas Fir "No. 2 or Better" grade	WCLIB 122-b
Studs, Blockings and Furring	Douglas Fir "Construction" grade	WCLIB 122-b
Beams and Headers	Douglas Fir "No. 1 Structural" free of heart center (FOHC)	WCLIB 123-b
Posts	Douglas Fir "No. 1 Structural" free of heart center (FOHC)	WCLIB 123-b
Plywood Sheathing	Pressure treated Douglas Fir "Structural #1" CDX	APA-CC-EXT

B. Wood-Preservative Treatment:
   1. Pressure-treat with waterborne preservative complying with IBC Chapter 23 and AWPC Standards referenced in paragraph 1.02F.
   2. After treatment, kiln-dry all lumber to maximum 15% moisture content.
   3. Pressure preservative treat all wood sills, sleepers, blocking, furring, stripping, roof nailing strips, and curbs, and similar members in contact with concrete or soil, unless heartwood grade Redwood is used.
   4. Treat all heartwood redwood in contact with soil or concrete by immersion for 5 minutes in copper nepthenate wood preservative having VOC limit of 350 or less and complying with the AQMD having jurisdiction. DAP Marine Woodlife Preservative; or equal.

C. Wood-Fire Retardant Treatment:
   1. Fire-retardant wood shall have a flame spread class of 25 or less when tested in accordance with ASTM E84 and show no evidence of significant progressive combustion when test is continued an additional 20 minutes.
   2. Treat all wood used for backing and blocking in metal stud walls.

D. Sealer: "Woodlife," "Penta-WR," or "Woodtax" or equal, penetrating liquid water-repellent preservative.

E. Rough Hardware: Furnish all nails, spikes, bolts, screws, and framing connectors of standard manufacture required to complete the work:
   1. Hot dip galvanizes all items exposed to moisture or weather.
   2. Nails: FF-N-101 common or box type sizes as shown or as required by IBC Chapter 25.
   3. Bolts and screws ASTM A307: Hex head machine bolts, carriage bolts with hex nuts, hex head lag screws and wood screws; provide cut washers unless malleable washers indicated.
   4. Joist hangers and framing connectors: Simpson, Silver Metal Products; or equal, complete with required fasteners. Catalog numbers of the first named manufacturer are used on Drawings to indicate size and function.
   5. Expansion bolts: See Section 05090.

2.02 FABRICATION OF GLUED LAMINATED STRUCTURAL MEMBERS

A. Fabricate all glued laminated members in strict accordance with favorably reviewed shop drawings and referenced standards.

B. Appearance:

C. Where exposed in finished structure, AITC "Architectural Grade, resaw finish."

D. Where concealed, AITC "Industrial Grade."

E. Grade Combination: As scheduled in this Section or shown on the Drawings.

F. Moisture content of any piece shall not exceed 12% or be less than 7% at time of gluing: The range of moisture content of various laminations assembled into a single member shall not exceed 5%.

G. At cantilevers, or where tension occurs at top of member, tension-zone requirements shall apply to top of beam (AITC 117). Top face shall be plainly marked.

H. Ends shown as special shape shall be cut at time of fabrication: Do not trim ends until dimensions are verified in field.

I. End joints shall be fabricated in compliance with product standard PS 56.

J. Provide camber in units in accordance with requirements indicated on Drawings.

K. Sealer:
   1. After trimming, all members shall be end sealed with specified sealer.
   2. Field cuts shall be touched up prior to staining.

2.03 SOURCE QUALITY CONTROL

A. Manufacturers' Testing and Inspection:
   1. Glued-Laminated Timber: Quality control as required by AITC A190.1 and ASTM D3737.
   2. I-Beam Joists: Provide quality control inspections by a compliance assurance and/or inspection agency listed by the National Evaluation Service Committee. Identify each joist with a stamp indicating the type of joist, NER report number, manufacturer's name, plant number, and inspection agency.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General:
   1. Coordination and Layout: Before starting work, review proposed mechanical and electrical systems with other trades. Make required adjustments in framing to facilitate installation of systems with least possible cutting. Report possible discrepancies for clarification and adjustments.
   2. Accurately cut and solidly fit together all work to provide strong, rigid joints, with full bearing for all members.
   3. Obtain Engineer's written approval before cutting, drilling or notching framing members to permit the installation of utilities, ductwork, or other items.
   4. Reinforce members damaged by cutting or boring with steel straps acceptable to Engineer.
   5. Split, warped, curled, or otherwise defective material or careless or improper workmanship will not be accepted. Engineer reserves right to reject and have replaced at Contractor's expense split studs and joists as well as any twisted or warped studs or joist that are not in alignment with rest of wall or roof.
   6. Erect all work with surfaces level, plumb, and true.
   7. Provide all accessories and install as per manufacturer's specifications.

B. Vertical and Horizontal Controls: Establish and maintain necessary benchmarks, lines, or controls throughout the execution of the work.

C. Tolerances: Design, construct, set and maintain framing to ensure completed work is within tolerance limits of 1/8 inch.

D. Fit closely and set accurately all framing lumber and other rough carpentry. Install work at the required lines and levels and secure in place in a rigid and substantial manner. Drive spikes and nails with the heads flush with the surfaces of the outer members. Draw bolts tight upon installation and re-tightened immediately prior to closing the work with finishes.

E. Sill Plates:
   1. Set in uniform, solid ½-inch-thick latex bonded mortar bed. Set perfectly level with engineer's level. Set outside edge straight to a stretched string or laser beam.

2. Bolt all sills to foundation at 4 feet-0-inch o.c. and within 9 inches of each end, unless otherwise noted on Drawings. Minimum two bolts per member.
3. Treat all cuts and holes with a concentrated preservative compatible with that used for pressure treatment.

F. Stud Wall Framing:
1. Cut studs and posts with square ends, unless otherwise shown, and erect plumb.
2. Select studs for straightness and set plumb, true and in alignment.
3. Place studs in walls with the shortest dimension parallel to the run of the wall:
   a. Provide 2x6 studs or as indicated on Drawings, spaced 24 inches on center, unless otherwise closer spacing is shown.
   b. Use full length studs from sill or bottom plate to top plate.
4. Use double studs on each side of all openings, unless more studs or larger members are shown on the Drawings.
5. Provide triple studs at corners unless more studs are shown. Arrange framing at corners to provide a bearing surface for sheathing and/or finishes. Frame solids corners where stud wall or partitions meet.
6. Frame openings in stud walls and partitions with headers across the top with a minimum size of a full stud depth x stud width resting on cripple studs, unless greater bearing area is shown.
7. Provide double top plates; set one at a time; and provide single bottom plates secured as shown:
   a. Install double top plates in the greatest length available and lap splices a minimum of 4 feet. Lapped double plates at corners.
   b. Obtain Engineer's written approval prior to drilling, cutting, or notching plates. Where openings are cut through plates, install 16-gauge steel strap ties 1 1/4 inches wide at single plate and 2 5/16 inches wide at double plates extending at least 9 inches past each cut.
8. Frame walls and partitions containing plumbing, heating, or other pipes as required to give proper clearances for piping without notching, cutting, or boring studs.
9. Reinforce holes through framing as shown.
10. Provide 2x fire stops the full depth of the studs as required by code and as indicated on Drawings. Install blocking for miscellaneous items as required for the support of such items.

G. Cutting, Drilling and Notching:
1. Obtain the Engineer's written approval before cutting wood girders, beams, or joists. Limit cutting and drilling for electrical conduits and mechanical pipes to the top of beams and to a depth of one-fifth of the beam depth and located not further from the support than three times the beam depth and not closer to the support than the beam depth:
   a. Cuts in excess of this or single bored holes with diameter of more than 1 inch are not permitted without special provisions for reinforcing the beams, acceptable to Engineer.

H. Construct Bolted Connections in accordance with the provisions of the "National Design Specification for Stress-Grade Lumber and Its Fastenings," latest edition.

I. Provide nailing in accordance with applicable nailing tables in Chapter 23 of IBC.

J. Nailing:
   1. Conform to IBC nailing in accordance with Nailing Tables in Chapter 23 of IBC, unless otherwise shown.
   2. Use only common nails, unless otherwise noted: Where required, predrill to prevent splitting.

K. Light Gauge Metal Framing Connectors: Install patented joist hangers and framing connectors according to manufacturer's recommendations. Fill all nail holes with required fasteners.

L. Replace structurally and/or architecturally objectionable split members.

3.02 BACKING AND BLOCKING

A. Provide wood blocking and backing in partitions and elsewhere for the attachment of fixtures and equipment: In metal stud partitions, provide fire-treated wood backing.

B. Obtain templates or drawings from fixture and equipment suppliers showing type and location of backing required. Install backing before wall finishes are in place.

C. Fit backing tightly between studs and secure to studs using at least two nails or screws through studs and into each end of backing member: In metal stud partitions, notch or kerf backing to the depth of return flanges of "C" studs, allowing the face of backing to be installed flush with face of studs.

3.03 ROUGH HARDWARE

A. Anchor Bolts: Set anchor bolts in the forms and secure in position prior to placement of concrete. Installing anchor bolts by inserting them in fresh concrete will not be permitted.

B. Framing Devices: Install framing devices in conformance with, and using the fastenings indicated in the manufacturer's recommendations.

3.04 NAILERS AND GROUNDS

A. Provide wood nailers and grounds for fastening wood trim, finish materials and other materials where required. Install grounds in proper alignment to create flat level and plumb surfaces. Test grounds with 8-foot straight edge; correct deviations that exceed 1/8 inch in 10 feet.

3.05 TEMPORARY SUPPORTS

A. Provide temporary bracing and shoring required to support rough carpentry work during construction.

END OF SECTION

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SECTION 07410

MANUFACTURED METAL (STEEL) ROOF PANELS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Manufactured metal roof panels.

B. Furnish all labor, material, tools, equipment and services for all preformed roofing as indicated, in accordance with provisions of Contract Documents.

C. Completely coordinate with work of all other trades.

D. Although such work is not specifically indicated, furnish and install all supplementary or miscellaneous items, appurtenances and devices incidental to or necessary for a sound, secure and complete installation.

1.02 REFERENCES

A. "Architectural Sheet Metal Standards" by Sheet Metal and Air Conditioning Contractors National Association (SMACNA), latest edition.

B. ASTM International (ASTM):
   1. A653 Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron-Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   2. E1592 Standard Test Method for Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference.

C. Federal Specification (FS)
   1. FS UU-B-790A - Building Paper, Vegetable Fiber: (Kraft, Waterproofed, Water Repellent and Fire Resistant)

D. International Code Council (ICC):
   1. 2019 Oregon Structural Specialty Code (OSSC)

1.03 SUBMITTALS

A. Product Data: Fully describe all materials proposed for use.

B. Shop Drawings: Show the design, dimensions, materials, methods of construction and installation of each piece to be installed.

C. Samples: Manufacturer’s full range of color finishes applied to sheet metal swatches for selection of color.

1.04 QUALITY ASSURANCE

A. Qualifications: Manufacturer has a minimum of 5 years of experience in manufacturing metal roof systems. Panels shall be produced in a factory environment (not with a portable roll former with fixed-base roll forming equipment) and in line leveling assuring the highest level of quality control. A letter from the manufacturer certifying compliance will accompany the product material submittals. Installation contractor shall be an approved installer, certified by the manufacturer before the beginning of installation of the metal roof system. Provide certification letter that installation contractor has a minimum of 3 years of metal product installation experience immediately preceding the date upon which work is to commence.

B. Trade Association Standards: Comply with Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) specifications for material and workmanship not otherwise specified herein.

1.05 GUARANTEE/WARRANTY

A. Furnish the Owner with a written guarantee. The Contractor shall provide to the Owner, a Standard warranty signed by the roofing manufacturer of the roof system as outlined below:

B. Single Source Warranty: Single Source Warranties require a certified installer on site at all times.
   1. For a period of ten (10) years from the date of substantial completion, the roofing manufacturer WARRANTS to the Owner: To furnish roof panels, flashing and related items used to fasten the roof panels and flashing, will not allow intrusion of water from the exterior of the roofing manufacturer's roof system into the building envelope when exposed to ordinary weather conditions and ordinary wear and usage. The Date of Substantial Completion is the date that is certified by the Architect, Owner, or Owner's Representative, when the roofing manufacturer's roofing system is completed and accepted by or on behalf of the Owner.
   2. The roofing manufacturer shall have the SOLE AND EXCLUSIVE obligation for all warranty work commencing on the date of substantial completion and under all circumstances terminates on the ten (10) year anniversary of the date certified as Substantial Completion of the roofing manufacturer's roof system. During the period in which the roofing manufacturer has any warranty obligation, the roofing manufacturer shall take appropriate actions necessary to cause the non-performing portions of the Roof System to perform their proper functions.
   3. Roofing Manufacturer's Liability: The total liability of the roofing manufacturer shall be a no dollar limit of the manufacturer’s roof system as invoiced to the roofing manufacturer’s customer.

C. Applicator shall furnish written warranty for a two (2) year period from date of substantial completion of building covering repairs required to maintain roof and flashings in watertight condition.

1.06 DELIVERY AND STORAGE

A. Deliver materials to the job site in the factory packaging with identifying labels intact and to provide protection against transportation damage.

B. Handling: Exercise extreme care in unloading, storing and erecting metal roof system to prevent bending, warping, twisting and surface damage.

C. Storage: Store bundled sheets off the ground sufficiently high enough to allow air circulation beneath bundle and to prevent rising water from entering bundle. Slightly elevate one end of bundle. Prevent rain from entering bundle by covering with tarpaulin, making provision for air circulation between draped edges of tarpaulin and the ground. Prolonged storage of sheets in a bundle is not recommended. If conditions do not permit immediate erection, extra care should be taken to protect sheets from staining or watermarks.

PART 2 - PRODUCTS

2.01 ROOFING SYSTEM

A. Furnish materials that are all manufactured by a single company.

B. Standing Seam and Batten Roofing: Pac-Clad Metals; Craftsman Series by MBCI; Batten System by ASC Profiles; or equal (minimum slope of 3:12). Include rain gutters, fascias, downspouts and flashing contiguous with roofing system.

C. Fabricate roofing panels and battens in continuous lengths from eave to ridge without intermediate joints or laps.

2.02 MATERIALS

A. Fabricate all roofing components from factory prefinished, minimum 24-gauge galvanized steel sheet meeting ASTM A653, G-90 Commercial Class 1.25, minimum zinc coating: 1.25 ounces per square foot of surface. See paragraph 2.02F for factory finish.
   1. Metal pans: 22-1/2-inches wide with 3/4-inch turn-up each side.
   2. Metal battens: 1-1/2-inch wide x 2-inch high with hold-down clips.
   3. Ridge and hip covers: Formed sheet metal in continuous lengths without seams or laps.
   4. Rain gutters and downspouts: Formed sheet metal to configuration shown.
   5. Starters, trim, batten closures: Manufacturer's factory formed sheet metal shapes.
   6. Closures between battens: Neoprene, factory cut for snug, watertight fit.
   7. Hold-down clips: Concealed, combination pan hold-down and batten snap-on clip, factory formed.

B. Flashing: 24-gauge galvanized sheet metal custom-formed to suit conditions.

C. Fasteners:
   1. To metal deck: Self-drilling, self-tapping, TEKS by Buildex; Redhead self-tapping screws by Phillips; or equal.
   2. Provide fasteners of sufficient length for anchorage to metal deck. Field verify length(s) per Drawings and manufacturer's recommendations.
   3. Component fasteners: Stainless steel, Type S-12, self- drilling, self-tapping screws.
   4. All self-tapping/self-drilling fasteners, bolts, nuts, self-locking rivets and other suitable fasteners shall be designed to withstand specified design loads. Use long life fasteners for all interior and exterior metal roof system applications.
   5. Provide fasteners with a factory applied coating in a color to match metal roof system application. Provide neoprene washers under heads of exposed fasteners. Locate and space all exposed fasteners in a true vertical and horizontal alignment. Use proper torque settings to obtain controlled uniform compression for a positive seal without rupturing the neoprene washer.

D. Air and Vapor Barrier Underlayment: VapAir Seal MD by Carlisle for direct application over metal decks; or equal

E. Finish: Smooth texture; Fluoropolymer resin base, thermo-cured two-coat system, 1-mil thickness minimum; Kynar 500; Duranar 200; or equal. Furnish manufacturer's 20-year written guarantee against failure of the finish.
   1. Roofing panels, battens and trim will be all one color, selected from manufacturer's standard range.
   2. Rain gutters and downspouts will be one different color selected from manufacturer's standard range.
   3. Provide factory finished sheet metal components, including flashings and trim to match roof panels.

F. Insulation Board: Pre-formed, closed-cell, rigid CFC free, high density polyisocyanurate insulation board. Provide minimum thermal resistance of 5.7 per inch. Provide R-values and thicknesses as called out on Drawings. Carlisle HPH Polyiso, Johns-Manville, Owens Corning; or equal.

G. Cover Board: A rigid insulation panel composed of a high-density (100 psi), closed-cell polyisocyanurate foam core laminated to coated-glass fiber-mat facer for use as a cover board or recover board. Minimum R-value of 2.5. Carlisle SecurShield, Dow, Owens Corning, Kingspan; or equal.

H. Sealant: One-part polyurethane, Vulkem 116; Sikaflex Ia; or equal.

I. Building Paper: Rosin sized, unsaturated paper, weighing approximately 6 pounds per 100 square feet, or a water-repellent smooth building paper meeting requirements of FS UU-B-790A, Type I Barrier Paper, Grade A (High water vapor resistance).

PART 3 - EXECUTION

3.01 PREPARATION

A. Inspect all surfaces to receive roofing and have defects corrected before proceeding.

B. Coordinate all work with the work of other trades that adjoins, combines or aligns with this work.

C. Take field measurements before proceeding with the work. Verify that installation may be made in accordance with approved shop drawings and manufacturer's instructions. This specifically includes verifying that secondary structural members and/or decking are installed to meet UL and building code requirements. Coordinate with metal roof system manufacturer to ensure that any reduced clip spacing at eave, rake, ridge and corner areas are accommodated.

D. Discrepancies: In event of discrepancy, notify the Architect and Owner. Do not proceed with installation until discrepancies have been resolved.

3.02 INSTALLATION

A. General:
   1. Install metal roof system so that it is weathertight, without waves, warps, buckles, fastening stresses or distortion, allowing for expansion and contraction.
   2. Install metal roof system in accordance with manufacturer's instructions and shop drawings.
   3. Provide concealed anchors at all panel attachment locations.
   4. Install panels plumb, level and straight with seams and ribs parallel, conforming to design as indicated. Align panels straight and perpendicular to roof eaves and ridges.
   5. Lay out battens equidistant from corners or ends.
   6. Lay out battens so they meet each other at hips and ridges.
   7. Provide panels and battens in one-piece lengths from eaves to ridges.

B. Underlayment: Install in accordance with manufacturer’s recommendations. Lap sides 3-12-inches minimum, and ends 6 inches minimum.

C. Hold-Down Clips: Anchor panel hold-down clips to deck with screws. Space clips 36 inches on centers maximum.

D. Fasteners: Conceal all fasteners wherever possible. Provide fiber washers under heads of exposed screws.

E. If not applied by factory, provide a continuous strip of sealant tape or a bead of sealant on each upstanding panel leg prior to installing battens.

F. Seamless Rainwater Gutters and Rainwater Downspouts:
   1. Install gutters along roof edge using stainless steel fasteners. Seal joints in accordance with manufacturer's recommendations.
   2. Install rainwater downspouts 3 inches square minimum with all related fittings. Connect downspouts to rain gutters where shown using special gutter fittings with downspout sleeve. Seal all joints. Attach to building with matching prefinished straps and stainless-steel fasteners.

G. Flashing: Provide flashing at all pipes and penetrations through roof. Provide flashing at vertical surfaces adjoining the roof. Install flashing as shown detailed. If not detailed, do work equal to that shown in the SMACNA Architectural Sheet Metal manual to obtain a weathertight and watertight installation.
   1. Roof penetrations shall be located between standing seams.
   2. Penetrations that require flashing to extend beyond a standing seam shall lap the seam a minimum of 4 inches and follow SMACNA Figure 112, Al.
   3. Penetrations larger than the metal panel width shall be centered on a panel and use a curb system similar to SMACNA Figure 113.

H. Accessories: Provide ribs, cleats, stiffeners, sleeves, hangers, and other reinforcements required to make sections rigid and substantial in the same metal as roofing system.

I. Sealant: Apply sealant to concealed lap joints and at other locations as required for a watertight installation.

J. Finish Repair:
   1. Touch up scratches and small blemishes with compatible finish material.
   2. Replace items that are dented, creased, bent, or rusted with new sound items.

3.03 CLEANING AND PROTECTION

A. Dispose of excess materials and remove debris from site.

B. Clean work in accordance with manufacturer's recommendations.

C. Protect work against damage until final acceptance. Replace or repair to the satisfaction of the Architect and Owner, any work that becomes damaged prior to final acceptance.

D. Touch up minor scratches and abrasions with touch up paint supplied by the metal roof system manufacturer.

E. Do not allow panels or trim to come in contact with dissimilar metals such as copper, lead or graphite. Water run-off from these materials is also prohibited.

END OF SECTION

SECTION 07600

FLASHING AND SHEET METAL

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Galvanized steel sheet metal flashing, counterflashing, copings, expansion joints, and all other sheet metal work not covered in other sections.

1.02 REFERENCES

A. "Architectural Sheet Metal Standards" by Sheet Metal and Air Conditioning Contractors National Association (SMACNA), latest edition.

B. ASTM International (ASTM):
   1. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
   2. A924 - Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process

C. International Code Council (ICC):
   1. 2019 Oregon Structural Specialty Code (OSSC)

1.03 SUBMITTALS

A. Product Data: Fully describe all manufactured items to be furnished.

B. Shop Drawings: Show all custom-fabricated items clearly illustrating the design, dimensions, materials, methods of construction and installation of each piece of work.

C. Manufacturers' Instructions: For manufactured items.

1.04 QUALITY ASSURANCE

A. Comply with the adopted edition of the 2019 Oregon Structural Specialty Code (OSSC), especially Chapters 14, 15 and 25.

B. Where specific details are not provided comply with applicable details in the SMACNA Architectural Sheet Metal Standards.

C. Except where otherwise indicated, comply with minimum thickness or gage requirements as specified in SMACNA Architectural Sheet Metal Manual.

1.05 PRODUCT DELIVERY, STORAGE AND HANDLING

A. For unpainted items, deliver all items to the job site, allowing time for field priming and incorporation into work of other trades.

B. Store materials under dry conditions and protect from moisture and physical damage.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Sheet Steel: Copper bearing, 26-gauge or heavier where noted; hot dip galvanized complying with ASTM A653 and A924, G90 Commercial Class 1.25 ounce per square foot, mill phosphatized for maximum paint adherence.
   1. Pre-finished metals to have factory finish (Kynar 500 or equal), 24 gauge minimum, color as selected from manufacturer's full range of standard, premium and custom colors.

B. Fasteners:
   1. To Concrete Masonry Units: Deformed steel wedge pins driven into lead expansion shields; RAWL, Tapcon, or equal.
   2. To Wood Nailers and Sills: Pan head, noncorrosive, sheet metal screws.
   3. Component Fasteners: Self-drilling/self-tapping, stainless steel screws, type S-12, Buildex TEKS; Fastenal; or equal.
   4. Screw heads shall be furnished with neoprene washers.

C. Sealant: Polyurethane sealant type as specified in Section 07900. Where specified sealant is incompatible with other adjacent sealants, Contractor shall submit a sealant suitable for intended use and of equivalent life expectancy.

D. Isolating Material: Alkali-resistant bituminous paint or varnish.

E. Flashing for Vent Pipes, Conduits, Etc.: Provide round base, UV-resistant pipe flashing in diameter sized to penetration. Include aluminum insert to conform to panel configuration and/or roof pitch. Flashing to be black in color.

2.02 FABRICATION

A. Before fabrication, take field measurements, ascertain existing field conditions and have discrepancies corrected before proceeding with sheet metal work.

B. Fabricate sheet metal items in the shop to the greatest extent possible. Fabricate using techniques and methods described in the SMACNA Architectural Sheet Metal Standards.

C. Make sections uniform with true, straight breaks, accurately fitted and rigidly secured. Provide overlapping tabs for soldered joints. Fabricate items in maximum lengths.

D. Provide accessories necessary to complete installation. Provide ribs, cleats, stiffeners, sleeves, hangers and other reinforcements required to make sections rigid and substantial, in same metal as basic unit.

E. Miter corner joints and reinforce with extended tabs or backing plates.

F. Lap expansion joints at least 4 inches and seal with polyurethane sealant, type “B”.

PART 3 - EXECUTION

3.01 INSPECTION

A. Examine surfaces to receive sheet metal work for defects that will adversely affect the execution and quality of the work.

B. Do not start work until all unsatisfactory conditions are corrected.

C. Ensure that all wood nailers have been properly installed.

D. Ensure that all galvanized sheet metal items are prime coat painted on all concealed and exposed surfaces, under Section 09900, before installation.

3.02 WORKMANSHIP

A. All work shall be watertight and shall drain properly.

B. Make proper allowance for expansion and contraction of the metals and of the materials to which they are fastened.

C. Form work accurately to sizes, shapes, and dimensions indicated or necessary, with angles and lines in true alignment, straight and sharp; miters and joints accurately fitted.

D. Erect work plumb, level and in proper plane, without bulges, or waves. Fit metal closely and neatly to cores or framework. Cope or flange intersections to fit accurately. Reinforce heavily loaded joints with screws or rivets. Corners shall be reinforced, and seams made waterproof. Exposed work shall be free of dents and other defects. Edges of sheet metal shall be hemmed.

E. Set items in sealant or plastic cement as shown or noted; or when such application is necessary to provide a watertight job.

F. Provide isolation between dissimilar metals or other materials with sealant, butyl tape, bituminous paint or asphalt saturated felt. Provide waterproof neoprene washers wherever fasteners penetrate sheet metal. Exposed fasteners will not be permitted for any portion of this work.

G. Perform sealant work in conformance with the requirements of Section 07900.

3.03 FLASHING

A. Install all Flashings as required to provide watertight protection.

B. Lap all seams in direction of water flow.

C. Carry Flashings around corners at least 4 inches.

D. Lap joints 4 inches minimum. Apply sealant to the overlapping surfaces of the joints. Beads of sealant which will be concealed in the finished work shall be continuous with no voids of material.

3.04 INSTALLATION

A. Provide sill and head Flashing at all louvers, doors and windows as shown and as required for a watertight installation. Furnish in the same metal as the louver.

B. Provide Flashing where shown and where required for a watertight installation.

3.05 CLEANUP

A. Clean all finished surfaces, removing all excess sealant, etc. Wash down all work with soap and hot water, flush with clean water, and wipe dry.

B. Repair or replace all damaged or defective areas to ensure watertightness and neat appearance.

END OF SECTION

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. ASTM International (ASTM):
   1. C920 Standard Specification for Elastomeric Joint Sealants

B. International Code Council (ICC):
   1. 2019 Oregon Structural Specialty Code (OSSC)

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 Oregon Structural Specialty Code (OSSC), 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 ASTM C920, 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.
   3. For Wood: Sand or scrape.

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 08110

HOLLOW METAL WORK

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: All hollow metal work including doors and frames.

1.02 REFERENCES

A. American Nation Standards Institute (ANSI):
   1. ANSI A250.4 Test Procedure and Acceptance Criteria for Physical Endurance for Steel Doors, Frames and Frame Anchors
   2. ANSI A250.8 Specifications for Standard Steel Doors and Frames

B. ASTM International (ASTM):
   1. ASTM A1008 Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
   2. ASTM A653 Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
   3. ASTM A1011 Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
   4. ASTM E283 Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen

C. International Code Council
   1. 2019 Oregon Structural Specialty Code (OSSC).

D. National Association of Architectural Metal Manufacturer's (NAAMM) "Guide Specification for Commercial Laminated Core Hollow Metal Doors and Frames, HMMA 867-16.

E. Steel Door Institute (SDI):
   1. ANSI/SDI A250.4 Standard Test Procedure and Acceptance Criteria for Physical Endurance for Steel Doors, Frames and Frame Anchors.

F. UL LLC (UL):
   1. UL 1784 Standard for Air Leakage Tests of Door Assemblies and Other Opening Protectives

1.03 SUBMITTALS

A. Product Data: Fully describe all products proposed for use. Include data and details on door construction including internal reinforcement and door edge construction.

B. Shop Drawings: Submit custom prepared project-specific shop drawings showing dimensions and details. Include a schedule showing locations of doors and frames complete with listing of types and styles. Field measure before ordering. Provide frames with throat opening size required by field conditions regardless of size shown on drawings. Review of door frame submittal DOES NOT include review of throat opening dimension for compatibility with field requirements or Contract Documents.

C. Manufacturers' Certificates of Compliance: Before delivery of doors, frames, and accessories, submit certificates from the manufacturer attesting that doors, frames and accessories meet the requirements of the referenced standards.

1.04 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Comply with the following:
      a. 2019 Oregon Structural Specialty Code (OSSC).

1.05 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Inspect doors, frames, and accessories delivered to the site for damage. Unload and store with a minimum of handling. During delivery, strap door frames of welded unit construction together in pairs with the head of one frame inverted for bracing. Replace doors and frames damaged during delivery.

B. Provide a bottom spreader bar tack welded to frames to maintain jamb alignment until frames are installed.

C. Storage: Store doors and frames carefully on platforms under cover in dry and accessible locations, which are adequately ventilated and free from dust or water and which permit easy access for inspection and handling. Avoid the use of non-vented plastic or canvas shelters that create a humidity chamber.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Acceptable manufacturers include Forderer Hollow Metal Products; Republic; Steelcraft; or equal.

2.02 MANUFACTURED UNITS

A. Frames, Galvannealed:
   1. Fabricate from carbon steel sheet that has been coated by a continuous hot-dip process and further treated to convert the zinc coating into a zinc-iron alloy meeting ASTM A653 A60.

2. Minimum zinc coating: 0.60 total both sides ounces per square foot of metal surface.
3. Metal thickness: .067 in. or heavier where noted.

B. Doors, Galvannealed:
1. Fabricate face sheets and edge channels from carbon steel sheet that has been coated by a continuous hot-dip process and further treated to convert the zinc coating into a zinc-iron alloy meeting ASTM A653 A60 or A1008 commercial class 0.60.
2. Minimum Zinc Coating: 0.60 ounces per square foot of metal surface.
3. Metal Thickness: .053 in. or heavier where noted.

C. Jamb Anchors:
1. Provide the number of anchors required by the fire rating but not less than the following number for each jamb.
   a. Frames up to 7'-6" high, three anchors.
   b. Frames 7'-6" to 8'-0" high, four anchors.
   c. Frames over 8'-0" high, four anchors plus one additional anchor for each 2 feet or fraction thereof above 8 feet.
   d. Provide head anchors at 2-foot centers for openings wider than 3 feet.
2. Frames in Masonry Walls: Provide adjustable tee strap, jamb anchors. Metal thickness: .053 in. minimum.
3. Provide special anchors when specified or detailed.

D. Floor Anchors: 0.053 in. minimum thickness, welded to frame at each jamb or mullion, punch for two 3/8-inch-diameter anchor bolts. Additional jamb anchors do not waive the requirement for floor anchors.

2.03 FABRICATION

A. General: Fabricate in the shop. Accurately fit all work and fabricate in a manner to produce smooth, even surfaces free from warp, wave, buckle and other defects. Make square corners and angles unless shown otherwise on the Drawings. Set members in proper alignment, with edges straight and clean. Make provisions for hardware at locations in accordance with prevailing accepted standards, and as shown on the Drawings.

B. Galvannealed Doors and Frames, Where Required: All exterior doors and frames shall be galvannealed. All other doors and components noted, specified or scheduled "Galvanized" shall be galvannealed.

C. Preparation for Hardware: Make to hardware templates and physical hardware. Locate center of panic hardware pushbars, door knobs, and lever handles 38 inches above the floor. Locations shall be coordinated between frames and doors, as shown on the Drawings, and all applicable accessibility and other code requirements. Punch stops of all frames for silencers, three in latching stop for single doors, two in head of double door frames.

D. Frames: Fully welded, seamless construction with no visible seams or joints, strong, rigid and constructed so as not to bind, sag, twist or otherwise fail in use. Provide frames with throat opening dimension required to meet field requirements regardless of throat size shown.
1. Frame members: Form each frame member from one piece of sheet steel.

2. Joints: Miter corner joints, including integral stops, reinforce and weld continuously full length of joint. Fit other joints neatly and weld continuously full length of joint.
3. Jamb anchors: Weld to inside jamb.
4. Floor anchors: Weld to bottom of door frame jambs.
5. Spreaders: Connect removable steel channel spreader ties across bottoms of welded door frames to hold rigid during shipping and until they are secured in place in the work.
6. Hardware reinforcing: Weld in place, comply with NAAMM HMMA 867-16 standards. Shop drill and tap for template hardware. Field-drill and tap for surface mounted hardware.
    a. Templates: Obtain from finish hardware manufacturer.
    b. Hinges: 7-gauge steel, 1-1/4 inches wide by not less than 10 inches long. Prepare for full mortise hinges.
    c. Strikes: 12-gauge steel, 1-1/2 inches wide with minimum lap of 2 inches beyond cutout.
    d. Closers: 12-gauge steel, length to accommodate closer. Provide reinforcing at two locations on each frame for installation of either regular or parallel arm closers, whether or not closers are scheduled.
    e. Plaster guards: 24-gauge steel, provide at strike and hinge reinforcing.
    f. Flush bolts: 12-gauge steel.
7. At exterior locations and where noted, provide shop welded 0.53 in. galvanized steel rain hood at head of door frame.

E. Doors:
1. Type: SDI Type III, extra heavy duty, fully welded style 2 full flush hollow steel construction for interior doors and exterior doors. Doors shall have no visible joints or seams on exposed faces and vertical edges.
2. Top and bottom rails: .053 in. channel; fully flush design, continuous welded to face sheets.
3. Face sheet (or face panel) reinforcing shall meet the requirements of ANSI A250.4 for twist strength. The following methods are acceptable:
    a. Continuous vertical stiffeners of not lighter than .026 in. steel, spaced not to exceed 6 inches on centers and spot welded to both face sheets at intervals not greater than 6 inches. Fill all voids with insulation.
    b. An inner grid system consisting of vertical and horizontal members of not lighter than .042 in. steel, welded or interlocked for maximum strength and spaced not to exceed an average of 12 inches in either direction, and spot welded to both face sheets at intervals not greater than 6 inches. Fill all voids with insulation.
    c. A continuous formed sheet steel truss core, full height and width, spot welded to face sheet at intervals not greater than 6 inches in both directions. Fill all voids with insulation.
    d. Doors required to have a maximum temperature rise on the protected side shall have insulating cores as required to achieve the specified performance.
4. Edge profile: Bevel vertical edges of stiles 1/8-inch in 2 inches.
5. Door thickness: 1-3/4 inches or thicker as noted.

6. Clearances: 3/32-inch clearance at jambs and head and 3/8-inch clearance at bottom; 1/4-inch clear between door and threshold where threshold occurs. Provide required clearance between door and stop to accommodate smoke gasket.
7. Exterior doors: Provide a watertight flush closing channel at the top edge. Provide weep holes in the bottom closure to permit escape of entrapped moisture.
8. Door cutouts: Cut outs for door openings shall be spaced at least the distance away from door edges or recesses for hardware that is required to maintain door fire rating and guarantee. All cut outs shall be made in the shop fabricating the doors.
9. Hardware reinforcing: Comply with NAAMM HMMA 867-16 Standards. Shop drill and tap for template hardware. For surface mounted hardware, drill and tap in the field.
    a. Hinge: .167 in.
    b. Lockset: .093 in.
    c. Flush bolt: .093 in.
    d. Closer: .152 in.
10. Provide reinforcement for closers both sides of all interior doors whether closers are scheduled or not.

2.04 FINISHES

A. Refer to Section 09900 for surface preparation, pretreatment, primers, and application techniques.

B. Apply one shop coat of rust inhibiting primer to all ferrous metal not scheduled to be galvanized.

C. Galvanized work is to be prepared and field prime painted coat and finish coat painted under Section 09900. DO NOT SHOP-PRIME GALVANIZED WORK.

2.05 GALVANIZING REPAIR

A. Repair damaged galvanizing by heated substrate repair method. Repair materials shall be Galv Bar as manufactured by US Alloy Company; or Gal-Viz as manufactured by The Harris Products Group; or equal.
    1. Heat substrate to 600°F, or apply hot process touch-up material right after welding before metal has cooled below 600°F.
    2. 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.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Frames: Set accurately in position, plumbed, aligned and braced securely until permanent anchors are set. Anchor bottom of frames securely to floors. Secure wall anchors to adjoining construction as indicated or required.

B. Hanging Doors: Set accurately, snug against all stops and free from hinge bind. If shimming is required use sheet brass shims. Install hardware and weatherstripping. Adjust closing and latching speed of door closers for smooth operation, self-closing and automatic positive latching. Fasten with matching machine screws or bolts at all points where fasteners are indicated or required. Leave hardware in perfect working order. Clean and polish.

C. Remove locksets, kickplates, etc. for field painting of doors. Replace hardware after painting work is completed.

D. Repair damaged galvanizing by the heated substrate repair method using galvanized touch-up material specified in Part 2 of this Section.

END OF SECTION

SECTION 08330

OVERHEAD COILING DOORS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Section Includes: Power-operated insulated overhead coiling doors with factory finish.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A123 Standard Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products
   2. A653 Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
   3. E84 Standard Test Method for Surface Burning Characteristics of Building Materials
   4. E90 Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements

B. International Code Council
   1. 2019 Oregon Structural Specialty Code (OSSC).

C. National Electrical Manufacturer Association (NEMA):
   1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
   2. NEMA MG 1 - Motors and Generators.

D. UL LLC (UL):
   1. UL 325 - Standard for Door, Drapery, Gate, Louver, and Window Operators and Systems
   2. UL 1784 - Standard for Air Leakage Tests of Door Assemblies and Other Opening Protectives

1.03 SUBMITTALS

1. Product Data: Describe every product or item proposed for use:
   a. Preparation instructions and recommendations.
   b. Storage and handling requirements and recommendations.
   c. Details of construction and fabrication.
   d. Installation methods.
2. Shop Drawings: Prepare especially for the project, showing elevations at ¼ inch = 1'-0" and details at 3 inch = 1'-0", or larger if necessary for clarity. Field measure openings and verify clearance prior to preparing shop drawings. Show connections to adjacent construction. Show electrical details.
3. Samples: Full range of manufacturer's colors (including custom colors) for Factory Finish.

4. Manufacturer's Certificates: Certify products meet or exceed specified requirements.
5. Operation and Maintenance Data: Submit lubrication requirements and frequency, and periodic adjustments required.

1.04 QUALITY ASSURANCE

A. Qualifications:
   1. Provide overhead coiling doors manufactured by a firm specializing in overhead coiling industrial doors with a minimum of five (5) years' experience.
   2. Install door using a Specialty Contractor, with a minimum of five (5) years' experience, engaged exclusively in providing and installing overhead coiling and other industrial doors and who is approved by the door manufacturer.

B. Regulatory Requirements:
   1. Comply with the following:
      a. Applicable Federal and State Occupational Safety and Health Regulations (OSHA)
      b. 2019 Oregon Structural Specialty Code (OSSC).

1.05 DELIVERY, STORAGE, AND HANDLING

A. Store products in manufacturer's unopened packaging until ready for installation.

B. Protect materials from exposure to moisture. Do not deliver until after wet work is complete and dry.

C. Store materials in a dry, warm, ventilated weathertight location.

1.06 PROJECT CONDITIONS

A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

1.07 COORDINATION

A. Coordinate Work with other operations and installation of adjacent materials to avoid damage to installed materials.

1.08 WARRANTY

A. Manufacturer's Warranty: Provide manufacturer's two-year limited warranty. System warranty of all parts and components of the system except counterbalance spring and finish for 3 years or 20,000 cycles, whichever comes first.

PART 2 - PRODUCTS

2.01 POWER-OPERATED OVERHEAD COILING DOOR

A. Acceptable Manufacturers: Manual-operated door as manufactured by the Cookson Company, equivalent by Overhead Door Corporation; or equal.

B. Construction and Features:
1. Galvanized coating: Hot-dip galvanized steel components. Hot-dip galvanize sheet steel thinner than 1/8-inch with a zinc coating of at least 1.25 ounce per square foot in accordance with ASTM A653. Hot-dip galvanized steel 1/8-inch thick and heavier in accordance with ASTM A123.
2. Curtain: Double skin interlocking roll formed interior and exterior metal slats filled with 7/8-inch-thick closed cell pressure foamed in place urethane insulation with a Flame Spread Index of 0 and a Smoke Developed Index of 10 as tested per ASTM E84. Curtain assembly materials to meet the foam plastic insulation requirements of the 2019 OSSC. Slat to have an R value of 8.0 as calculated using the ASHRAE Handbook of Fundamentals. Sound Transmission Class (STC) rating to be minimum 30 for the curtain and up to 22 for the entire assembly, as tested per ASTM E90. Fabricate interlocking slats from not less than 18-gauge galvanized copper bearing strip steel in a flat face pattern, No. 4 slat by Cookson Company; equivalent by Overhead Door Corporation; or equal. Reinforce bottom slat with two structural steel angles, minimum 1/8-inch thickness, back-to-back. Design door to withstand wind load of 20 pounds per square foot. Support load of barrel and curtain by two grease-sealed ball bearings.
3. Guides: Fabricate from hot-rolled structural steel angles bolted with 3/8 inch-diameter bolts to form a slot of sufficient depth to retain curtain in guides during periods of heavy wind pressure. Make wall angles continuous. Flare the top of each guide to facilitate entry of curtain and cast-iron stops. Provide galvanized steel bolts, anchor bolts, nuts, and washers. Galvanize guides and remove any bumps on curtain contact surfaces.
4. Brackets: Fabricate from steel plate of not less than 5/16-inch thickness. Bolt brackets to wall angle with a minimum of two 1/2-inch-diameter bolts.
5. Hood: Fabricate from one piece of 24-gauge galvanized steel sheet. Form to fit curvature of brackets with sufficient beads or flanges to prevent deflection. Provide a neoprene wind baffle in constant contact with the full width of the curtain coil.
6. Windlocks: Provide wind locks at both ends of alternating slats to prevent pull out of slats from side guides.
7. Gears: Cast iron with teeth cast from machine cut patterns. Provide not less than 3-inch pitch diameter for pinion gears. Design gear ratio for a maximum manual effort of not more than 35 pounds.
8. Provide galvanized chain operator with provisions for padlocking chain operator 4 feet above the floor.
9. Barrel: Fabricate from steel tubing not less than 4 inches in diameter, designed to limit maximum deflection to 0.03-inch per foot of span. Provide oil-tempered torsion springs capable of correctly counterbalancing the weight of the curtain. Provide adjustable springs by means of an exterior wheel.

10. Weatherstrip at side guides to properly seal door perimeter without affecting ease of operation. Provide flexible neoprene strip at door bottom.

C. Factory Finish: The finish on the door curtain, guides, hood and bottom bar shall be factory applied coating; Cookson ColorCote or equal consisting of the following:
   1. Hot dipped galvanized G-90 coating consistent with ASTM A-653
   2. Bonderized coating for prime coat adhesion
   3. Factory applied thermosetting powder coating applied with a minimum thickness of 2 mils. The color shall be selected by the Owner and shall be chosen from manufacturer's full-range (standard and custom) of color charts.

D. Motor Operating Equipment:
   1. Provide all equipment required for completely automatic operation from remote control station(s). Include the following features:
      a. Integral power unit: Include motor, motor starter, limit switches, gear unit, disc brake, and hand chain operator. Provide NEMA Type 4X enclosures for electrical controls.
      b. Motor: Totally enclosed squirrel cage motor rated at 120V, 60 hertz, horsepower required by size of door (horsepower size to be assumed to be 1 horsepower or less). Mount motor so it is removable without affecting the chain operator or limit switch adjustments.
      c. Motor starter: Reversing magnetic starter with three overload relays and sized to suit the motor.
      d. Reversing Safety Edge: Provide safety feature at foot piece astragal consisting of a vinyl or neoprene loop-type seal on 1/8-inch thick (min.) steel bottom bar, with Cookson "Featheredge"; or equal safety device that uses air waves to detect an object in its path and reverse direction of travel if door contacts an obstruction during the closing cycle.
      e. Brake: Disc brake, self-adjusting, removable without affecting chain operator or limit switch setting.
      f. Hand-chain operator: For emergency use, provide electrical interlock. Configure so operation by hand chain does not affect the timing of the limit switch. Provide for padlocking of operator chain to lock curtain in closed position only.
      g. Limit switch: Geared limit switch to set open and close positions and prevent over-travel.
      h. Gear unit: Fully enclosed and operating in an oil bath.
      i. Capacity: Provide a power unit that has the capacity to raise and lower roll-up door at the rate of 2/3-foot per second.
      j. Control Station, each door: One 3-position pushbutton station marked "Open," "Close," and "Stop." Wire "Close" position for constant pressure operation. Door closing motion will automatically stop when pushbutton is released.
      k. Wiring: All shall be factory prewired electrical connections to the extent permitted by local codes.
      l. Provide an integral power unit approved and listed by UL LLC.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install doors using manufacturer's trained and authorized specialist.

B. Install, adjust, and test doors in accordance with manufacturer's printed instructions.

C. Attach guides to concrete walls with machine bolts in concrete anchors. Attach guides to steel construction using drilled and tapped machine bolts. Use anchorage devices to securely fasten assembly to wall construction and building framing without distortion or stress. Securely and rigidly brace components suspended from structure. Secure guides to structural members only. Fit and align assembly including hardware; level and plumb, to provide smooth operation.

D. Seal bottom of door guides to the floor to prevent water and wind leakage at base of door guides.

E. Coordinate work with electrical and other trades.

3.02 CLEANING

A. Clean curtain and components using non-abrasive materials and methods recommended by manufacturer.

B. Remove labels and visible markings.

C. Touch-up, repair or replace damaged products before Substantial Completion.

3.03 PROTECTION

A. Protect installed products until completion of project.

END OF SECTION

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SECTION 08700

FINISH HARDWARE

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Furnish and install all commercial finish hardware.
   2. Door hardware includes, but is not necessarily limited to, the following:
      a. Mechanical door hardware.
   3. Coordination, preparation, and installation of Finish Hardware by a certified Architectural Hardware Consultant (AHC).

1.02 REFERENCES

A. American National Standards Institute (ANSI) and Builders Hardware Manufacturer's Association (BHMA) Product standards for all specified items:
   1. A156.1 Butts and Hinges
   2. A156.2 Bored and Preassembled Locks and Latches
   3. A156.3 Exit Devices
   4. A156.4 Door Controls-Closers
   5. A156.5 Auxiliary Locks and Associated Products
   6. A156.6 Architectural Door Trim
   7. A156.7 Template Hinge Dimensions.
   8. A156.8 Door Controls-Overhead Holders
   9. A156.13 Mortise Locks and Latches
   10. A156.15 Closer Holder Release Devices
   11. A156.16 Auxiliary Hardware
   12. A156.18 Materials and Finishes

B. Americans with Disabilities Act (ADA):
   1. 2010 ADA Standards for Accessible Design

C. Door and Hardware Institute (DHI):
   1. Basic Architectural Hardware
   2. Abbreviations and Symbols

D. UL LLC:
   1. UL 10B Fire Tests of Door Assemblies
   2. UL 10C Standard for Positive Pressure Fire Tests of Door Assemblies
   3. UL 305 Panic Hardware
   4. UL 1784 Standard for Air Leakage Tests of Door Assemblies and Other Opening Protectives

E. National Fire Protection Association:
   1. NFPA 80 Standard for Fire Doors, Fire Windows
   2. NFPA 105 Standard for Smoke Door Assemblies and Other Opening Protectives
   3. NFPA 252 Standard Methods of Fire Tests of Door Assemblies

1.03 SUBMITTALS

A. Product Data: Fully describe every product proposed for use. Clearly identify substitutions or changes, as a result of coordinating hardware components.

B. Shop Drawings: Submit hardware list and schedule prepared by a certified Architectural Hardware Consultant in accordance with DHI recommendations. The Owner's review of schedule shall neither be construed as a complete check nor shall it relieve the Contractor of responsibility for errors, deviations, or omissions from the specified requirements to provide complete door hardware for the Project. Organize the hardware list and schedule in the same order as the Door Hardware Schedule at the end of Part 3 of this specification Section. Include the following information:
   1. Type, style, function, size, label, hand, and finish of each door hardware item.
   2. Manufacturer of each item.
   3. Fastenings and other pertinent information.
   4. Location of each door hardware set; cross-referenced to the Door Hardware Schedule.
   5. Explanation of abbreviations, symbols, and codes used in the schedule.
   6. Mounting locations for door hardware. Supply templates to door and frame manufacturers to enable proper and accurate sizing and locations of cutouts for hardware.
   7. Manufacturer's Instructions: For mounting, installing and adjusting hardware. Installation instructions shall be available at jobsite during construction for reference.
   8. Door and frame sizes, materials, hand, and door rating.
   9. Description of electrified door hardware sequences of operation and interfaces with other building control systems.

C. Door Hardware Schedule: Prepared by or under the supervision of Installer, detailing fabrication and assembly of door hardware, as well as installation procedures and diagrams. Coordinate final door hardware schedule with doors, frames, and related work to ensure proper size, thickness, hand, function, and finish of door hardware.

D. Keying Schedule: Contact Owner representative for information regarding Owner's keyway system. Prepared under the supervision of the Owner, separate schedule detailing final keying instructions for locksets and cylinders in writing. Include keying system explanation, door numbers, key set symbols, hardware set numbers and special instructions. Owner to approve submitted keying schedule prior to the ordering of permanent cylinders.

E. Warranties: Submit special warranties as specified in this Section.

F. Maintenance Tools and Instructions: Furnish a complete set of specialized tools and maintenance instructions for the Owner's continued adjustment, maintenance, removal and replacement of door hardware. For each type of door hardware to include in maintenance manuals

G. Product Test Reports:
   1. For compliance with accessibility requirements, based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency, for door hardware on doors located in accessible routes.

2. Indicating compliance with cycle testing requirements, based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified independent testing agency.

H. Operating And Maintenance Manuals: Provide manufacturers operating and maintenance manuals for each item comprising the complete door hardware installation in quantity as required in Division 01, Closeout Submittals. The manual to include the name, address, and contact information of the manufacturers providing the hardware and their nearest service representatives. Include final hardware and keying schedule. The final copies delivered after completion of the installation test to include "as built" modifications made during installation, checkout, and acceptance.

1.04 QUALITY ASSURANCE

A. Hardware Supplier:
1. Engaged in supplying builder’s hardware for commercial projects of similar nature and comparable size for at least 5 years.
2. Has a full-time certified Architectural Hardware Consultant (AHC) on staff that will prepare the hardware submittal and supervise installation of all finish hardware.

B. Architectural Hardware Consultant (AHC) Qualifications: A person who is experienced in providing consulting services for door hardware installations that are comparable in material, design, and extent to that indicated for this Project and who is currently certified by DHI as follows:
1. For door hardware, an Architectural Openings Consultant (AOC).

C. Perform Work in accordance with the following requirements:
1. ANSI/BHMA A156 Series
2. NFPA 80
3. UL 305

D. Regulatory Requirements:
1. 2019 Oregon Structural Specialty Code (OSSC), shall be used as the primary regulatory requirement for access individuals with disabilities. Federal and other State disabled access requirements shall be followed for conditions not regulated by the CBC.
2. 2010 ADA Standards for Accessible Design.
3. UL LLC requirements for fire-rated assemblies.

E. Source Limitations: Obtain each type and variety of Door Hardware specified from a single source and qualified supplier unless otherwise indicated.

F. Means Of Egress Doors: Latches do not require more than 15 lbf to release the latch. Locks do not require use of a key, tool, or special knowledge for operation.

G. Keying Conference: Conduct conference at Project site. In addition to Owner and Contractor, conference participants shall also include Installer's Architectural Hardware Consultant and Owner's security consultant. Incorporate keying conference decisions into final keying schedule after reviewing door hardware keying system including, but not limited to, the following:

1. Function of building, flow of traffic, purpose of each area, degree of security required, and plans for future expansion.
2. Preliminary key system schematic diagram.
3. Requirements for key control system.
4. Requirements for access control.
5. Address for delivery of permanent keys, cores, access control credentials, software and related accessories.

1.05 SPECIAL WARRANTY

A. Door Hardware:
   1. Structural failures including excessive deflection, cracking, or breakage.
   2. Faulty operation of doors and door hardware.
   3. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.
   4. Electrical component defects and failures within the systems operation.

B. Standard Warranty Period: One year from date of Substantial Completion, unless otherwise indicated.
   1. Mortise Locks and Latches: 10 years
   2. Exit Devices: 5 years.
   3. Manual Closer: 10 years.

1.06 MAINTENANCE SERVICE

A. Maintenance and Instructions: Furnish a complete set of specialized tools and maintenance instructions as needed for Owner's continued adjustment, maintenance, and removal and replacement of door hardware.

1.07 DELIVERY

A. Deliver hardware with items for each opening packed together, complete and ready for installation with necessary fittings, trim, fasteners and accessories. Mark packages with opening number for identification.

B. Deliver permanent keys, cylinders, cores, and related accessories directly to Owner via registered mail or overnight package service. Instructions for delivery to the Owner shall be established at the Keying Conference. Deliver templates and installation instructions.

PART 2 - PRODUCTS

2.01 GENERAL

A. Provide hardware that complies with applicable building code requirements. Provide all hardware, smoke gaskets, and thresholds listed for a fire assembly of the required rating for all doors required to be fire rated.

B. Provide hardware that fits perfectly, is of uniform color, and is free of imperfections affecting serviceability or marring appearance.

C. Deliver hardware in a timely manner as required by the Contractor’s Schedule. Furnish materials or templates to others when required for factory installation or preparation.

D. Provide adequate functioning hardware for all doors whether scheduled or not.

E. Where the hardware manufacturer's product number specified does not provide hardware meeting fire codes, condition of use, function, hand, mounting conditions, strikes, stops, keepers or fasteners required for a satisfactory installation, provide items of equivalent quality or better meeting applicable project conditions.

F. Hardware shall be from one manufacturer for each item specified in Part 2.

G. Coordinate with the work of other trades in furnishing and placing finish hardware.

2.02 HARDWARE

A. Fasteners: Furnish all necessary screws, bolts or other fastenings of suitable size and type to anchor the hardware in position for heavy use and long life; provide fasteners that match the material and finish of the hardware. Where necessary, provide expansion shields, sex bolts, screws, or other anchors appropriate for substrate that the hardware is installed on. Provide machine screws and soft metal expansion shields to fasten hardware to concrete, masonry, plaster, and similar materials. Plastic or fiber inserts are not acceptable.

B. Finish: Provide all steel hardware with the following finish:
   1. US32D (630) satin stainless steel.
   2. Aluminum hardware shall be clear anodized unless otherwise noted.

C. Locksets:
   1. Cylindrical Locksets: BHMA A156.2 Heavy duty, with interior parts of stainless steel and other noncorrosive metals. Provide key-in-knob, 6-pin cylinders to match Owner's keyway. Schlage Series "C" with stainless steel mechanism with lever handle (lever shall be curved with a return to within ½ of the door), "Rhodes;" Corbin Russwin "CL3100;" or equal. Provide UL-rated latch bolts for fire-rated doors.
   2. Mortise Locksets: BHMA A156.13 Heavy duty, with 6-pin cylinder matching Owner's system. Schlage “L“ Series; Corbin 9700 Series; or equal. Provide lever handles (lever shall be curved with a return to within ½ of the door), Design: Schlage 03; Corbin ML2000 Series; or equal.
   3. Backset: 2¾ inches.
   4. Strikes: Furnish standard strikes with curved lip extended to protect trim from being marred by latch bolt. Provide dust boxes. Verify whether standard or ANSI cutouts are provided in metal frames.
   5. Cylinder Guards: Free-spinning, tapered, to prevent the forced unscrewing of the lock cylinder. Keedex or equal.

D. Keys and Keying:
   1. All keyed locksets and padlocks shall be supplied with interchangeable core cylinders to match the Owner’s interchangeable core and keying system.
   2. All cylinders shall be supplied with temporary construction cores for Contractor's use. Permanent cores shall be delivered directly to the Owner’s Representative.

3. Tag keys with location, and schedule heading number and deliver them to Owner upon completion of work. Deliver permanent keys directly to Owner.
4. Furnish construction keying. Provide construction master keyed cylinders or temporary keyed construction cores. Provide construction master keys in quantity as required by project Contractor. Replace construction cores with permanent cores. Furnish permanent cores for installation as directed under specified "Keying Conference". Deliver two extra keys directly to the Owner's Representative. Retain construction keys and cores for future lockout purposes. Padlocks:
5. Solid brass or stainless steel, with case hardened steel shackle, minimum 1-inch clearance, with 9-inch-long chain.
6. Keying: Interchangeable 6-pin cylinders matching Owner's keyway.

E. Hinges:
1. Butts, Full Mortised. Conform to ANSI/BHMA A156.1. Provide heavy weight, 5-knuckle ball bearing stainless steel butts for interior doors and heavy weight 5-knuckle stainless steel ball bearing butts for exterior doors.
2. Stanley FBB199 for interior doors, Stanley FBB199 for exterior doors, McKinney, or equal.
3. Provide non-removable pins for all exterior outswinging doors.
4. Unless otherwise specified, determine the size of the butts by the following table:
   a. Doors 1-¾-inch thick and up to 42-inch wide to have 4-½-inch.
   b. Doors 2-inch-thick, and 1-¾-inch doors over 42-inch wide to have 5-inch extra heavy.
5. Provide widths sufficient to clear trim projection when door swings 180 degrees.
6. Provide three (3) hinges to 90-inch high for each door leaf:
   a. Four (4) hinges to 120-inch high for each door leaf.
   b. Five (5) hinges to 150-inch high for each door leaf.
   c. Six (6) hinges to 180-inch high for each door leaf.

F. Closers: Provide heavy-duty door closers of one manufacturer; non-handed double arm, with metal covers full rack and pinion type ANSI/BHMA A156.4 Grade 1 with steel spring and non-gumming, non-freezing hydraulic fluid; non-sized adjustable for interior doors to 5 feet wide and exterior doors to 4 feet wide (cylinder sizes 1 through 6).
1. Provide controls for regulating closing, latching speeds and back check non-handed double arm. Provide all closers with a cushion stop built into closer arm that can be adjusted to stop door opening at a pre-set angle. Provide closers designed with spring power adjustment required for easy opening usable by the physically disabled; 8.5 pounds for exterior doors and 5 pounds for interior doors.
2. Provide parallel-arm closers at reverse bevel doors and where doors swing full 180 degrees.
3. Include all through bolts, mounting brackets, mounting plates, shoes, and accessories required for proper function and installation.
4. Furnish hold open arms when specified. Provide maximum degree of opening attainable consistent with closer function specified.

5. Provide plated finish on metal cover, arm, and fasteners.
    a. Acceptable Manufacturers:
        1) LCN 4111 Series or equal; plated finish.

G. Exit Devices, Touch bar type: Heavy-duty type UL listed for accident hazard and capable of meeting UL "A" label rating, rim latch or mortise design with 3/4-inch anti-friction latch bolt. Latch bolt shall retract when horizontal pressure is exerted on touch bar. Latch bolts on vertical rod devices shall remain retracted until door closes. Plate all exposed surfaces to match hardware finishes. Provide stainless steel touch bars, US32D finish.

H. Doorstop, Floor-Mounted: Stainless steel or solid brass plated to match hardware. Provide risers to increase height as required to suit conditions.

I. Doorstop, Wall-Mounted: Stainless steel or solid brass plated to match hardware. Furnish with durable high-grade shock-resistant rubber bumper.

J. Doorstop/Holder, Floor-or Wall-Mounted: Provide a strike with a hinged hook that fits flush with the strike when unit is acting as a stop only. The hook is manually lifted to engage the hold-open lug. When released, the hook drops back flush with the strike. Provide in stainless steel or solid brass finished or plated to match hardware. Note: UL requirements do not permit hold-open feature on fire-rated door assemblies.

K. Kickplates: All material shall be stainless steel, bronze or brass finished to match hardware, 0.050 gauge with beveled edges, 12 inch high x 1½ inch narrower than single door or 1 inch narrower than pairs of doors.

L. Thresholds: Furnish white or yellow bronze thresholds to match other door hardware unless noted otherwise. Anodized aluminum is not acceptable.

M. Silencers: Pneumatic rubber, installed in metal frame stops. Furnish three for single doors and two for pair of doors. Omit silencers where door seal occurs and for exterior doors.

N. Weatherstripping: Provide door seal at all exterior doors: 3/16 inch by 3/8 inch closed-cell PVC with adhesive back tape. Pemko 241; Reese; or equal.

O. Manual Flush Bolts: Provide concealed manual top and bottom flush bolts on the active leaf of pairs of doors. Provide bolts designed to be mounted in the edge of the door with concealed vertical rod activators, having a 5/8-inch throw and a 7/8-inch adjustment and a spring snap lever action. Provide dustproof strike for bottom flush bolt. Glynn-Johnson #FB-6 for metal doors.

P. Mortised Drop Bottom: Fully mortised, plunger activated, automatic drop bottom, extruded tempered aluminum, clear anodized finish, grey sponge neoprene inserts, stainless steel fasteners suitable for hollow metal doors. Pemko 434PKL; Reese; or equal. Door Shoe Sweep: L-Shaped Aluminum with neoprene sweep insert and integral rain drip. Pemko 216 A PK; Reese; or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General: The Contractor is responsible for the proper location, fit, and operation of all finish hardware items under the appropriate headings. Install finish hardware according to the Drawings, Specifications and finish hardware manufacturer's instruction. Place and adjust stops and or shim hinges to provide clearance for smoketight gaskets and to prevent doors from binding on stops or frames.
   1. Examine scheduled openings, with Installer present, for compliance with requirements for installation tolerances, labeled fire door assembly construction, wall and floor construction, and other conditions affecting performance.
   2. Notify the Engineer of any discrepancies or conflicts between the door schedule, door types, drawings, and scheduled hardware. Proceed only after unsatisfactory conditions have been corrected and such discrepancies or conflicts have been resolved in writing.

B. Make the right-hand door or right-hand reverse door the active leaf of a pair of doors, unless indicated otherwise.

C. Mounting Heights: Mount door hardware at the following heights unless specifically indicated otherwise on the Drawings.
   1. Locksets and latchsets: 38 inches above finish floor to center of lever.
   2. Deadbolts: Not more than 44 inches above finish floor to operating trim.
   3. Exit Devices: 40 inches above finish floor to center of touch bar.

D. Fitting: Properly cut, drill, shape, reinforce, and otherwise fabricate items upon which finish hardware is to be installed according to templates, physical hardware, and finish hardware manufacturer's instructions to ensure proper attachment and function.

E. Key Control System: Tag keys and place them on markers and hooks in key control system cabinet, as determined by final keying schedule.

F. Adjustment: Install all lock cylinders to accept keys with the teeth facing up. Adjust, shim, align all hardware to operate smoothly without binding or rubbing and so that self-closing and automatic closing doors will latch automatically.

G. Doorstops/Holders/Keepers, Cane Bolts:
   1. Where physical conditions do not permit installation of the specified doorstop, holder, or keeper without creating a tripping hazard, provide a suitable item of comparable quality that will perform the intended function and can be installed such as a wall-mounted or surface overhead door-mounted device.
   2. Locate doorstops, holders, and keepers so doors will be held open in the maximum open position.

3.02 ADJUSTING

A. Adjust and check each operating item of door hardware and each door to ensure proper operation and function of every hardware component. Replace hardware components that cannot be adjusted to operate as intended.

B. Adjust door closers to compensate for building pressures and operation of forced air mechanical equipment to comply with accessibility requirements.

C. Initial Adjustment: Adjust and check each operating item of door hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate as intended. Adjust door control devices to compensate for final operation of heating and ventilating equipment and to comply with referenced accessibility requirements.
   1. Door Closers: Adjust sweep period to comply with accessibility requirements and requirements of authorities having jurisdiction.

D. Occupancy Adjustment: Approximately 6 months after date of Substantial Completion, Installer's Architectural Hardware Consultant shall examine and readjust each item of door hardware, including adjusting operating forces, as necessary to ensure function of doors and door hardware.

E. Defective Installation: Appearance, installation, attachment, and operation of finish hardware shall be subject to review by the Owner. Hardware that is scratched, broken, dirty, improperly painted, binds, or fails to function shall be replaced.

3.03 CLEANING AND PROTECTION

A. Clean adjacent surfaces soiled by door hardware installation. Clean hardware components as necessary to restore proper finish.

B. Provide protection during subsequent work progress to maintain conditions that ensure door hardware is in perfect working order and without damage or deterioration at the time of Substantial Completion.

3.04 HARDWARE SCHEDULE

A. The Contractor is responsible for providing all finish hardware together with all components, accessories, and fasteners necessary for a complete and smooth operating installation.

B. The door hardware sets represent the design intent and direction of the Owner and Architect. They are a guideline only and should not be considered a detailed hardware schedule. Discrepancies, conflicting hardware, and missing items should be brought to the attention of the Architect with corrections made prior to the bidding process. Omitted items not included in a hardware set should be scheduled with the appropriate additional hardware required for proper application and functionality.

C. The supplier is responsible for handing and sizing all products as listed in the door hardware sets. Quantities listed are for each pair of doors, or for each single door.

D. Only one manufacturer per product may be used on the project.

E. Items in the following hardware schedule are referenced for standards of quality and utility.

Item	1st Manufacturer	2nd Manufacturer
Butts, hinges	Stanley	Hager, or equal
Lockset, latches, cylinders, padlocks	Schlage	Corbin
Closers	LCN	Sargent, or equal
Exit devices	Von Duprin	Sargent, or equal
Silencers, stops, holders	Glynn-Johnson	Builder's Brass, or equal
Flush bolts, strikes	Ives, Glynn-Johnson	Builder's Brass, or equal
Door Shoe with Drip, Automatic Door Bottom with drip	Pemko	Reese, or equal
Thresholds	Pemko	Reese, or equal

F. Schedule of Hardware Groups:

1. Hardware Group 1 (Doors 01)
   Each door shall have:
   1-1/2 pair butt hinges
   1 mortise lockset, ANSI function 09
   1 door closer
   1 kickplate
   1 door shoe with drip
   1 set weatherseal gasketing
   1 door stop/holder
   1 threshold

2. Hardware Group 2 (Doors 02)
   Each door shall have:
   1 padlock

END OF SECTION

SECTION 08925

INSULATED TRANSLUCENT PANELS

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes the insulated translucent sandwich panel system (for windborne debris resistance) and accessories, factory unitized, as shown and specified. Work includes providing and installing:
   1. Flat factory prefabricated structural insulated sandwich panels
   2. Aluminum installation system
   3. Aluminum sill flashing
   4. Translucent Polycarbonate Panels

1.02 REFERENCES

A. American Architectural Manufacturers Association (AAMA):
   1. AAMA 2605 Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels

B. American National Standards Institute (ANSI)

C. ASTM International (ASTM):
   1. ASTM C297 Standard Test Method for Flatwise Tensile Strength of Sandwich Constructions
   2. ASTM D1002 Standard Test Method for Apparent Shear Strength of Single-Lap-Joint Adhesively Bonded Metal Specimens by Tension Loading (Metal-to-Metal)
   3. ASTM D2244 Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
   4. ASTM E72 Standard Test Methods of Conducting Strength Tests of Panels for Building Construction
   5. ASTM E283 Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
   6. ASTM E330 Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference
   7. ASTM E331 Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference
   8. ASTM E1886 Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials

9. ASTM E1996 Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Windborne Debris in Hurricanes

D. International Code Council (ICC):
   1. ICC-ES: Evaluation Reports
   2. 2019 Oregon Structural Specialty Code (OSSC)

E. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA):
   1. Architectural Sheet Metal Manual

F. UL LLC (UL):
   1. UL 723 Standard for Test for Surface Burning Characteristics of Building Materials

1.03 SUBMITTALS

A. Submit manufacturer's product data. Include construction details, material descriptions, profiles and finishes of components. Product data to include Flame Spread, Impact Strength, Structural Performance, Insulation U-Factor.

B. Submit shop drawings. Include elevations and details.

C. Submit manufacturer's color charts showing the full range of colors available for factory-finished aluminum.
   1. When requested, submit samples for each exposed finish required, in same thickness and material indicated for the work.

D. Submit structural analysis data signed and sealed by the qualified professional engineer (licensed in the State where project is located) responsible for their preparation.

E. Submit Installer Certificate, signed by installer, certifying compliance with project qualification requirements.

F. Submit product reports indicating that each panel system complies with the project performance requirements.
   1. Reports required are:
      a. International Building Code Evaluation Report
      b. Water Penetration (ASTM E 331)
      c. 1200°F Fire Resistance (SWRI)
      d. ASTM E1886/1996.

1.04 QUALITY ASSURANCE

A. Manufacturer's Qualifications
   1. Material and products shall be manufactured by a company continuously and regularly employed in the manufacture of specified materials for a period of at least 10 consecutive years and which can show evidence of those materials being satisfactorily used on at least six projects of similar size, scope and location. At least three of the projects shall have been in successful use for 5 years or longer.
   2. Panel system must be listed by an ANSI accredited Evaluation Service, which requires quality control inspections and fire, structural and water infiltration testing of sandwich panel systems by an accredited agency.

B. Installer's Qualifications: Installation shall be by an experienced installer, which has been in the business of installing specified panel systems for at least 2 consecutive years and can show evidence of satisfactory completion of projects of similar size, scope and type.

1.05 PERFORMANCE REQUIREMENTS

A. The manufacturer shall be responsible for the configuration and fabrication of the complete unitized panel system.
   1. Standard panel system shall have less than 0.01 cfm/ft² air leakage by ASTM E283 at 6.24 PSF (50 mph) and no water penetration by ASTM E331 at 15 PSF; and structural testing by ASTM E330.
   2. Structural Loads; Provide system capable of handling the following loads:
      a. Positive Wind Load: 27 PSF (Ultimate)
      b. Negative Wind Load: 36 PSF (Ultimate)

1.06 DELIVERY STORAGE AND HANDLING

A. Deliver panel system, components, and materials in manufacturer's standard protective packaging.

B. Store panels on the long edge; several inches above the ground, blocked and under cover in accordance with manufacturer's storage and handling instructions.

1.07 WARRANTY

A. Submit manufacturer's and installer's written warranty agreeing to repair or replace panel system work, which fails in materials or workmanship within one year of the date of delivery. Failure of materials or workmanship shall include leakage, excessive deflection, deterioration of finish on metal in excess of normal weathering, defects in accessories, insulated translucent sandwich panels and other components of the work.

PART 2 - PRODUCTS

2.01 MANUFACTURER

A. Kalwall Corporation; Danpal; or equal. The basis for this specification is for products manufactured by Kalwall Corporation. Other manufacturers may bid this project provided they comply with all of the performance requirements of this specification and submit evidence thereof.

2.02 PANEL COMPONENTS

A. Face Sheets
   1. Translucent faces: Manufactured from polycarbonate thermoplastic resins, with ultraviolet stabilizers, formulated specifically for architectural use.
      a. Face sheets shall not vary more than ± 10% in thickness and be uniform in color.
      b. Face sheets shall not deform, deflect or drip when subjected to fire or flame.

2. Interior face sheets:
    a. Flame spread: UL LLC (UL) listed, with flame spread rating no greater than 50 and smoke developed no greater than 250 when tested in accordance with UL 723.
    b. Interior face sheets: Smooth .045 inch thick and white in color.
3. Exterior face sheets:
    a. Exterior face sheets: Smooth .052 inch Hi-impact (thick) and white in color.
    b. Color stability: Full thickness of the exterior face sheet shall not change color more than 3 CIE Units DELTA E by ASTM D2244 after 5 years outdoor weathering at 5° facing south, determined by the average of at least three white samples with and without a protective film or coating to ensure long-term color stability. Color stability shall be unaffected by abrasion or scratching
    c. Strength: Exterior face sheet shall be uniform in strength, with panel meeting ASTM E1996 and ASTM E1886.

B. Grid Core
1. I-beam Thermal break: Minimum 1 inch, thermoset fiberglass composite.
2. Laminate Adhesive:
    a. Heat and pressure resin type adhesive engineered for structural sandwich panel use, with minimum 25-years field use.
    b. Minimum tensile strength of 750 PSI when the panel assembly is tested by ASTM C297.
    c. Minimum shear strength of the panel adhesive when tested by ASTM D 1002.

2.03 PANEL CONSTRUCTION

A. Provide sandwich panels of flat polycarbonate translucent face sheets laminated to a grid core of mechanically interlocking I-beams. The adhesive bonding line shall be straight, cover the entire width of the I-beam and have a neat, sharp edge.
1. Thickness: 4 inch.
2. Light transmission: 30%
3. Panel U-factor by NFRC certified laboratory: 2¾ inch thermally broken grid min 0.52.
4. Complete insulated panel system shall have NFRC certified U-factor of 0.52.
5. Grid pattern: Nominal size to be equal spacing to accommodate varying custom openings. See also Drawings and field verify rough openings prior to fabrication.

B. Standard panels shall deflect no more than 1.9" at 30 PSF in 10' 0" span without a supporting frame by ASTM E72.

C. Standard panels shall withstand 1200°F fire for minimum one hour without collapse or exterior flaming.

2.04 BATTENS AND PERIMETER CLOSURE SYSTEM

A. Closure system: Thermally broken extruded aluminum 6063-T6 and 6063-T5 alloy and temper clamp-tight screw type closure system.

B. Sealing tape: Manufacturer's standard, pre-applied to closure system at the factory under controlled conditions.

C. Fasteners: 300 series stainless steel screws for aluminum closures, excluding final fasteners to the building.

D. Finish: Anodized; color to be selected from manufacturer’s standard colors.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Installer shall examine substrates, supporting structure and installation conditions.

B. Do not proceed with panel installation until unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Metal Protection:
   1. Where aluminum will contact dissimilar metals, protect against galvanic action by painting contact surfaces with primer or by applying sealant or tape recommended by manufacturer for this purpose.
   2. Where aluminum will contact concrete, masonry or pressure treated wood, protect against corrosion by painting contact surfaces with bituminous paint or method recommended by manufacturer.

3.03 INSTALLATION

A. Install the panel system in accordance with the manufacturer's suggested installation recommendations and approved shop drawings.
   1. Anchor component parts securely in place by permanent mechanical attachment system.
   2. Accommodate thermal and mechanical movements.
   3. Set perimeter framing in a full bed of sealant compound, or with joint fillers or gaskets to provide weather-tight construction.

B. Install joint sealants at perimeter joints and within the panel system in accordance with manufacturer's installation instructions.

3.04 CLEANING

A. Clean the panel system interior and exterior, immediately after installation.

B. Refer to manufacturer's written recommendations.

END OF SECTION

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SECTION 09900

PAINTING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. A painter's finish on all exterior and interior surfaces, except:
      a. Integrally finished materials such as glass, concrete masonry units, concrete floors, laminated plastic, etc.
      b. Factory finished items such as anodized aluminum, light fixtures, etc.
   2. Painter's top coat or refinishing coat in a color to match adjacent surfaces on:
      a. Miscellaneous mechanical and electrical items that are furnished with a factory finish that does not match the color of surrounding surfaces such as panelboards, air supply or return registers, fire extinguisher cabinets, hose reel cabinets, access doors and similar items that are located in finished walls or ceilings.
   3. Prime coat paint on all exposed and concealed surfaces of sheet metal flashings prior to installation. See also Section 07600.

1.02 REFERENCES

A. Where standards of surface preparation are described by citing SSPC specification numbers reference is made to "Systems and Specifications" Volume 2 published by The Coatings Society at SSPC.

1.03 SUBMITTALS

A. Contractor Qualifications: Submit a list of at least five projects completed in the past 5 years where High-Performance Coatings, similar to those required for this project, were applied by the Specialty Painting Contractor proposed for this project.
B. Product Data:
   1. Submit complete technical data on all materials to be used on the project for review prior to ordering material. Include manufacturer's brand name and type of material for each coat of each system to be used.
   2. The Contractor shall base his bid on using the products specified. If the products specified are not available in formulations that meet applicable Air Quality Management District regulations on maximum VOC levels, the Contractor shall submit products of equivalent quality and function that comply with regulations in effect at that time.
   3. If products manufactured by makers other than the first named product by the first named maker listed in Part 2 of this Section are submitted, submit supporting performance test results prepared by an independent paint testing laboratory for comparison with the performance of the first named product by the first named maker.

4. If the Contractor's second submittal of a proposed equivalent material is not favorably reviewed the Contractor will be back-charged by the Owner for the cost of subsequent reviews.

C. Manufacturer's Certification: That products furnished meet applicable Air Quality Management District regulations as to allowable VOC content for the place of application and use intended.

D. Samples: For paints submit two 8½ by 11-inch brush-outs of each paint system and each color on cardboard.

1.04 QUALITY ASSURANCE

A. Contractor Qualifications: The Contractor is cautioned that the application of High Performance Architectural Coatings (HPAC) specified under this Section requires special skill, knowledge and equipment. 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 are suitable for intended use, and has included in his bid the cost of all labor and material required to achieve a successful coating system that meets 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. Coatings or primers applied at locations other than the project site shall be done in accordance with local air quality regulations in effect at the place the coating is applied.

1.05 WARNING

A. The Contractor is advised that the application, mixing and/or cleaning of paint and finishing material may be hazardous. The Contractor shall take all necessary precautions to ensure the safety of workers and property. This includes, but is not limited to, the use of NIOSH-approved respirators, and all applicable personal protective equipment (PPE), for example, cloth coveralls, eye protection, gloves and head coverings.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver all materials in unopened containers with manufacturer's label. Label shall state VOC content.

B. Store in assigned area. Maintain storage area clean and fire safe. Dispose of used rags and clean buckets daily. Store solvents in closed approved storage containers.

C. Submerge solvent soaked rags in water.

1.07 PROJECT CONDITIONS

A. Environmental Requirements:
   1. Provide ambient temperatures recommended by manufacturer of material to be applied.
   2. Provide adequate ventilation.
   3. Provide 40- to 50-foot candles of illumination on all surfaces in areas to be painted including floors, walls and ceiling that may not require painting.
   4. Use temporary dust barriers to close off areas being painted from areas where other work is being performed.

1.08 COLORS AND COLOR SAMPLES

A. Before starting work, obtain color schedule and samples of colors selected for this project by the Architect. The colors selected may not be standard colors for the manufacturer whose materials are being used in which case custom colors shall be mixed to match the samples provided by the Architect. “Deep tone” highly pigmented accent colors may be selected for up to 10% of the area painted.

B. Colors are to be factory or machine mixed, using light-fast colorants proportioned by accurate measurement into a proper tinting base. The color formula for each color shall be submitted to facilitate future color matching.

C. Exterior deep tone colors are to be factory ground into the pigment for maximum color fastness.

PART 2 - PRODUCTS

2.01 MATERIALS - GENERAL

A. Coatings used shall be “top of the line” and of the type recommended by the manufacturer for the intended use and substrate.

B. Applicable Air Quality Management District regulations prohibit the manufacture, sale or application of Architectural Coatings and Specialty Coatings having greater than stipulated levels of volatile organic compounds.

C. If the Contractor applies any coatings for which it has not submitted certificates indicating the VOC content and that the product complies with applicable Air Quality Management District regulations, or if it applies coatings that have been modified or thinned other than as recommended by the manufacturer, the Contractor shall be responsible for any fines, costs, remedies, or legal actions that may result.

D. The Contractor shall not submit or use any material containing Trichlorethylene III because of its potential cancer-causing properties. If any of the materials specified in this Section contain trichlorethylene, they shall be considered deleted from this Specification.

2.02 SPECIALTY COATINGS: PRIMERS, STAINS, SEALERS AND CLEARS

A. Products and makers listed establish type of material and level of quality. Equivalent products manufactured by Glidden Professional Paints, Sherwin-Williams, or equal may be submitted for review.

B. Specialty Coatings: Coatings listed under this category include primers, sealers, stains and clear coatings. All products provided shall comply with the maximum allowable VOC limit assigned to that category of product by the Air Quality Management District having jurisdiction.
   1. LATEX UNIVERSAL RUST INHIBITING PRIMER
      Primer for galvanized metal, shop primed steel, etc. Maximum allowable VOC limit 350. Glidden Professional Acrylic Enamel Devflex 4020PF; Sherwin-Williams Pro Industrial Pro-Cryl Universal Acrylic Primer B66W01310; or equal.
   2. CHROMATE METAL PRIMER
      Maximum allowable VOC limit 350. N/A. Otherwise, Glidden Devguard 4160; Sherwin Williams DTM Acrylic Primer/Finish; or equal.
   3. INTERIOR LATEX PRIMER SEALER
      Latex primer sealer for interior walls, concrete block and concrete. Maximum allowable VOC limit 350. Glidden PVA Drywall Primer and Sealer; Sherwin-Williams PVA Drywall Primer & Sealer; or equal.
   4. ALKYD PHENOLIC GALVANIZED METAL PRIMER
      Solvent thinned, alkyd phenolic galvanized metal primer. Maximum allowable VOC limit 450. XIM 360 Gray NT Primer; Tnemec-Zinc Series 90-97; Glidden Devguard 4160; Sherwin-Williams Sherwin Williams DTM Acrylic Primer/Finish; or equal.
   5. CONCRETE AND MASONRY PRIMER/SEALER
      Sherwin-Williams PREPRITE® ProBlock Interior/Exterior Latex Primer/Sealer, or equal.

2.03 ARCHITECTURAL COATINGS

A. Coatings listed under this category consist of decorative and protective coatings used to protect surfaces and provide color for buildings and other structures. Most paints and enamels fall under this category. All products used under this category must comply with a VOC limit of 350 unless otherwise noted.

B. Products and makers listed establish type of material and level of quality. Equivalent products manufactured by Glidden, Sherwin-Williams, Devoe Coatings, or equal may be submitted for review.
   1. HIGH GLOSS EXTERIOR LATEX ENAMEL
      100% acrylic latex exterior enamel with excellent color and gloss retention and excellent weather resistance. Devoe Coatings Interior/Exterior Waterborne Acrylic Gloss Enamel Devflex No. 4208QD; Sherwin-Williams SuperPaint Exterior Acrylic Latex High Gloss A85 Series Paint; or equal.
   2. SEMI-GLOSS EXTERIOR LATEX ENAMEL
      100% acrylic latex (medium gloss) exterior house and trim enamel with excellent color and gloss retention and weather resistance. Glidden Premium

Exterior Semi-Gloss Paint; Sherwin-Williams SuperPaint Exterior Latex Gloss A84 Series; or equal.

3. SEMI-GLOSS INTERIOR LATEX:
   Sheen 35-45 at 60°, scrubbable. Sherwin Williams Emerald Interior Latex Semi-Gloss K38 Series; Glidden Premium Interior Latex Semi-Gloss ; or equal.
4. SEMI-GLOSS ACRYLIC LATEX INTERIOR ENAMEL
   Sherwin-Williams ProClassic® Interior Acrylic Latex Enamel Series; Glidden Diamond™ Interior Latex Semi-Gloss; or equal.
5. EGGSHELL ACRYLIC LATEX INTERIOR ENAMEL
   Sherwin-Williams ProClassic® Interior Acrylic Enamel Satin Series; Glidden Diamond™ Interior Latex Satin; or equal.
6. HIGH GLOSS INDUSTRIAL ENAMEL
   Sherwin-Williams Industrial Enamel B54 Series; Devoe Coatings Devguard 4308; or equal.

PART 3 - EXECUTION

3.01 CONDITION OF SURFACES TO BE PAINTED

A. Examine areas to receive work of this Section. Make certain that surfaces are even, smooth, sound, clean, dry, and free from defects or substances that might affect application.

B. Arrange for repairs or major cleaning as required. Starting work indicates acceptance of surfaces as satisfactory to achieve required result.

3.02 PREPARATION OF SURFACES

A. Check that hardware, trim, plates, lighting fixtures and similar items have been removed before starting work; coordinate with work under sections installing such items. Check that equipment adjacent to walls shall be disconnected and moved to permit wall surfaces to be painted before starting work under this Section.

B. Wash metal surfaces with solvent or cleaner to remove dirt or grease and clean off rust or scale with wire brush or sandpaper.

C. Bare or Shop Coated Steel: Remove rust and scale by wire brushing or sandblasting; wash with solvent or cleaner.

D. Galvanized Steel: Etch with phosphoric solution such as Watco “Galvaprime”, Endura “Galva-prep”, or equal; flush surface clean with water and allow to dry.

E. Prepare all surfaces in accordance with the more stringent of the coating material manufacturer’s recommendations, other requirements in this paragraph 3.02 or referenced or applicable requirements for surface preparation in “Systems and Specifications”, Volume 2, published by The Coatings Society, at SSPC.org and summarized below:

1. SSPC-SP1 - Solvent Cleaning: Removal of all oil, grease, soil, drawing compound, cutting compound and other soluble contaminates from the surfaces with solvents and/or commercial cleaners by wiping, dipping, steam cleaning or vapor degreasing.
2. SSPC-SP2 - Hand Tool Cleaning: Removal of all loose mill scale, rust, paint and other loose detrimental foreign matter by the use of non-powered hand tools.
3. SSPC-SP3 - Power Tool Cleaning: Removal of all loose mill scale, rust, paint and other loose detrimental foreign matter by the use of power-operated portable tools.
4. SSPC-SP5 – White Metal Blast Cleaning: Cleaning of a steel surface, previously painted or unpainted, to white metal condition through the use of abrasive blast media. The surface should, without magnification, be free of all visible oil, grease, dust dirt, mill scale, rust, coating, oxides, corrosion products, and other foreign matter.
5. SSPC- SP6 - Commercial Blast Cleaning: Removal of all oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products and other foreign matter by compressed air nozzle blasting, centrifugal wheels or other required methods. Remaining discoloration stains shall not exceed 33-1/3% of each square inch of surface.
6. SSPC-SP7 - Brush-Off Blast Cleaning: Removal of all oil, grease, dirt, dust, loose-mill scale and loose paint by compressed air nozzle blasting. Centrifugal wheels or other required means.
7. SSPC-SP11 – Power Tool Cleaning to Bare Metal: Removal of all stains from mill scale, rust or paint using power tools to take a surface to bare metal, while ensuring a minimum surface profile of 1 mil. Used in situations where abrasive blasting is not possible or feasible.
8. SSPC-SP13 – Surface Preparation of Concrete: Preparation of concrete surfaces prior to the application of bonded coating or lining systems by the removal of all surface contaminants including laitance, loose concrete and dust. Standard covers requirements for thermal, mechanical and chemical application methods.

F. Dust all surfaces and wipe clean with a tack rag just prior to coating.

3.03 APPLICATION

A. Apply all material in strict accordance with manufacturer's instructions. Apply first coat immediately after surface preparation.

B. Do not apply coatings when temperature is below 55°F. Do not apply exterior coatings in damp or rainy weather.

C. Brush out each coat to a uniform, even coating; lay material on in one direction and brush out at right angles. Special application techniques may be required for new coatings with low VOC content. Apply such coatings in strict accordance with manufacturer's detailed instructions. Allow material to dry 48 hours between coats unless longer period specified by manufacturer.

D. Paint items and surfaces before installation that will be difficult or impossible to paint after installation.

E. Apply not less than the number of coats specified. Apply additional coats if required for uniform coverage and full hiding. Apply finishes in their factory original consistencies. Do not thin unless specifically recommended by the manufacturer.

F. Finish work shall be uniform in color, full coverage, smooth and free of sags and brush marks

G. Do all cutting in to a sharp, true line. Repaint if necessary to correct over runs.

H. Do not paint over Underwriters' labels, fusible links, sprinkler heads, or fire alarm devices.

I. Paint access panels, electrical panels, air registers and similar items prior to installation to prevent edges from peeling or chipping when panels are removed.

J. Repaint factory finished electrical panels, air registers, and other items to match adjacent painted surfaces.

3.04 PROTECTION, CLEANING, AND COMPLETION

A. Protect finish work by suitable covering or other method as job progresses.

B. Remove paint spots from floors, glass and other surfaces, upon completion of work. Remove rubbish, empty containers and other accumulated materials from premises. Leave work in clean, orderly, acceptable condition.

C. Check work of this Section at completion of project. Touch-up or refinish marred or damaged surfaces. Replace glass damaged by operations under this Section. Leave entire area with finish free from imperfections.

3.05 PAINTING SYSTEMS AND SCHEDULE: ARCHITECTURAL COATING SYSTEMS

A. See Notes on Drawings for additional location of surfaces to receive paint systems.

B. Characteristics of paint materials are described in Part 2 of this Section. First-named products are listed in this Schedule. Equivalent products by other manufacturers may be submitted for review in accordance with paragraphs 1.03 and 2.02 of this Section.

C. System "A": EXTERIOR/INTERIOR HIGH-GLOSS LATEX ENAMEL
   1. First Coat:
      a. Shop primed ferrous metal: Touch-up with ALKYD RUST INHIBITING PRIMER. Devoe Coatings Multi-Purpose Tank and Structural Primer Devguard No. 4160.

b. Or, where shop prime coat is not suitable for overcoating with latex systems, re-prime entire surface with ALKYD PHENOLIC PRIMER. Devoe Coatings All Purpose Metal and Galvanized Primer Devguard No. 4160.
c. Unprimed ferrous metal: ALKYD RUST INHIBITING PRIMER.
d. Galvanized Metal: Pretreat with phosphate solution and prime with ALKYD PHENOLIC GALVANIZED METAL PRIMER. XIM 360 Gray NT Primer.
e. Wood: ALKYD EXTERIOR WOOD PRIMER. Sherwin-Williams Exterior Latex Wood Primer B42W08041.

2. Second and Third Coats:
a. Two coats of HIGH GLOSS EXTERIOR LATEX ENAMEL. Devoe Coatings Interior-Exterior Waterborne Acrylic Gloss Enamel, Devflex No. 4208QD.

D. System "B": EXTERIOR/INTERIOR SEMI-GLOSS LATEX ENAMEL.
1. First Coat:
a. Shop primed ferrous metal: Touch-up with ALKYD RUST INHIBITING PRIMER. Devoe Coatings Multi-Purpose Tank and Structural Primer Devguard No. 4160. Where shop prime coat is not suitable for overcoating with latex system, re-prime entire surface with ALKYD PHENOLIC PRIMER. Devoe Coatings Multi-Purpose Tank and Structural Primer Devguard No. 4160.
b. Unprimed ferrous metal: ALKYD RUST INHIBITING PRIMER. Devoe Coatings Multi-Purpose Tank and Structural Primer Devguard No. 4160.
c. Galvanized Metal: Pretreat with phosphate solution in accordance with paragraph 3.02D and prime with ALKYD PHENOLIC GALVANIZED METAL PRIMER. XIM 360 Gray NT Primer.
d. Aluminum: Pretreat with metal etch and prime over aluminum. XIM 360 Gray NT Primer, Devoe Coatings Multi-Purpose Tank and Structural Primer Devguard No. 4160.

2. Second and Third Coats: Two coats of SEMI-GLOSS EXTERIOR LATEX ENAMEL Sherwin-Williams SuperPaint Exterior Latex Gloss A84 Series.

E. System "C": SEMI-GLOSS ACRYLIC LATEX INTERIOR ENAMEL
1. First Coat:
a. On gypsum board: PVA SEALER. Glidden PVA Drywall Primer and Sealer.
b. Galvanized metal: Pretreat with phosphate solution in accordance with paragraph 3.02D and prime with ALKYD PHENOLIC GALVANIZED METAL PRIMER. XIM 360 Gray NT Primer, Devoe Coatings Multi-Purpose Tank and Structural Primer Devguard No. 4160.

2. Second and Third Coats: SEMI-GLOSS ACRYLIC INTERIOR ENAMEL: Sherwin-Williams ProClassic® Interior Acrylic Latex Enamel Series.

F. System "D": EGGSHELL ACRYLIC LATEX INTERIOR ENAMEL
1. First Coat:
a. On gypsum board: PVA SEALER: Glidden PVA Drywall Primer and Sealer.

b. On plywood: Wood Primer: Sherwin-Williams Exterior Latex Wood Primer No. B42W08041.
c. On metal: ALKYD RUST INHIBITING PRIMER. Devoe Coatings Multi-Purpose Tank and Structural Primer Devguard No. 4160.

2. Second and Third Coats: EGGSHELL ACRYLIC LATEX INTERIOR ENAMEL. Sherwin-Williams ProClassic® Interior Acrylic Enamel Satin Series.

G. System "E": ACRYLIC LATEX MASONRY PAINT for Exterior Concrete or Concrete Block:
1. Surface Preparation: Very light brush-off blasting to create a fine tooth: SSPC-SP 7.
2. First Coat:
a. On Concrete: CONCRETE AND MASONRY PRIMER SEALER, applied at the rate recommended by the manufacturer. Sherwin-Williams PREPRITE® ProBlock Interior / Exterior Latex Primer / Sealer.
b. On Concrete Block: LATEX BLOCK FILLER. Sherwin-Williams PREPRITE® Interior/Exterior Latex Block Filler B25W00025.
3. Second and Third Coats: FLAT ACRYLIC EXTERIOR MASONRY PAINT, applied at the rate recommended by the manufacturer. Sherwin-Williams SuperPaint Exterior Latex Flat A80 Series.

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, polyethylene, and polypropylene piping.
   7. Stainless steel.
   8. Bronze, brass.
   9. Nameplates and grease fittings.
   10. Factory finished electrical panels.
   11. Factory fusion-bonded epoxy coated items.
   12. Aluminum or galvanized ductwork enclosed inside furred ceiling spaces.
   13. Aluminum handrail and aluminum guardrail.
   14. Fiberglass.
   15. Electrical conduit.
   16. Copper pipe.

C. 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 Standard Construction Specifications.

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.
   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 state and local regulatory agency 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. 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.
9. 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.
10. 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.
11. 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.
12. 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 state or local regulatory body 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 state or local regulatory agency 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. 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. 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. Protection of coating systems
k. One-year inspection
l. Coordination with other trades / work activities/schedule
m. 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, or SSPC - CAS LEVEL II 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 two (2) hours' notice prior to performing a Hold Point Inspection.
2. 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.

3. The Contractor shall indicate the execution and nature of each Hold Point Inspection in the daily report.
4. 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.
5. Failure to comply with any or all of the Hold Point Inspection requirements may result in the rejection of all subsequent work.
6. 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. 1: Epoxy	Metal	Interior Exterior (covered) No Direct Sunlight Non Immersion Non-Corrosive
System No. 2: Zinc-Epoxy-Urethane	Metal	Atmospheric Exterior Direct Sunlight Non Immersion Mildly Corrosive
System No. 10: Epoxy	Galvanized Steel	Interior or Exterior Non Immersion Non-Corrosive
System No. 11: Acrylic (Latex)	PVC, CPVC, and Polyethylene Pipe	Interior or Exterior Non Immersion

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 Ferrous Metal Piping (indoor service)	Ferrous metal	No. 1	Owner Determined
Exposed Ferrous Metal Piping (outdoor service)	Ferrous metal	No. 2	Owner Determined
Bollards	Galvanized steel	No. 10	As Shown
Exposed PVC Piping (outdoor service)	Thermoplastic	No. 11	Owner Determined

   2. Colors shall be selected by the Owner.

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.

F. Masonry Surfaces:
1. Prepare masonry surfaces such as Concrete Masonry Units (CMU) to remove chalk, loose dirt, dried mortar splatter, dust, peeling, or loose existing coatings, or otherwise deleterious substances to leave a clean, sound substrate.
2. Be certain masonry surfaces are dry prior to coating application. If pressure washing or low pressure water blast cleaning is used for preparation, allow the masonry to dry for at least 5 days under dry weather conditions or when the minimum ambient temperature is 70˚F prior to coating application work.

G. Thermoplastic Surfaces:
1. Prepare thermoplastic surfaces of polyethylene, PVC, CPVC, or FRP by sanding to establish uniform surface roughness and to remove gloss from the substrate. Vacuum clean substrate to remove loose dust, dirt, and other materials. Next, solvent clean using clean white rags and allow solvent to completely evaporate before application of coating materials.

H. Galvanized Steel Surfaces
1. Prepare in accordance with SSPC-SP16 to impart a uniform surface profile to the galvanized steel surfaces. Where this cannot be performed, prepare by abrading in accordance with SSPC-SP3, Power Tool Cleaning to achieve a uniform surface profile. Vacuum clean and solvent clean after blast cleaning or abrading and allow the solvent to fully evaporate prior to any coating application.

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.

END OF SECTION

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.

TEST REQUIREMENT	REFERENCE STANDARD	INTERVAL/FREQUENCY
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.
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 (ferrous metal/magnetic substrates)	SSPC-PA 2	After coating has properly cured. After each layer (component) of the specified coating system.
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 (destructive method – all substrates)	ASTM D 4138	Whenever verification as to the accuracy of other methods is deemed necessary.

TEST REQUIREMENT	REFERENCE STANDARD	INTERVAL/FREQUENCY
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.
Final Cure (solvent rub – organic coatings)	ASTM D 5402	After coating system has been cured per manufacturer's published recommendations.

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SECTION 09960

APPENDIX B – COATING DETAIL SHEETS

HIGH PERFORMANCE COATINGS

	System No. 1
Coating Detail Sheet:	
Coating Material:	Epoxy
Surface:	Metal
Service Condition:	Interior; exterior, covered, not exposed to direct sunlight, mildly corrosive exposure.
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-5 (White Metal Blast Cleaning) to achieve a uniform surface profile of 2.0 to 2.5 mils and spot primed with the primer specified. Shop epoxy primed surfaces shall require light abrasive and vacuum cleaning blasting prior to receiving finish coats.
Ferrous Metal:	Bare ferrous metal surfaces shall be prepared in accordance with SSPC SP-6 (Commercial Blast Cleaning) to achieve a uniform, surface profile of 2.0 to 2.5 mils. Ferrous metal with rust bleeding shall be cleaned in accordance with SSPC SP-1 (Solvent Cleaning). Areas of rust penetration shall be spot blasted to SSPC SP-10 (Near White Blast) (to achieve the 2.0 to 2.5 mil surface profile) and spot primed with the specified primer. For ductile iron surfaces, refer to the requirements in Section 09960, paragraph 3.02.D.
Non-ferrous and Galvanized Metal:	Nonferrous and galvanized metal shall be prepared in accordance with SSPC SP-16 to achieve a uniform, minimum surface profile 1.0 to 1.5 mils.
Application:	Field
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.

System No. 1

Coating Detail Sheet:

Ferrous Metal:	Prime coats shall be an epoxy primer compatible with the specified finish coats and applied in accordance with the written instructions of the coating manufacturer.
Non-ferrous and Galvanized Metal:	Non-ferrous and galvanized metal shall be cleaned prior to the application of the prime coat in accordance with SSPC SP-1 (Solvent Cleaning).
System Thickness:	Minimum 10 mils dry film.
Coatings:	
Primer:	One coat at coating manufacturer's recommended dry film thickness.
Finish:	One or more coats at the coating manufacturer's recommended dry film thickness per coat to achieve the specified system thickness.

Approved Manufacturers:

1. All of U.S. except California:

System Manufacturer	First/Prime Coat(s)	Finish Coat(s)
PPG	Amerlock 2/400	Amerlock 2/400
Carboline	Carboguard 890	Carboguard 890
International	Devran 224 HS	Devran 224 HS
Sherwin Williams	Macropoxy 646 CA	Macropoxy 646 CA
Tnemec	Series V69	Series V69

END OF SYSTEM NO. 1

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. All of U.S. except California:

System Manufacturer	First/Prime Coat(s)	Intermediate Coat(s)	Finish Coat(s)
PPG	Amercoat 68HS	Amercoat 385	Amercoat 450H
Carboline	Carbozinc 859	Carboguard 890	Carbothane 134
International Paint	Cathacoat 313	Devran 223 or Devran 224 HS	Devthane 379
Sherwin Williams	Zinc Clad IV	Macropoxy 646	Hi Solids Polyurethane
Tnemec	Series 90-97	Series V69	Series 1075

END OF SYSTEM NO. 2

Coating Detail Sheet:	**System No. 10**
Coating Material:	Epoxy
Surface:	Galvanized Steel
Service Condition:	Interior; exterior, covered, non-corrosive exposure. Do not use in immersion service.
Surface Preparation:	
General:	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.
Galvanized Metal:	Non-ferrous and galvanized metal shall be prepared in accordance with SSPC SP-16 impart a 1 to 2 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.
Application:	Field
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.
Galvanized Metal:	Non-ferrous and galvanized metal shall be cleaned prior to the application of the prime coat in accordance with SSPC SP-1 (Solvent Cleaning).
System Thickness:	5 to 8 mils dry film.
Coatings:	
Primer:	One coat at coating manufacturer's recommended dry film thickness.
Finish:	One or more coats at coating manufacturer's recommended dry film thickness per coat to the specified system thickness. If the coated galvanized steel is to be exposed to ultraviolet light, apply one polyurethane top coat from Coating System No. 2 over the second coat of the two epoxy coats specified.

Approved Manufacturers:

1. All of U.S. except California:

System Manufacturer	First/Prime Coat(s)	Finish Coat(s)
PPG	Amerlock 2/400	Amerlock 2/400
Carboline	Carboguard 894	Carboguard 894
International	Devran 224 HS	Devran 224 HS
Sherwin Williams	Macropoxy 646 (B67-600)	Macropoxy 646 (B67-600)
Tnemec	Series V27 or V69	Series V69

END OF SYSTEM NO. 10

Coating Detail Sheet:	**System No. 11**
Coating Material:	Acrylic (Latex)
Surface:	PVC and CPVC pipe.
Service Condition:	Exterior, direct sunlight exposure.
Surface Preparation:	Plastic pipe shall be cleaned with solvent compatible with the specified primer and sanded to uniformly roughen surfaces to achieve a uniform surface profile of 1.0 to 1.5 mils. Vacuum clean after sanding to remove all loose dust, plastic particles, and dirt.
Application:	Field
System Thickness:	Minimum 3 mils dry film.
Coatings:	
Primer:	One coat at the coating manufacturer's recommended dry film thickness.
Finish:	One or more coats at the coating manufacturer's recommended dry film thickness per coat to the specified system thickness and to ensure adequate / uniform coverage of the substrate.

Approved Manufacturers:

1. All of U.S. except California:

System Manufacturer	First/Prime Coat(s)	Finish Coat(s)
PPG	Amercoat 220	Amercoat 220
Carboline	Carbocrylic 120	Carbocrylic 3359
International	Prep and Prime Gripper	Ultrahide 250-1406
Sherwin Williams	Sher Cryl HPA	Sher Cryl HPA
Tnemec	Series 1028 or 1029	Series 1028 or 1029

END OF SYSTEM NO. 11

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SECTION 10200

LOUVERS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Wall louvers.

1.02 REFERENCES

A. Sheet Metal and Air Conditioning Contractors National Association (SMACNA)
   1. Architectural Sheet Metal Manual

B. Air Control Division of the Air Movement and Control Association (AMCA)
   1. AMCA-500-L-12 Laboratory Methods of Testing Louvers for Rating
   2. AMCA-511 Certified Ratings Program – Product Rating Manual for Air Control Devices

C. National Association of Architectural Metal Manufacturers (NAAMM)
   1. AMP 500 Metal Finishes Manual

1.03 SUBMITTALS

A. Submit the following:
   1. Product Data: Fully describe all items proposed for use.
   2. Shop Drawings: Custom prepared for this project.
   3. Certified Test Data: Air and acoustic performance of louvers.

1.04 QUALITY ASSURANCE

A. Comply with details and standards in the “Architectural Sheet Metal Manual” published by Sheet Metal and Air Conditioning Contractors National Association (SMACNA).

B. Comply with AMCA Standard 500-L-12 for measuring air performance, water penetration and air leakage and Standard 511 for the AMCA Certified Ratings Program.

PART 2 - PRODUCTS

2.01 STATIONARY EXTRUDED ALUMINUM FRAMED CONTINUOUS BLADE LOUVERS

A. Manufacturer: Louver style K6774 exposed vertical mullion type manufactured by Airolite; Construction Specialties; or equal.

B. Design Criteria: Design and test louvers to AMCA Standard 500 for air performance and water penetration. Test a 4 by 4-foot louver with a minimum free area of 7.89 square feet to pass at least 800 FPM through the free area at a pressure drop not exceeding 0.15 in W.G. Limit water penetration to 10 ounces of water per square foot of free area when tested at 720 FPM for 15 minutes per AMCA Standard 500.

2.02 MATERIALS / FABRICATION

A. Provide extruded aluminum framed continuous blade louvers with exposed jambs and mullions 4 inches deep with blades spaced 3 inches on center. Use aluminum alloy 6063-T52 for all parts.

B. Use extruded blades, 12-gauge (0.81 inches) thick, having a downward turned stiffening leg along the front bottom edge and an up turned leg with a forward-facing lip to stop water migration along the top rear edge. Use blades that have an extruded hood on their bottom surface to interlock with mullion support brackets. Set louver blades at a 30-degree angle for exhaust and 45-degree angle for intake.

C. Contain louver blades in a frame made of 3/4-inch by 4-inch extruded aluminum “C” sections.

D. Provide louvers that have all joints concealed.

E. Continuously weld all joints in the louver assembly using a shielded arc process.

F. Provide aluminum insect screens in folded extruded aluminum frames. Where fan housing/mounting board is attached to the interior side of louver, provide holder for screen frame that can be built into mounting board support and so arranged that by removing the fan housing/mounting board, screen can be slid out for cleaning without disassembling louver and supports. Where there is no ductwork attached to interior of louver, provide a holder for insect screen frame designed so that screen can be removed for cleaning and replaced without using tools.

G Provide all related break shape and extruded aluminum sills, flashings, and sub-frames. Flashings shall be 0.050 or thicker as indicated.

H. Provide matching 1/8-inch-thick dark bronze anodized aluminum backing plates to cover the rear of decorative louvers and portions of louvers outside of air intake or exhaust ductwork.

I. Provide all required aluminum angles, tees, plates, and other shapes required for a complete installation.

2.03 FINISH

A. Finish all parts with an anodized finish at least 0.7 mils thick conforming to NAAMM AA-M10C22A44; color as selected by Engineer from manufacturer’s standard colors.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Protect all aluminum in contact with steel or galvanized metal with a coating of bituminous paint.

B. Install louvers as shown in the Contract Drawings and as shown in Plates 137B and 139A of the 4th edition of the SMACNA Architectural Sheet Metal manual.

C. Provide insect screens on all louvers. Install on the interior side. Use stainless steel screws throughout.

D. Install sill flashing as shown detailed and as required to provide a watertight installation.

E. Install sheet metal drip at head of louvers where shown.

F. Apply sealant "B" all around frame, at joint with interior and exterior wall surfaces.

END OF SECTION

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SECTION 10400

IDENTIFYING DEVICES

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes: Room Signs, Decals, and Tags.

1.02 REFERENCES

A. American National Standards Institute / American Society of Mechanical Engineers (ANSI/ASME), ASME A13.1 - 2015, "Scheme for the Identification of Piping Systems."

B. American National Standards Institute (ANSI), ICC A117.1 - 2009, "Accessible and Usable Buildings and Facilities".

C. Oregon Building Codes Division
   1. 2019 Oregon Structural specialty Code (OSSC)

D. National Fire Protection Association (NFPA) NFPA 704, "Standard System for the Identification of the Hazards of Materials for Emergency Response".

1.03 SUBMITTALS

A. Product Data: Fully describe all items proposed for use.

B. Shop Drawings: Scaled drawings or images of custom-made signs, showing style and size of lettering and colors.

C. Samples: Provide one full size representative sample of each signage type, made of the specified material, from Part 2 of this Specification. Provide manufacturer’s standard color palette for each selection.

1.04 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with the following:
   1. Americans with Disabilities Act (ADA).
   2. 2019 Oregon Structural Specialty Code (OSSC)
   3. Federal and Oregon State Occupational Safety and Health Act (Oregon OSHA): Referenced sections, specifications for accident prevention signs and tags and exit signs.

B. Comply with the manufacturer's published recommendation for installation of materials used.

PART 2 - PRODUCTS

2.01 SIGNS

A. Architectural Signs:
   1. Office/Facility Signs:

a. Vomar Products, Inc.; ES 100 Series; Apco Graphics IM System; or equal.
b. Sign characteristics:
   1) Material: Integral color acrylic.
   2) Frame and plaque in contrasting colors separated by a 1/16-inch reveal. Colors as selected from manufacturer's standard palette. Rectangular shape unless noted otherwise. Self-adhesive backing.
   3) Text Helvetica Bold all caps: Size shown.
   4) Sign size shall be as shown unless a larger size is required to accommodate lettering.
   5) Braille: All signs to include contracted (Grade 2) braille and comply with ICC A117.1-2009 Chapter 7 Communication Elements and Features.

c. Schedule of signs required:

Quantity	Text	Text Height	Size (Inches)	Comments
1	Cake Storage East Bay	3/4	9Wx5-1/2 H	Provide one sign at one exterior door face
2	Dewatering Room	3/4	9Wx5-1/2 H	Provide one sign at one exterior door face

2.02 SAFETY SIGNAGE

A. Hazard Alerting Signage (CAUTION, WARNING, DANGER):
   1. Refer to the Signage Schedule at the end of this section to identify the sign types and quantities for the project.
   2. Manufacturer: Seton Nameplate Company; W.H. Brady Company; or equal.
   3. Signage Design:
      a. Size: 14 inches wide by 10 inches high
      b. Material: 60-mil rigid plastic, coated for weather and vandalism protection
      c. Text, format, and color:
         1) Conforming to OSHA 1910.145(d), Specifications for Accident Prevention Sign Design.
         2) Text as scheduled below.
      d. Provide eyelet holes at each corner for mounting.
   4. Text as scheduled below:

Quantity	Text
4	AUTHORIZED PERSONNEL ONLY
2	CAUTION EQUIPMENT STARTS AUTOMATICALLY

B. Fire Equipment Location Signs:
   1. One-way Fire Equipment Location Signs:
      a. Manufacturer: Seton Nameplate Company; W.H. Brady Company; or equal.
      b. Size: 18 inch height (approximate size).
      c. Material: 60-mil rigid plastic, coated for weather and vandalism protection. Provide eyelet holes at each corner for mounting.
      d. Text: Bright, fade-resistant red on white downward facing directional arrow on red field. Text is shown on schedule below.
      e. Schedule of signs required:

Text	Quantity		
	1-way	2-way	3-way
"FIRE EXTINGUISHER"	6	___	___

C. Security and General Policy Safety (NOTICE) Signs
   1. Notice (Informational) Signs:
      a. Manufacturer: Seton Nameplate Company; W.H. Brady Company; or equal.
      b. Size: 14 inches wide by 10 inches high.
      c. Material: 60 mil rigid plastic, coated for weather and vandalism protection
      d. Provide eyelet holes at each corner for mounting.
      e. Schedule of signs required:

Quantity	Text
4	NOTICE KEEP OUT EMPLOYEES ONLY

2.03 PIPE MARKERS

A. Seton Nameplate Company; SetMark, W.H. Brady Company; Piper Marker System 1; or equal.

B. Pipe Markers conforming to ANSI A13.1. See paragraph 3.03 for required locations.

C. Material: Acrylic plastic snap-around type or pressure sensitive vinyl, temperature tolerance range of -40°F to 250°F, non-fade, colored fields, lengths as shown below.

D. Text: Non-fade ink, lettering size, as shown below:

Outside Diameter of Pipe (Inches)	Length of Color Field (Inches)	Size of Letters (Inches)
3/4 to 1-1/4	8	1/2
1-1/2 to 2	8	3/4
2-1/2 to 6	12	1-1/4
8 to 10	24	2-1/2
Over 10	36	3-1/2

E. Provide directional arrows to indicate flow direction. See paragraph 3.03.

F. Pipe Marker Schedule:

Text	Field Color	Letter Color
Filter Drain	Gray	Black
Potable Water	Green	White
Liquid Ammonium Sulfate	Orange	Black
Sodium Hypochlorite	Orange	Black

PART 3 - EXECUTION

3.01 SIGN INSTALLATION

A. Install signs where directed by the Engineer.

B. Install signs after painting surfaces to receive signs. Follow manufacturer's written installation instructions.

C. Use fasteners as follows:
1. To concrete and masonry materials: 4-1/4-inches diameter expansion anchors.
2. To sheet metal (gauges 28 to 6) #10 sheet metal screws.
3. To plywood backing boards: #10 wood screws.
4. To machinery: Fasteners as suitable.

3.02 PIPE MARKERS

A. Pipe Markers shall be applied where piping enters or leaves the wall or floor of a structure, adjacent to tanks or other hydraulic containments, at each valve, at each piping change in direction, and shall be applied along piping runs not exceeding 16 feet on center.

B. Directional Arrows: Point in the direction of flow.

C. Locate pipe markers for easy reading. Where pipes are located above normal line of vision, the lettering and directional arrows shall be placed below the horizontal centerline of the pipe. Where pipes are below normal line of vision, lettering and directional arrows shall be above the horizontal centerline of the pipe.

END OF SECTION

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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, 13, 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.

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).

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. Shop Drawings: 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.

B. 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.

C. Operations and Maintenance Manuals: Prepare and submit manuals covering installation, operation and maintenance of all equipment and machinery specified in Divisions 11, 13, 14, and 15.

D. 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

A. DESIGN

B. 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.

C. Seismic: Refer to Section 01190 of the Specifications for the seismic design criteria.

D. 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. Details of fabrication shall be in accordance with Section 05100.

B. 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. Stainless steel leveling blocks, shims or jackscrews shall be used for leveling bases prior to grouting. Leveling nuts may be used for leveling equipment less than 200 pounds. All leveling shall be against steel surfaces (jackscrew plates, leveling blocks, or leveling nuts). Bases for equipment with drivers weighing more than 500 pounds shall be provided with axial and transverse jackscrews to facilitate horizontal and longitudinal adjustment. Mount all equipment bases and baseplates on reinforced concrete pads at least 4 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 1½ 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.

C. Anchors shall be provided in accordance with the requirements of Sections 01190 and 05090.

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 OR/OSHA.

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.

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 09900 and 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 in excess of that permitted by 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: Grouting for installation of equipment on concrete pads shall take place prior to connection of piping or electrical and instrumentation systems. Initial fitting and alignment of connected piping is acceptable, however, final alignment and connection of piping shall be done after equipment grouting is completed. Level and align equipment base on the concrete foundation, then clamp making snug–tight. The Contractor shall ensure the correct level and alignment has been maintained after clamping. 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, leveling blocks and shims or jacking screws shall be removed or leveling nuts shall be backed off to allow the grout to fully support the equipment base. Tighten nuts on anchor bolts to one-quarter turn past snug-tight in an alternating pattern to avoid stress concentration on the grout surface. Blockouts for access to leveling nuts or leveling blocks and shims shall be filled with the grout material

installed under the based and pointed. Holes in the base associated with jackscrews shall be filled with flexible sealant. 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.
2. Grout: Unless otherwise approved, all grout shall be a favorably reviewed non-shrink, non-metallic grout per Section 03600.
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 Engineer.

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 Section 01700 and 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 Centers
   4. Section 16924: Variable Frequency Drives (VFD) Over 5 Horsepower

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. UL LLC (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. Manufacturer's name.
   2. Manufacturer's type and frame designation.
   3. Horsepower output.
   4. Time rating.
   5. Maximum ambient temperature rating.
   6. Insulation system designation.
   7. RPM at full load.
   8. Voltage, number of phases, frequency and full load amperes.
   9. Code letter for locked rotor kVA.
   10. Service factor at 40°C ambient.
   11. NEMA design letter.
   12. Enclosure type.
   13. Lubrication requirements, including type and frequency.
   14. KW input power and power factor at 75% and 100% of rated horsepower output.
   15. Guaranteed minimum efficiency and nominal efficiency per MG1 12.55.
   16. Nominal efficiency.

B. Provide installation, operation and maintenance instructions, and renewal parts list as required for maintenance manuals under Section 01300, paragraph 1.08.

C. Shop Drawings: Submit signed and sealed structural calculations and detailed drawings for the attachments and anchorage to the structure of the equipment and appurtenances in this Section. Calculations shall conform to the requirements of Section 01190.

D. Submit Level 1 Certification from the manufacturer that the equipment is capable of resisting seismic loads. Loading shall be as described in Section 01190.

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 or shall be listed and labeled by other organizations acceptable to the authority having code enforcement jurisdiction.

B. Unless otherwise specified with the driven equipment, provide motors with the following typical characteristics:
   1. Motors shall be single speed and designed for continuous duty and full voltage starting. Motors shall provide standard starting torque.
   2. Voltage Ratings:
      a. 1/2 horsepower or less: 115 volts, single phase, 60 Hz, capacitor start. Small fan motors may be split phase or shaded pole type if standard for the equipment.
      b. Above 1/2 horsepower: 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. Each motor shall have an overall sound power level at no load not greater than given in NEMA MG1-12.49.
   9. 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.

C. Motors used with variable frequency drives shall have inverter duty complying with NEMA MG-1, Section IV, Part 31.

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 six (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.

TABLE 11002-1

MOTOR NOMINAL EFFICIENCIES AT FULL LOAD

HP	900 RPM	1,200 RPM	1,800 RPM	3,600 RPM
Open Drip-Proof and Weather Protected Type 1 Motors				
1	78.5	78.5	82.5	80.0
1.5	80.0	80.0	84.0	81.5
2	85.5	82.5	82.5	85.5
3	85.5	82.5	82.5	84.0
5	86.5	86.5	85.5	86.5
7.5	87.5	89.5	87.5	88.5
10	90.2	90.2	89.5	86.5
15	90.2	91.7	90.2	89.5
20	91.7	91.7	91.0	90.2
25	91.7	92.4	91.7	90.2
30	92.4	93.0	92.4	92.4
40	91.7	93.0	93.6	93.6
50	93.0	93.0	93.6	93.6
60	93.6	93.6	94.1	94.1
75	94.1	93.6	94.1	93.6
Total Enclosed Fan Cooled Motors				
1	78.5	78.5	82.5	80.0
1.5	80.0	80.0	84.0	81.5
2	85.5	82.5	82.5	85.5
3	86.5	86.5	82.5	84.0
5	88.5	87.5	85.5	86.5
7.5	89.5	90.2	87.5	88.5
10	90.2	91.0	89.5	90.2

HP	900 RPM	1,200 RPM	1,800 RPM	3,600 RPM
15	90.2	92.4	91.0	91.7
20	91.7	92.4	91.0	91.7
25	91.7	93.0	92.4	92.4
30	92.4	93.0	93.0	93.0
40	92.4	93.6	94.1	94.1
50	93.6	93.6	94.1	94.1
60	93.6	94.1	94.1	94.1
75	94.1	94.1	94.1	94.5

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. Premium efficiency motors shall have nominal efficiencies at full load not less than those listed in Table 11002 1.
   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 WOUND ROTOR MOTORS

A. Provide wound rotor motors where called for in the Specifications for the driven equipment. Wound rotor motors shall be General Electric Type M, Louis Allis, or equal. Provide removable inspection covers over slip rings.

2.09 THERMAL PROTECTION

A. In each motor to be used with adjustable speed drives, in all motors 60 horsepower and larger, or where called for in the Specifications for the driven equipment, provide integral thermostats or other approved devices to protect the motor from overheating.

2.10 SPACE HEATERS

A. Where called for in the Specifications for the driven equipment, provide space heaters or solid-state motor winding heating systems for motors. Heaters shall be 120 or 240 volts, single-phase, as required by the control circuit voltage or be of the SCR voltage-controlled type. Heater wattage and voltage ratings shall be indicated on motor nameplate. Motor winding heating systems shall be as specified in Section 16920.

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.

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.

END OF SECTION

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SECTION 11215

WASHDOWN PUMP

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: A horizontal centrifugal booster pump designed for maintaining constant pressure in the 2W water system supplying the utility water stations. The system also includes all piping, fittings and electrical equipment to make the system functional, as shown on the Drawings and as specified herein.

1.02 PERFORMANCE AND DESIGN REQUIREMENTS

A. The booster pump shall meet the following performance and design requirements:

Item	Data
Equipment Number	WW1-016P0011
Pump Type	Horizontal centrifugal booster
Minimum Flow Condition	10 GPM @ 213 ft TDH
Maximum Flow Condition	30 GPM @ 135 ft TDH
Motor Speed	3868 RPM
Maximum Motor Horsepower	2 HP
Suction Flange	1.00 inch
Discharge Flange	1.25 inch

B. Pump shall operate without excessive noise or vibration over the full operating range indicated in the performance and design criteria schedule.

1.03 SUBMITTALS

A. Shop Drawings and Product Data: Submit the following as a single complete initial submittal in accordance with Section 01300:
   1. Product data to demonstrate that the equipment conforms to the Specifications.
   2. Field-verified initial pressure reading on new water line at plant.
   3. Motor data.
   4. Pump layouts and dimensions.
   5. Pump performance curves.

B. Performance Testing: Submit certified non-witnessed factory performance test results in accordance with the Hydraulic Institute. Receive favorable review of test results prior to shipping the equipment.

C. Manuals: Furnish manufacturer's installation, lubrication, operation and maintenance manuals, bulletins, and spare parts lists.

D. Affidavits: Submit affidavit 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. Equipment furnished under this Section shall be supplied by one or more manufacturers who have been regularly engaged in the design and manufacture of the equipment for at least 5 years.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Pump: Grundfos CMBE booster pump, or equal.

2.02 MATERIALS

A. Pump materials shall be as specified below:

Item	Value
Body	Stainless Steel
Pump Sleeve	Stainless Steel
Impeller	Stainless Steel
Shaft	Stainless Steel
Shaft Seal	Carbon with Resin/Ceramic

2.03 EQUIPMENT

A. Required Equipment: Provide centrifugal pump with control valve, diaphragm tank, pressure sensor, discharge flanges and electric motor, controller; and required appurtenances. Comply with construction features of ASME B73.1 except where indicated differently in this Specification.

B. Seismic: Entire system shall comply with the seismic requirements for the project area.

C. Pump Motor:
1. The pump drive motor shall be NEMA standard design. Motor shall be of standard manufacturing catalogue design and must not use special bearings as thrust handling device.
   a. The motor rating shall be as follows:
      3868 RPM
      1-phase
      60 Hz
      240 volts
      TEFC motor enclosure

Motors shall be suitable for operation over the specified operating range of the pump and shall comply with Section 11002.

D. Controller: The pump controller shall be an integrated speed controller.
   1. Additional control panels, PLCs or other external devices, shall not be necessary to accomplish complete control of pump and motor.
   2. Standard system hydraulic settings shall be set during startup to meet demand (pressure) requirements for specified equipment: Pump pressure setting shall be coordinated with the Engineer during startup with a preliminary value of 100 psi.
   3. An integrated inlet pressure switch shall be provided to prevent the pump from operating in case of low inlet pressure.
   4. Interface: The control panel unit shall contain hand-on-off controls and the following:
      a. Indicator lights.
      b. Variable pressure settings (field programmable).
      c. A pressure sensor shall be included.

2.04 ACCESSORIES

A. Fiberglass Enclosure: Provide an unheated fiberglass enclosure featuring a hinged, vandal resistant access cover. Openings shall accommodate suction and discharge piping. Enclosure can be anchored to concrete pad. Enclosure shall have minimum internal dimensions of L20” X W15” X H23” and shall be as manufactured by Hot Box, or equal.

2.05 FINISHES

A. Provide pumps, motors and bases with the manufacturer's standard factory-applied paint finish except as noted.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install the pumping system in strict conformance with manufacturer's installation instructions. Check pump and motor alignment according to the Standards of the Hydraulic Institute after complete unit has been installed at the site.

3.02 FIELD TESTING

A. Field test pumping system in accordance with the manufacturer’s recommendations. For further requirements on performance tests, refer to Section 11001.

END OF SECTION

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SECTION 11240

LIQUID EMULSION POLYMER SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

A. This Section describes liquid polymer activation units to automatically prepare a homogeneous polymer solution. Provide complete, tested and operating systems as shown on the Drawings and as specified herein.

1.02 SUBMITTALS

A. Shop Drawings: Submit the following as a single complete initial submittal in accordance with Section 01300. Sufficient data shall be included to show that the product conforms to Specification requirements. Provide the following information:
   1. Product data and catalog.
   2. System general assembly drawings, layouts, equipment dimensions, detailed installation drawings, and schematics.
   3. Motor data.
   4. Weights and materials of construction.
   5. Control panel layout, elementary and connection wiring diagrams clearly showing external connections to other equipment.
   6. Detailed narrative description explaining how the equipment is operated and controlled.
   7. Seismic design and certification in accordance with Section 01190.

B. Manuals and Parts List: Furnish manufacturer's installation, lubrication, operation and maintenance manuals, bulletins, and spare parts lists.

C. Affidavits: Furnish affidavits from the manufacturers stating that each system has been properly installed, adjusted and tested and is ready for full-time operation.

D. Certificate of Proper Installation.

E. Certificate of Compliance.

1.03 QUALITY ASSURANCE

A. All products furnished under this Section shall be supplied by a single manufacturer who has been regularly engaged in the design and manufacture of the equipment specified for a minimum of 10 years. Demonstrate to the satisfaction of the Engineer that the quality is equal to the equipment made by the manufacturers specifically named herein.

B. All components and equipment shall be suitable for the chemicals to be prepared.

C. Comply with the following Regulatory Standards:
   1. Uniform Fire Code (UFC), Article 80, Hazardous Materials, with local amendments, if any.

D. The Contractor shall assign unit responsibility to the equipment manufacturer for all equipment and components specified and referred to in this section. A completed certificate of unit responsibility shall be provided. The equipment manufacturer shall be responsible for selection and purchase of all system components supplies under this contract, and shall assume unit responsibility and certify that the components provide a functional unit suitable for the specified performance.

E. The complete system shall be fully factory tested prior to shipment. Testing shall include: setting and verification of all instrumentation and sensors per the design requirements of the application; pressure testing all plumbing systems for a minimum of 1 hour at 100 psi. If leaks are found they shall be fixed and a new test shall be conducted for 1 hour at 100 psi until the plumbing system is verified to be leak free; verification of system design flow rates, and; complete functional simulation of operation.

PART 2 – PRODUCTS

2.01 MANUFACTURER

A. VeloDyne VeloBlend System modified to meet these specifications in full; or equal.

2.02 PERFORMANCE AND DESIGN REQUIREMENTS:

A. Liquid Polymer Activation Unit Schedule:

Equipment Number	Anticipated Neat Polymer Concentration	Anticipated Neat Polymer Viscosity	Anticipated Polymer Solution Concentration	Neat Polymer Flow (GPH)	Dilution Water Flow (GPM)
WW1-062M0011	35-50%	2000 cps	0.5%	0.25 - 5.0	2 - 20
WW1-062M0012	35-50%	2000 cps	0.5%	0.25 - 5.0	2 - 20

2.03 MATERIALS

A. The following material requirements will be strictly adhered to:
   1. System skid: Type 304 stainless steel
   2. Hardware: Type 18-8 stainless steel
   3. Inlet and Outlet fittings: 304 stainless steel
   4. Piping & pipe fittings: schedule 80 PVC
   5. Tubing and tube fittings: polyethylene, polypropylene, stainless steel and Viton
   6. Water solenoid valve: brass
   7. Pressure gauges: stainless steel, liquid filled
   8. Pressure switches: NEMA 4, brass connection
   9. Flow meter: acrylic, stainless steel, PVC and or polypropylene

10. Water control valve: stainless steel with stainless steel seat
11. Mixing chamber body/flanges: Stainless Steel
12. Mixing chamber cover/chamber: clear polycarbonate
13. Mixing Chamber Discharge: stainless steel
14. Impeller: Type 304 stainless steel
15. Impeller shaft seal: Viton, stainless steel, ceramic, carbon
16. Mixing chamber pressure relief valve: brass
17. Metering pump wetted parts: stainless steel & Viton
18. Seals: Viton, ceramic, and or carbon
19. Control enclosure: NEMA 4X (FRP)

2.04 EQUIPMENT

A. Polymer Activation & Blending Chamber:
   1. These specifications are based on a multi-stage, multi-zone, Hydro-Mechanical polymer activation & blending technology. Alternate technologies will only be considered if proven to provide an equal level of performance, versatility, reliability and quality, otherwise the following technology will be provided without exception.
   2. In order to provide control and versatility to optimize the performance of the wide range of polymers available and to optimize system reliability, a multi-stage Hydro-Mechanical polymer blending technology shall be provided with both a non-mechanical and mechanical mixing stage:
      a. Non-Mechanical Stage: To optimize reliability, the device shall be capable of activating and blending polymer based on plant water pressure alone at 30 psid or greater. Polymer shall be injected directly into a water jet by means of an injection quill positioned such that the non-mechanical mixing energy is no way diminished prior to polymer and water contact. The non-mechanical zone shall be designed such that the velocity of the mixing energy-producing water jet is maintained or increases as flow decreases.
      b. Hydro-Mechanical mixing Stage: In order to provide optimal polymer performance under all operating conditions and to provide total control over mixing energy, in addition to the non-mechanical mixing stage the device shall be capable of producing its mixing energy independent of plant water pressure through a variable intensity, controllable stainless steel hydro-mechanical mixer. The mixing impeller shall be fully controllable and capable of inducing ultra-high, non-damaging mixing energy at all flow rates. This shall be accomplished by controlling mixing intensity and preventing over exposure to, or damaging recirculation through the impeller. The polymer mixing impeller shall be designed to produce both axial and radial flow to optimize mixing effectiveness and to effectively inducing high, non-damaging mixing energy over the systems full flow range.
      c. Mixers that rely solely on plant water pressure and or flow for mixing energy will not be acceptable. Mixers where performance is affected by flow rate and therefore retention time resulting in under or over exposure to mixing energy, or which rely on constant speed impellers or that rely on close tolerances for blending shall not be acceptable.

3. In order to prevent polymer build-up, the mixing chamber shall maintain high velocity in the entire chamber. At no time shall there be low velocity within any portion of the mixing chamber.
4. The mixing impeller shall be controlled by an SCR motor controller and driven by a wash-down duty motor meeting the requirements of Section 11002. The motor shall be mounted horizontally or above the mixing chamber. Motors mounted under the mixing chamber where seal failure or leaks can damage the motor shall not be acceptable.
5. The mixer drive shaft shall be sealed by a mechanical seal which shall have an integrally mounted and factory plumbed seal flush. A drain port behind the seal shall be provided in the mixing chamber to drain the polymer solution in case of a seal failure. The seal shall be easily accessible for replacement. Systems without a seal flushing system shall not be considered. All bearings shall be external from the mixing chamber. Internal bearings shall not be acceptable.
6. Both mechanical and non-mechanical mixing zones shall be clear polycarbonate to view the mixing action and blending effectiveness. Acrylic chambers prone to becoming brittle over time and cracking, or opaque pipe shall not be acceptable to meet this requirement. The clear cover shall have a stainless steel reinforced gusseted flange with a stainless steel discharge connection in order to handle maximum operating pressures.
7. The mixing chamber shall have a maximum rated pressure of 100 psi. Provide a pressure relief on the mixing chamber factory set at 75 psi.
8. Provide a neat polymer check valve specifically designed to isolate neat polymer from dilution water. The valve shall be designed with an open, unobstructed path to the valve seat. To minimize check valve plugging due to normally occurring polymer agglomerations, the minimum open area up to and including the valve seat shall be 3/16 inch without exception. The valve body shall be constructed of Teflon with Viton seals. The valve poppet and spring shall be stainless steel. The spring shall be outside of the polymer flow path to prevent build-up and plugging. The locking pin used to hold the valve in place shall be attached to the mixing chamber with a lanyard. The valve shall be readily accessible for cleaning and shall not require tools for removal, cleaning or replacement. Conventional check valves, valves that rely on ball seals, and or check valves that are installed inside the mixing chamber, or which require mixing chamber disassembly for servicing will not be accepted.

B. Dilution Water Assembly:
1. The dilution water flow rate shall be monitored by a rotameter type flow meter having the range as specified above. Unions or flanges shall be provided on the flow meter to allow easy removal for cleaning.
2. The unit shall have an electric solenoid valve for on/off control of total dilution water flow.
3. A differential pressure type low water differential pressure alarm shall be provided. The switch shall be adjustable between 9 and 60 psid. Static working pressure shall be 500 psi. Proof pressure shall be 2000 psi minimum. The pressure switch shall be as manufactured by Ashcroft.
4. Provide a 2½-inch stainless steel liquid filled pressure gauge to monitor dilution water inlet pressure.

C. Progressive Cavity Neat Polymer Metering Pump:
   1. The unit shall have one (1) neat polymer metering pump(s) integrally mounted on the systems skid. The metering pump(s) shall have a range as specified above. The pump shall be a positive displacement, progressive cavity type constructed of stainless steel and Viton. The shaft seal shall be an adjustable packing type seal. Mechanical seals shall not be used. A 90 Vdc wash-down duty motor shall drive the pump. A gear reducer shall be provided to produce a maximum pump shaft speed of not more than 545 rpm. The motor shall be controlled by an SCR motor controller located in the system control panel.
   2. Provide a calibration column with two full port PVC ball valves having Viton O-rings. The column shall be calibrated for a 1 minute draw-down at maximum pump rate and read in GPH and milliliters. The calibration column shall be rigidly mounted to the systems frame with a minimum of two heavy duty brackets. Mounting the calibration to the neat polymer inlet piping shall not be acceptable. Provide a breather plug in the top of the calibration column designed to allow adequate displacement of air during calibration while preventing water or other foreign material from entering the calibration column.
   3. Provide a pressure relief on the discharge of the metering pump, adjustable between 25 and 100 psi. The valve shall be factory plumbed to the suction of the pump. The valve shall have a stainless steel or PVC body with stainless steel, Viton and Teflon internals. Brass pressure relief valves shall not be acceptable.
   4. Provide a pressure gauge/switch assembly with stainless steel diaphragm isolator to monitor polymer line pressure.
   5. Provide a non-intrusive type loss of polymer flow sensor. Flow sensors that restrict flow or rely on an insertion type sensing probe and therefore are prone to polymer build-up and failure shall not be used. There will be no exception to this requirement. Loss of flow sensor shall be by IFM.

D. Solution Discharge Assembly:
   1. Provide a 2½-inch stainless steel liquid filled pressure gauge to monitor system discharge pressure.

E. Controls:
   1. A control panel integral to the systems frame shall be provided. The enclosure shall be rated NEMA 4X and constructed of Fiber-Reinforced Plastic. The control panel shall consist of all controllers, digital displays, potentiometers, switches, lights, relays, and other control devices required for a complete operable system. The control panel and all components shall be industrial duty. All skid mounted electrical components interconnected to the control panel shall terminate at numbered and labeled terminal blocks. The terminal blocks shall be sized for 14-gauge wire. Wires shall be neatly run through wire race-way and numbered with shrink tubing type labels. Adhesive labels shall not be used. The control panel shall be positioned such that there are no obstructions in front of the control panel per related NFPA requirements.
   2. Power: 120 VAC, 1Ph, 60/50 Hz. with a main power rotary style disconnect switch.
   3. A circuit breaker on the main control circuit and on each motor shall be provided as manufactured by Allen Bradley or equal. Fuses shall not be used for circuit protection.

4. Operator Interface – Discrete Selector Switch:
    a. System ON/OFF(reset)/Remote
    b. One-Turn Potentiometer – Mixer Speed
    c. Ten-Turn Potentiometer – Progressive Cavity Metering Pump Control
5. Status/Alarm Indicators:
    a. Main power ON
    b. Display of Metering Pump Rate (diaphragm pump only: located on diaphragm metering pump face)
    c. Low water differential pressure alarm
    d. Low polymer flow alarm
6. Inputs:
    a. Remote Start/Stop (discrete dry contact)
    b. Pacing Signal Based on Process Flow (4-20mA)
7. Outputs:
    a. System Running (discrete dry contact)
    b. Remote (discrete dry contact)
    c. Low water differential pressure alarm (discrete dry contact)
    d. Low polymer flow alarm (discrete dry contact)
    e. Polymer pump rate (4-20mA)

F. System Skid:
1. The system's frame shall be Type 304 stainless steel construction. No mild steel shall be used. All piping shall be rigidly supported.
2. The pump suction shall not exceed 5 inches from the bottom of the skid for progressive cavity pumps.
3. The skid shall have an integral stainless steel drip pan located under the neat polymer metering pump. Provide one dozen absorbent pads designed for oil and sized to fit within the drip pan.

2.05 POLYMER SYSTEM ACCESSORIES

A. General: Materials of construction shall be satisfactory for continuous exposure to the hereinbefore-listed chemicals.

2.06 SPARE PARTS

A. Furnish spare parts that are necessary for continued operation of the equipment and any special tools required for replacement of parts and adjustment of equipment, including the following:
1. One progressive cavity pump stator (per polymer feed system)
2. One progressive cavity pump shaft seal (per polymer feed system)
3. One banding clamp tool for replacement of the progressive cavity metering pump pin joint banding clamps
4. One neat polymer check valve, complete (per polymer feed system).

2.07 ANCHORS

A. Provide anchors meeting the requirements of Sections 01190 and 05090.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install the equipment in strict accordance with the manufacturer's instructions and with favorably reviewed shop drawings.

B. Upon completion of the installation, the Contractor shall submit a certification, as specified in Section 01650, from the manufacturer stating that the installation of the equipment is satisfactory, that the equipment is ready for operation, and that the operating personnel have been suitably instructed in the operation, lubrication, and care of each unit.

3.02 IDENTIFICATION

A. Identification of hazardous materials is required for the system.

3.03 TRAINING AND FIELD SERVICES

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. Provide an engineer or technician from the equipment supplier for a minimum of 8 hours to thoroughly check and inspect the equipment after installation, place the equipment in operation, make necessary adjustments, calibrate instruments, and conduct field tests, record the results of testing, and issue a manufacturer’s affidavit of proper installation as described in Section 01650.

C. Contractor shall provide polymer required for testing and run the system test with appropriate polymer in all operational and alarm modes to show conformance with the Drawings and the Specifications. Demonstrate that the installed polymer activation units can prepare the polymer solution at the volume and concentrations specified in this Section, and all system accessories are working properly. The polymer used shall be favorably reviewed by the Engineer prior to the test. Provide MSDS for the polymer during the testing of the system. Testing shall be conducted in accordance with the requirements of Section 01650 and Section 11001.

D. Training: Provide 6 hours of additional service by an engineer or technician from the equipment supplier to train plant personnel in system operation, maintenance, and safety procedures.

E. Disposal: Dispose of water used for testing (and cleaning if applicable to the section).

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SECTION 11340

ROTARY SCREW PRESS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Two complete equal sized dewatering systems suitable for dewatering municipal waste activated sludge. Dewatering equipment specified will be installed in an existing dewatering building. Each system to include dewatering screw press, flocculation tank, electrical/control panels, instrumentation and other needed appurtenances as specified in this Section. All equipment shall be provided by a single manufacturer.

1.02 REFERENCES

A. American Bearing Manufacturers Association (ABMA)

B. American Gear Manufacturers Association (AGMA)

C. American National Standards Institute (ANSI)

D. American Society of Mechanical Engineers (ASME)

E. American Welding Society (AWS) D1.1, Structural Welding Code

F. Institute of Electrical and Electronics Engineers, Inc. (IEEE)

G. National Electric Code (NEC)

H. National Electrical Manufacturers Association (NEMA)

1.03 DEFINITIONS

A. Solids Processing Capacity: The number of tons per day of oven-dry feed solids to the dewatering equipment, based on continuous operation, exclusive of process interruptions during wash water cleaning cycles.

B. Total Solids (TS): The weight fraction (expressed as a percentage) of the remaining oven-dried sample of solids to the weight original sample prior to oven drying at 105 degrees Celsius for 24 hours. Total solids shall be determined as specified in Standard Methods for the Examination of Water and Wastewater, 21st edition.

C. Total Suspended Solids (TSS): Shall be determined as specified in Standard Methods for the Examination of Water and Wastewater, 21st edition.
   a. Feed: The total solids content of the solids input to the Dewatering System.
   b. Cake: The total solids content of the product from the Dewatering System.

c. Filtrate. The total suspended solids concentration of the filtrate water returned from the press.

D. Solids % Capture: The percent of the feed solids that remain in the dewatered end product on a weight basis during the normal operating dewatering cycle of the equipment (exclusive of wash cycles).

E. Polymer Demand. The number of pounds of bulk dry active polymer used to produce one dry ton of Cake Solids produced (pounds /dry ton).

1.04 DESIGN CRITERIA AND PERFORMANCE REQUIREMENTS

A. The screw press systems provided under this section will be operated simultaneously in parallel, each being fed from a separate sludge feed pump. They will be used to dewater municipal waste activated sludge. Screw presses will be designed to automatically respond to and accommodate fluctuations in feed flow rate without loss of performance as measured by the requirements specified below.

B. The following design criteria apply to the dewatering system equipment:

Item	Value
Equipment Number	WW1-015M1141, WW1-015M1142
Feed sludge solids concentration, percent total solids	0.8 to 1.2 (1.0 average)
Maximum solids loading rate, dry lbs/hour, ea press	820
Maximum feed flow, ea press, gpm[(a)]	164

Note:

(a) At feed sludge solids concentration of 1.0%. Flow does not include polymer.

C. The dewatering system equipment shall meet the following performance requirements:

Item	Value
Equipment Number	WW1-015M1141, WW1-015M1142
Minimum dewatered sludge concentration, percent total solids[(a)]	16
Minimum solids capture, percent	95
Maximum polymer consumption, active lbs/dry ton	25

Note:

(a) At feed sludge solids concentration of 1%.

1.05 SUBMITTALS

A. 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. Detailed drawings, layouts and descriptions of all required equipment as specified herein. Include information showing all dimensions, parts, constructed details, materials of construction, connection sizes, required overhead and disassembly clearances, and capacity and location of lifting eyes.
3. Motor data as specified in Section 11002.
4. Calculated AFBMA L-10 bearing life and type of lubrication recommended for all equipment (if applicable).
5. Complete system schematic (elementary) wiring diagrams.
6. PLC Input/output (I/O) diagrams.
7. List of relevant Ethernet/IP objects to allow the Owner to complete SCADA configuration.
8. Detailed written control description including modes of operation, interlocking and process control requirements for the complete dewatering system.
9. Panel control and power wiring diagrams, including all connections to external devices.
10. Variable frequency drive details showing conformance to IEEE-519 Standards.
11. Seismic design and certification in accordance with Section 01190.
12. Information on field and installation requirements, including: mounting and access requirements, total number of components to be handled, weight of each component and each complete assembly, overall dimensions of each component and complete as assembly instructions, indication of heaviest and largest (bulkiest) components for handling and lifting, locations for mechanical and electrical connections on the equipment, installation manual with manufacturer's installation instructions, clear delineation on installation drawings of those items being furnished by the manufacturer and those to be furnished (if any) by others.
13. Field Testing Plan: Provide a detailed plan for conducting the specified Functional and Performance Testing in accordance with this Section and Section 01650. As a minimum, the plan shall include procedures that will be used during the testing, and an outline of necessary coordination with the Owner, Engineer, and Contractor.

B. Manuals: Furnish manufacturer's installation, lubrication, operation and maintenance manuals, bulletins, and spare parts lists.

C. Affidavits: Submit affidavit from the manufacturer stating that the equipment has been properly installed, adjusted, and tested and is ready for full time operation.

1.06 QUALITY ASSURANCE

A. 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 10 years. Demonstrate to the satisfaction of the Engineer that the quality is equal to equipment made by those manufacturers named herein.

1.07 DELIVERY, STORAGE AND HANDLING

A. General: Ship items as complete assemblies except where partial disassembly is required to allow for installation into the existing dewatering building, or by transportation regulations or for protection of components.

1.08 WARRANTY

A. The Contractor shall guarantee the equipment to be free from defective material and workmanship for a period of 1 year from the date of acceptance of the equipment by the Engineer. The Contractor shall replace any defective materials, components, or workmanship during this time, including but not limited to all materials, labor, shipping, and transportation, at no additional cost to the Owner. Any repair work performed during this warranty period shall also be guaranteed to be free from defective material or workmanship for a period of 1 year from the date the work is complete and shall be addressed in the same manner at no additional cost to the Owner.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Dewatering screw presses shall be as manufactured by Fukoku Kogyo Company (FKC); no equal.

B. Polymer inline mixing valve and injection ring shall be as manufactured by Alfa Laval, or equal.

2.02 MATERIALS

A. Wetted Parts: Stainless Steel, Type 304, unless otherwise indicated.

B. Non-wetted parts: Stainless Steel, Type 304, unless otherwise indicated.

C. Miscellaneous piping, hardware, including bolts, nuts, washers, and fastener clips in the wetted area: Stainless steel, Type 304, unless otherwise noted.

2.03 EQUIPMENT

A. Housing:
   1. Housing shall be rigid steel weldment, supported by hot-dipped galvanized steel base and shall have removable steel covers for screen access.
   2. Sludge feed connections and filtrate discharge connections shall be Type 304 stainless steel 6-inch flanges meeting ANSI/ASME B 16.1, Class 125, or ANSI/ASME B 16.5, Class 150.
   3. Press shall have Type 304 stainless steel discharge box with hinged lid. Discharge box shall have a flanged connection for attachment of a stainless steel discharge chute.

4. Housing shall be designed for noise reduction, to act as a protective guard, and to provide a complete enclosure for odor containment.
5. The screw press shall be provided with Type 304 stainless steel spray covers on the top and sides of the screw press drums where necessary for sanitation and personnel protection. Side covers shall be easily removable by a single person.
6. Each screw press shall include three foul air connections suitable for a clamped, flexible duct connection. Each foul air connection shall consist of a Schedule 20, Type 304 stainless steel pipe stub. Minimum 4-inch nominal diameter connections shall be provided at the headbox and discharge box. A minimum 6-inch nominal diameter connection shall be provided on the press itself.
7. Provide screw press support structure as shown on the Drawings designed and manufactured by the screw press manufacturer. Support structure shall be hot-dipped galvanized steel conforming to Sections 05090, 05100, and 05500.

B. Drive System:
1. General: Drive system shall consist of an electric motor suitable to use with a variable speed drive (VFD) system as required to provide full load capacity and also to withstand the full starting torque of the system. VFD shall be provided as part of the Screw Press Local Control Panel and meet the requirements of Section 16924.
2. Screw speed shall be electronically controlled by means of a VFD located in the screw press local control panel. Maximum screw speed shall be 1 rpm or lower.
3. Speed Reducer:
   a. Provide speed reducer rated for uniform shock load classification with a cyclo reducer with a minimum service factor of 1.20 based on operating horsepower at maximum solids throughput rate
   b. Speed reducer shall be Sumitomo or approved substitute.
4. Shaft Seals shall be Musashi double lip spring-loaded Nitrite oil seal or approved substitute.
5. Bearings:
   a. Screw press shall be designed so that the entire rotating assembly is supported by 2 main bearings. Each main bearing shall be a grease lubricated ball or spherical roller type bearing. Bearing shall be conservatively designed to withstand all stresses of the service specified. Main bearings shall have a minimum B-10 life rating of 500,000 hours at standard operating speeds.
   b. Bearings for the screw shall be anti-friction with grease lubrication.
6. Flexible connectors for the drive motor and screw press junction boxes shall be furnished by the installing Contractor such that all local electrical codes are met.
7. Screw Press Motor:
   a. Type: Severe duty IEEE 841 motors rated for inverter duty suitable for 3 phase, 460 volt service meeting the requirements of Section 11002 and those of the variable frequency drive provided via Section 16924.
   b. Maximum power shall be 5 HP.
   c. Motors shall have special insulation for damp locations, thermal protection, and motor heater per requirements of Section 11002.

C. Screw Assembly:
   1. Screw Shell: Stainless steel, Type 304.
   2. Helical flight welded to screw shell: Stainless steel, Type 304.
   3. No brushes or wipers shall be attached to the outside diameter of the screw flight. There shall be an air gap between the outside diameter of the screw flight and inside diameter of the screen to minimize wear and maintenance requirements.

D. Screen Assembly:
   1. Stainless steel composed of panels with punched holes. Wedge wire screens are not acceptable.
   2. The screens shall be replaceable in the field without replacing the entire drum assembly.

E. Shower Headers:
   1. Stainless steel pipe, fittings and shower nozzles.
   2. Provide a minimum of five shower headers per press. Shower headers shall be provided along the entire length of the drum set, beneath the headbox, and along the edge of the drain pan on the discharge end.
   3. Operating pressure for all shower headers shall be 30 to 45 psi. Showers requiring higher pressures or booster pumps are not acceptable.
   4. Shower headers shall be stationary and remain in a fixed position. Moving or rotational showers within the wetted, sludge dewatering area or underneath the press covers are not acceptable.
   5. Solenoid valves for the shower system shall meet the requirements of Section 15050.

F. Flocculation Tank:
   1. Flocculation tank shall be constructed of Type 304 stainless steel.
   2. Flocculation tank shall be designed for a volume of 540 gallons. The inlet of the tank shall be located at the bottom of the tank and conditioned sludge shall overflow from the discharge pipe located near the top of the tank. Provide 12-inch discharge pipe stub with flexible rubber hose sleeve connection.
   3. Provide flocculation tank support structure as shown on the Drawings designed and manufactured by the screw press manufacturer. Support structure shall be hot-dipped galvanized steel conforming to Sections 05090, 05100, and 05500.
   4. Flocculation tank shall be supplied complete with an agitator. The agitator drive shall be an SEW Eurodrive Varimot speed reducer/mechanical variator or approved substitute. Agitator speed shall be adjusted by VFD.
   5. Flocculation tank, agitator, and agitator drive shall be designed to handle the entire flow capacity range of the screw press. Motor shall be a minimum 1.5 hp, 460V, 3-phase, VFD-controlled severe duty motor complying with Section 11002.

G. Polymer Injection Ring:
   1. Polymer mixing shall be accomplished by a 6-inch inline mixing valve and polymer injection ring.
   2. The injection ring shall be installed so that the flow enters the valve assembly through the mixing ring.

2.04 INSTRUMENTATION AND CONTROLS

A. Screw press manufacturer shall provide the electrical/control panels, PLCs, uninterruptible power supplies (UPS), HMIs and field instrumentation for the Dewatering System meeting the requirements of Division 16 and Division 17. The Dewatering System shall have both manual and fully automated operating modes. The Dewatering System shall be designed to allow the Owner's Programmer to integrate the Dewatering System into the Owner's existing SCADA system for remote operation.

B. Electrical/Control Panel:
   1. Each enclosure shall be NEMA 4X stainless steel.
   2. The electrical/control panels shall house controls, starters, and drives. The electrical/control panels will serve as the source of power, communication, and control for all of the equipment supplied by the manufacturer. A single source of 480-volt, 3-phase, 60 Hz power will be brought to the control panel. The manufacturer will integrate motor starters, VFDs, the PLC, HMI and other required devices into the design of the control panel. Items using 480-volt power shall be separated from items using 120-volt power by being physically located on separate sides of the panel with separate access doors.
   3. VFDs shall meet requirements of Section 16924.
   4. Each control panel shall have an Ethernet switch per Specification 17330.
   5. Motor starters shall meet the requirements of Section 16920.
   6. Included in the front door of each electrical/control panel enclosure shall be an E-stop pushbutton, an alarm acknowledge pushbutton, an alarm silence pushbutton and alarm horn. In addition, the electrical/control panel shall include Hand-Off-Auto switches, VFD speed controls (0-100% speed potentiometer), run indicating lights, and fail and fail reset pushbutton lights. All pushbuttons, switches, and pilot lights shall be watertight and corrosion resistant. A run time meter and manual wash sequence initiation pushbutton shall be included in the HMI.
   7. The electrical/control panels will be mounted remotely, but within the same building as the screw presses. One control panel will be provided for each screw press.
   8. Each electrical/control panel shall be completely assembled and factory tested by the manufacturer for proper control of the Dewatering System. Ten (10) spare terminal connections shall be provided.
   9. All of the equipment integrally mounted to each dewatering skid shall receive power from and shall be logically controlled by its associated control panel. The Owner's existing Network cabinets shall be connected with CAT 6 cables between the screw press control panels and managed switch. The following is a list of power and logic control that shall at a minimum be provided with each control panel for equipment integral to the system:
      a. VFD for Screw Press.
      b. Start/Stop for Sludge Feed Pumps.
      c. All Required Motor starters
      d. H-O-A switch for dewatering system
      e. Shower water Open/Close
      f. Alarm indicators
      g. Speed adjustment for screw press

h. Speed adjustment for sludge feed pump
i. Speed display for screw press
j. Speed display for sludge feed pump
k. Emergency e-stop push button
l. Control panel main power supply disconnect switch
m. 4-20 mA digital output for polymer system
n. 4-20 mA digital input for headbox level transmitter
o. Polymer system start
p. Polymer system run
q. Polymer system alarm
r. VFD for flocculation tank agitator
s. Speed adjustment for flocculation tank agitator
t. Flocculation tank hi-level switch alarm
u. Start/Stop of sludge conveyors
v. Remote dewatering system start-stop
w. Remote dewatering system alarm

D. The PLC, I/O modules, and HMI shall meet the requirements of Section 17330. The manufacturer shall provide the PLC with sufficient I/O (plus at least 25% spare capacity) for operation of the Dewatering System equipment and for sending and receiving signals to/from the existing plant control system for initiating control adjustments to the polymer system, existing sludge feed pumps, and dewatered sludge conveyors.

E. Provide uninterruptible power supply per specifications 17330.

F. Screw press manufacturer shall provide a differential pressure sensing type level indicating transmitter flange mounted at the flocculation tank, Endress+Hauser series FMD77, or approved equal.

G. Flocculation tank high level conductivity probe with Type 316 stainless steel electrodes, IFM, or approved equal.

2.05 ANCHORS

A. Provide anchors meeting the requirements of Sections 01190 and 05090.

2.06 SPARE PARTS

A. Provide four (4) screens per screw press and one (1) motor coupling per screw press.

2.07 FINISHES

A. Painting: Apply manufacturer’s standard factory paint finish.

PART 3 - EXECUTION

3.01 FACTORY TESTS

A. Conduct factory tests to verify proper installation and operation of all Dewatering System components, including the screw presses, flocculation tanks, and electrical/control panels prior to shipping.

B. Conduct factory tests on all motors in conformance with NEMA MG1-12.51. All tests shall be in accordance with IEEE Standard 112.

3.02 INSTALLATION

A. The manufacturer shall provide instructions for proper handling and installation of the Dewatering System equipment.

B. Manufacturer's field services shall at a minimum include the following:
   1. Initial installation supervision: One trip with one day onsite service per machine.
   2. Inspection and Functional/Operational Testing: One trip with 4 days service.
   3. Performance Testing: One trip with 2 days service.
   4. Training: One trip with one day service.

C. Additional trips resulting from failing to meet the Design Performance Requirements and/or Minimum Performance for Acceptance shall be the sole responsibility of the manufacturer.

3.03 EQUIPMENT STARTUP AND TESTING

A. Perform start-up and testing for entire Dewatering System, with all units operating in AUTO mode. The Contractor and manufacturer shall have completed all programming and electrical/instrumentation and loop testing and the manufacturer shall review the programming to verify completeness prior to Functional Testing.

B. Startup and testing shall meet the requirements of this Section and Section 01650.

C. Sludge testing: Test feed sludge characteristics per manufacturer's standard procedures to confirm sludge characteristics and to aid in polymer dosing/selection a minimum of 60-days prior to beginning Performance Testing.

D. Functional Testing:
   1. The purpose of Functional Testing is to verify that the Dewatering System is functioning as intended by the manufacturer and as additionally described in these Specifications and that the PLC control system is automatically operating the equipment and providing the necessary alarm functions. Per requirements of Section 01010, time shall be provided during Functional Testing for the Owner's Programmer to integrate and test connection of the Dewatering System to the Owner's SCADA system.
   2. Functional Testing shall demonstrate functionality in both manual and automatic modes of operation.

3. Functional Testing shall demonstrate suitable automatic control of screw press operation in two separate modes of operation: with one press in operation and two dewatering presses controlled simultaneously.

E. Performance Testing:
   1. The purpose of Performance Testing is to verify that the Dewatering System meets the Performance Requirements specified. Performance testing shall be completed as part of the 7-day Operational Test specified in Section 01650.
   2. Manufacturer shall supervise all performance testing and shall be solely responsible for operating the Dewatering System and ancillary equipment.
   3. The Dewatering System shall be operated at the specified design criteria conditions to demonstrate compliance with the Performance Requirements. Samples of feed, filtrate, and cake shall be collected by the Owner and tested. The test will be deemed successful if average test results meet or exceed the specified performance requirements.
   4. Sample testing and analysis costs shall be the responsibility of the Owner.
   5. Data collected by the Manufacturer during each test run used to complete guaranteed performance testing shall include, as a minimum:
      a. Run number
      b. Date
      c. Feed sludge percent total solids, % TS
      d. Sludge feed rate, gpm
      e. Polymer name
      f. Polymer percent active, %
      g. Polymer feed rate (neat), gph
      h. Screw press speed, rpm
      i. Amperage draw by the screw press drive
      j. Cake percent total solids, %TS
      k. Filtrate solids concentration, % TSS
      l. Wash water flow rate, cycle frequency and total suspended solids concentration
   6. Provide calculated values for solids throughput, lbs/day dry solids.
   7. Total solids and total suspended solids concentrations will be determined using “Standard Methods” as specified above.
   8. Performance test runs will be conducted independently for each screw press as follows:
      a. Test runs shall consist of two 5-hour steady state runs performed on 2 consecutive days. Testing may be simultaneous. Maintain the specified design solids throughput through each press throughout the test runs.
      b. All sampling, test data and values and previously described and required to demonstrate compliance shall be taken and recorded at the start of each run and every hour thereafter. The averaged results for each sample shall be used to determine compliance with the Design Performance Requirements and Minimum Performance for Acceptance.
      c. The units shall be operated in AUTO mode at all times during the Performance Test runs.
      d. The Dewatering System shall meet every item of the Performance Requirements, as specified herein, prior to acceptance by the Engineer.

e. Should the installed equipment fail to meet the specified Design Performance Requirements, the manufacturer shall within 30 calendar days make all necessary changes to the equipment and/or operation at no cost to the Owner. Changes to the equipment or operation shall be agreed to by the Engineer. The equipment shall be retested using the same procedure indicated above.
f. If, after two (2) Performance Test runs at the design criteria, in the opinion of the Engineer, the Performance Testing results do not meet the Minimum Performance for Acceptance specified herein, the Engineer will notify the manufacturer of non-acceptable performance.
g. In the case of non-acceptable performance, the manufacturer shall have a maximum of sixty (60) calendar days in which to perform at its sole expense, any further testing, equipment adjustment changes or additions, and to perform a re-test of the non-acceptable system. Any equipment adjustment, changes or additions shall be agreed to by the Engineer. Damages for delays shall be applicable during this period of non-acceptable performance. If, after re-testing, the equipment again fails to meet the requirements specified herein, the manufacturer shall physically modify the dewatering system including but not limited to replacement of dewatering system equipment to bring it into compliance with performance requirements. Correcting non-acceptable performance shall be at no cost to the Owner.

9. The manufacturer shall prepare and submit a written report documenting the performance test data listed above and results.
10. Provide a computer spreadsheet compatible with Microsoft Excel (latest version) with the test data listed above.
11. Upon successful completion of Performance Testing, issue the affidavit per Section 01300.
12. Performance Testing shall be successfully completed prior to starting the Acceptance Test specified in Section 01650.

F. Witnessing: All field testing shall be witnessed by the Engineer.

G. A representative of the manufacturer shall be provided for the following:
1. To inspect the equipment and installation
2. To make any field adjustments to ensure proper equipment operation
3. To furnish affidavits stating that the dewatering system has been properly installed and has met the performance requirements as specified herein.
4. To inspect the equipment prior start-up, perform Functional Testing and perform Performance Testing.

H. Manufacturer shall inspect system before initial start-up to verify that system has been correctly installed and prepared for start-up.

I. Training: Manufacturer shall provide field training including safety procedures, operating instructions, preventative maintenance procedures, calibration and other pertinent services. Training shall include both classroom and field training. Provide a minimum of two, 4-hour training sessions.

J. Technical Support During Warranty Period: Provide ongoing technical support for Owner's operation staff during the standard 1-year warranty period.

END OF SECTION

SECTION 11350

COMPOST MIXER

PART 1 - GENERAL

1.01 SUMMARY

Section Includes: Electrically powered horizontal auger mixers on running gear with freestanding mobile electrically powered discharge conveyors specifically designed for use in mixing municipal wastewater solids and non-homogenous woody amendment materials for the production of compost.

1.02 SYSTEM DESCRIPTION

A. Compost Mixer Design Requirements: The mixer shall be capable of mixing non-homogenous material including wood chips, sawdust, and biosolids into uniform mix. The municipal biosolids shall be 15 to 24 percent total solids. Total solids content of the compost mix shall be 35 percent or greater. The compost mix density will be up to a maximum of 1,050 lb/cubic yard (total mix). The mixer shall meet the following design requirements:

Item	Value
Type	Horizonal Auger
Mixer volume, minimum, yd^3	440
Minimum Capacity, yd^3 per hour	52
Maximum Power, HP	60
Gross Vehicle Weight Rating, tons	20

B. Discharge Conveyor Design Requirements: The freestanding, wheeled, discharge conveyor shall receive material directly from the compost mixer and shall meet the following design requirements:

Item	Value
Type	Belt Conveyor
Capacity, yd^3/min	3
Maximum Power, HP	15
~~Length, ft~~	~~18~~
Incline angle, maximum, degrees	22
Discharge height, ft	10~~12~~

1.03 SUBMITTALS

A. 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.

B. Manuals: Furnish manufacturer's installation, lubrication, operation and maintenance manuals, bulletins, and spare parts lists.

C. 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.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Equipment shall be as manufactured by Lucknow*;* Rotomix; or equal.

2.02 EQUIPMENT

A. Horizontal Auger Mixer: Provide a mobile, electrically powered horizontal auger mixer on running gear with 2 to 4 mixing augers. Mixer shell shall be of heavy-duty construction with a minimum thickness of ¼ inch. Upper augur flighting shall have a minimum thickness of ½ inch. Lower augur flighting shall have a minimum thickness of 3/4 inch. Any portion of the mixer shell surface in contact with compost materials shall be Type 304 stainless steel. The unloading chute shall be Type 304 stainless steel. The unloading door shall allow for variable control of the door position. Mixer shall be provided with an electronic weigh scales with a digital readout. Scale contacts shall be integrated into the motor controls to allow its use in turning off the mixer when empty. Mixer shall be supplied with NEMA 4 rated operator control station mounted on the mixer to start and stop the mixer, open and close the discharge gate, and include an emergency stop. The control panel shall include motor starters and controls to operate the mixer and discharge conveyor. Controls shall include an RF remote control unit to allow the mixer to be started/stopped, discharge door opened/closed, and conveyor started/stopped from a remote location. Running gear shall be single axle with tapered roller bearings on the king pins and automotive style ball joints and a 60 degree turning radius. Tire size shall be 425 x 22.5 on heavy duty wheels. Running gear shall include an adjustable tongue assembly with 10-foot reach length and spring assisted lift and safety chain.

B. Freestanding Discharge Conveyor: Provide a mobile electrically powered freestanding discharge conveyor that is designed to accept material directly from the discharge gate of the mixer. Conveyor belt shall be smooth and have a minimum width of 36 inches. Conveyor capacity shall be such that it can convey the full contents of the mixer (minimum design volume) within 5 minutes. An emergency stop shall be provided. Conveyor shall plug into the mixer for power supply.

C. Motors: Motors shall be 480 VAC, 3-phase, severe duty, TEFC meeting the requirements of Section 11002.

2.03 ACCESSORIES

A. Provide a minimum 30-foot-long, heavy duty SOOW cable and switch rated 100-amp 480 volt, 3 phase plug by Meltric or equal. Match receptacle per Detail on the Contract Drawings.

B. Spare Parts: Provide an extra set of belts that connect the electric motor to the drive.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install compost mixing equipment in strict conformance with the manufacturer's installation instructions and at the location as indicated on the Drawings.

3.02 FIELD TESTING

A. Field test all equipment. For further requirements on performance tests, refer to Section 11001.

3.03 FIELD SERVICE

A. The equipment manufacturer shall supply a competent field service engineer to thoroughly check and inspect the equipment after installation, place the equipment in operation, make necessary adjustments, calibrate instruments, and conduct field tests.

B. The equipment manufacturer’s field service engineer shall provide field training including safety procedures, operating instructions, and preventive maintenance procedures for equipment before operation of the system will be taken over by the Owner. Provide a minimum of 4 hours of field training.

END OF SECTION

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SECTION 13131

MEMBRANE STRUCTURES

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. Scope:
   1. This section specifies an exterior architectural tensile membrane structure system, including the building frames, wall and roof covering systems as required. Supplier to provide lateral resistance bracing, etc. as designed by a Structural Engineer and required by Code.
   2. The tensile membrane structure Subcontractor shall be responsible for the detailing, fabrication, supply, and installation of the Work specified herein. The intent of this specification is to establish in the first instance an undivided, single-source responsibility of the Subcontractor for all of the foregoing functions.
   3. Work shall include, but not necessarily be limited to, the supply, fabrication, shipment, and erection of:
      a. The architectural membrane as indicated on the Drawings and in these specifications.
      b. Cables and end fittings.
      c. Perimeter, catenary, and sectionalized clamping system.
      d. Structural steel, including masts, trusses, struts, beams, and/or weldments, as indicated on the Drawings.
      e. Fasteners and gasketing.

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. American Institute of Steel Construction (AISC):
      a. AISC 360 — Specification for Structural Steel Buildings
      b. AISC 303 — Code of Standard Practice for Steel Buildings and Bridges
      c. AISC 341 — Seismic Provisions for Structural Steel Buildings
   2. American Society of Civil Engineers (ASCE):
      a. ASCE 19 — Structural Applications of Steel Cables for Buildings
   3. ASTM International (ASTM):
      a. ASTM A123 — Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products
      b. ASTM A586 — Standard Specification for Zinc-Coated Steel Structural Strand

c. ASTM A603 Standard Specification for Zinc-Coated Steel Structural Wire Rope
d. ASTM C423 Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method
e. ASTM D2136 Standard Test Method for Coated Fabrics—Low-Temperature Bend Test
f. ASTM D2261 Standard Test Method for Tearing Strength of Fabrics by the Tongue (Single Rip) Procedure (Constant-Rate-of-Extension Tensile Testing Machine)
g. ASTM D4851-88 Standard Test Methods for Coated and Laminated Fabrics for Architectural Use
h. ASTM D5035 Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)
i. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials
j. ASTM E108 Standard Test Methods for Fire Tests of Roof Coverings
k. ASTM E136 Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 Degrees C
l. ASTM E424 Standard Test Method for Solar Energy Transmittance and Reflectance of Sheet Materials
m. ASTM A325 Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
n. ASTM D2244 Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
o. ASTM D4214 Standard Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films
p. 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
5. American Welding Society (AWS):
   a. AWS 2.4 Symbols for Welding and Nondestructive Testing
   b. AWS A2.0 Self-Shielding Electrodes
   c. AWS D1.1 Structural Welding - Steel
6. International Code Council (ICC):
   a. 2019 Oregon Zero Energy Ready Commercial Code (OZERCC)
   b. 2019 Oregon Structural Specialty Code (OSSC)
7. National Fire Protection Association (NFPA):
   a. NFPA-701 - Standard Methods of Fire Tests for Flame Propagation of Textiles and Films
8. Society for Protective Coatings (SSPC):
   a. Steel Structures Painting Manual, Volumes 1 and 2

1.03 SUBMITTALS

A. Submit the following as a single complete initial submittal in accordance with Section 01300:
   1. Manufacturer's product data, specifications, and installation instructions for building components and accessories.
   2. Complete erection shop drawings showing foundation, anchor bolts settings, connection details, sidewall, endwall, and roof framing, transverse cross sections, covering and the trim details, interfaces with building construction by others, general seam arrangements and accessory installation details to clearly indicate proper assembly of building components. For structural steel, the drawings shall show all shop and erection details including cuts, copes, connection holes, threaded fasteners, bolts, studs and spacing, etc.
   3. Submittal shall be favorably reviewed prior to any work on the foundations, so that the anchorage and foundation loads may be coordinated with Engineer's design of the foundation. Contractor shall coordinate the anchorage with the foundation design provided in the contract documents.
   4. Test Reports: Provide test reports from a qualified testing laboratory that show compliance of the Subcontractor's HDPE (High Density Polyethylene) tensile membrane system with specification requirements, as follows:
      a. Physical test data of the actual fabric roll goods to be used in the project confirming conformance with specifications for the membrane.
   5. Certificates: Product certificates signed by the Subcontractor certifying materials comply with specified characteristics, criteria, and physical requirements.
   6. 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.
   7. Written certification prepared and signed by a professional Structural Engineer, registered to practice in the State of Oregon, verifying that the building design meets indicated loading requirements and code of the authorities having jurisdiction.
   8. Signed, sealed calculations and drawings for the design for the structure by a professional Structural Engineer, registered to practice in the State of Oregon. Calculations shall include:
      1) Complete calculations for building meeting the requirements of the applicable building codes and demonstrating that the design criteria used are in general conformance with the project standards and this specification.
      2) Design of anchorage to foundation complying with ACI 318 Chapter 17. Anchor design shall be in accordance with Section 01190.
      3) Reaction loads at each column for the Engineer to review, indicating the load combinations used to derive the loads.

1.04 WARRANTY

A. Warranty: Furnish a minimum 20-year manufacturer's covering and assembly warranty. Coverage shall be for material and installation.

B. Subcontractor warrants that the membrane, its perimeter attachment system, and the structural support system as supplied have been installed in accordance with the project specifications and will be free from defects in materials and workmanship that will impair their normal use or service.

1.05 OPERATION AND MAINTENANCE INSTRUCTIONS

A. 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. The manual shall include a schedule for routine inspection, an inspection checklist, instructions for emergency repair and use of emergency repair materials, and warranty. During the system erection period, the Owner shall provide maintenance personnel to be trained in the use of the repair materials.

1.06 SYSTEM REQUIREMENTS/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 Oregon Structural Specialty Code (OSSC).

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 OSSC and indicated on Structural Drawings. See also Sheet S-001. The tensile membrane structure shall not rely on the membrane for structural stability.

C. Fire Performance: Range of characteristics required of membranes:
   1. Burning Characteristics (ASTM E84).
      a. Flame Spread: 5 max.
      b. Smoke Generation (Tunnel Test): 20 max.
   2. Fire Resistance of Roof Coverings (ASTM E108).
      a. Burning Brand: Class A
   3. Incombustibility of Substrates (ASTM E136).
      a. Substrate Noncombustible: Pass
   4. Flame Resistance (NFPA 701 Small Scale, UL 94).
      a. Flame Out: 1 second after
      b. Char Length: 0.25 inch max.

1.07 QUALITY ASSURANCE

A. Subcontractor Qualifications: Fabrication and erection of tensile membrane structures is limited to firms with proven experience in fabrication and construction of complex tensile membrane structures. Such firms, through their own experience and/or that of their qualified subcontractors, shall meet the following minimum requirements:
   1. The Subcontractor shall have at least 10 years' experience in the successful fabrication and erection of permanent, custom tensile membrane structures.

2. The Subcontractor shall have designed, fabricated, and erected at least five HDPE tensile membrane structures of similar size and complexity as this project.
3. The Subcontractor shall demonstrate it owns and operates a fabrication facility of adequate capacity and will maintain a staff experienced in the fabrication of HDPE tensile membrane structures that will undertake the fabrication of this project.
4. The Subcontractor shall maintain an in-house Warranty and Service department to assist in repair and service calls.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store all materials so they will not be damaged or deformed.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. BriteSpan; Big Span Structures, Inc.; Rubb Building Systems; or equal.

2.02 ARCHITECTURAL MEMBRANE

A. General: The membrane used in these structures shall be high density polyethylene ("HDPE). All membranes to be water and mildew resistant, insect proof and UV stabilized.

B. Physical Characteristics:
1. Coated Fabric Weight (oz./sq. yd.): 12 min. (ASTM 4851)
2. Thickness (mils): 23 min. finished thickness. (ASTM 4851)
3. Grab Tensile Strength, lbs — 345 lbs Weft; 370 lbs Warp (ASTM 5035)
4. Tongue Tear Strength, lbs — 100 lbs Weft (ASTM D2261); 110 lbs Warp (ASTM D2261)
5. Mullen Burst — 650 psi (4428 kPa)
6. Cold Crack Resistance — -55ºC (ASTM D2136)
7. Resistance to UV & Weathering — 90% retention after 2000 hr.
8. Low Temperature Bend — -60ºCelsius ASTM D2136
9. FR Performance — ASTM E84Solar Transmission (%): 7 to 22 nom. (ASTM E424)
10. Solar Reflectance (%): 70 to 73 nom. (ASTM E424)

C. Materials:
1. Base Fabric: The yarns shall be free of broken fibers and suitable for coating. The fabric shall be woven with uniform tension and crimp in the warp and fill yarns and free of defects deleterious to the coating process.
2. After weaving, the base fabric shall be cleaned and primed to achieve optimum mechanical properties of the coated membrane. The coating shall be free of mud cracks and pinholes. Membrane to be UV-resistant per manufacturer’s warranty.
3. Membrane Color: To be selected by Owner from manufacturer’s standard colors.

2.03 CABLES AND END FITTINGS

A. Materials:
   1. All structural wire rope cables shall conform to the latest revision of ASTM A603.
   2. All structural strand cables shall conform to the latest revision of ASTM A586.
   3. All cables shall be coated to “Class A” zinc coating throughout.
   4. All cables in contact with the membrane shall be white PVC coated. All other cables may be galvanized only.
   5. All swaged and speltered fittings shall be designed and attached to develop the full breaking strength of the cable. Thimble end fittings shall develop a minimum of 90% of the cable breaking strength.
   6. Swaged end fittings, pins, nuts, and washers shall be hot dip galvanized per ASTM A153. Any damage to the zinc coating shall be cleaned and painted with a gray zinc-rich paint per ASTM A780.
   7. Speltered end fittings shall be hot dip galvanized per ASTM A153. Any damage to the zinc coating shall be cleaned and painted with a gray zinc-rich paint per ASTM A780.

2.04 STRUCTURAL STEEL

A. Materials:
   1. Structural steel for plates and bars shall conform to the requirements of ASTM A36 or ASTM A572, Grade 50, unless noted otherwise.
   2. Structural pipe shall conform to ASTM A53, Types E or S, Grade B.
   3. Structural tubing shall conform to ASTM A500 Grade B.
   4. Structural bolts.
      a. High strength bolts: ASTM A325, unless noted otherwise.
      b. Common bolts and nuts: ASTM A307.
      c. Threaded rods: ASTM A36, unless noted otherwise.
   5. Other materials: All other materials, not specifically described but required for a complete and proper installation of structural steel, shall be provided and shall be new, free from rust, first quality of their respective kinds, and subject to the approval of the Subcontractor.
   6. Workmanship: All members, when finished, shall be true and free of twists, bends, and open joints between the component parts.
   7. Grind all edges and corners that could contact membrane to a minimum 1/16-inch radius.
   8. Finish: Truss framework tubing and all structural members shall be hot dipped galvanized after fabrication in accordance with ASTM A123. No in-line galvanizing allowed.

B. Accessories:
   1. Base Plates and Anchor Bolts:
      a. Base plates supported on concrete, whether shop attached or shipped loose, shall be furnished and set on shims, leveling plates, or leveling nuts. Grouting shall be by the General Contractor.
      b. Anchor bolt locations shall be furnished by the Subcontractor and used by the General Contractor to set the bolts. The General Contractor is to check carefully the setting of the bolts to their proper position prior to placing of concrete. Anchor bolts, shall be provided per requirements of

Section 05090. Damaged threads shall be repaired or be cut to permit full tightening of nuts.

C. Connections:
   1. Connections shall be as indicated on the Drawings. When details are not shown the connections shall conform to the requirements of the AISC.
   2. Provide high-strength threaded fasteners for all structural steel bolted connections, unless noted otherwise.
   3. Combination of bolts and welds in the same connection are not permitted, unless otherwise detailed.
   4. Welded Connections:
      a. Operators: Welds shall be made only by operators who have been previously qualified by tests, as prescribed in AWS D1.1 to perform the type of work required.
      b. No members are to be spliced without prior approval.
      c. All welding shall be done in accordance with the reference specifications.
      d. The use of oxygen-cut holes for bolted connections or pin connections will under no circumstances be permitted.
   5. Tolerances: All tolerances shall be as per the AISC “Code of Standard Practice for Steel Buildings and Bridges” unless otherwise indicated. Limit variation in straightness to (member length)/960 measured in any direction for all members.

2.05 FASTENERS

A. General: Provide fasteners used to secure clamp systems to curbs and cables, assemblage of clamp systems, and other fasteners as required to complete the work specified herein.

B. Materials:
   1. All work shall comply with the latest edition of ASTM standards and American Iron and Steel Institute (AISI), as referenced herein.
   2. Fasteners used in membrane clamping systems shall be stainless steel. Bolts and studs shall conform to ASTM F593, Type 304. Nuts shall conform to ASTM F594, Type 316. Washers shall be plain, narrow, and conform to AISI Type 18-8.
   3. All clamping systems subjected to relative movement between clamping and curb shall receive a split-ring lock washer conforming to AISI Type 18-8.
   4. Unless otherwise specified on the Drawings, all other bolts and nuts shall conform to ASTM A307-76B, hot dipped galvanized.

2.06 GASKETING

A. General: All work shall comply with the latest edition of ASTM standards, as referenced herein.

B. Sponge Neoprene Gasketing:
   1. Material:
      a. All sponge neoprene shall be of a cellular elastomeric compound of a firm grade, which has been manufactured in pre-formed shapes for use as gasket and sealing material, as specified in ASTM C509.

b. Cellular elastomeric materials furnished to this specification shall be manufactured from natural or synthetic rubber, or mixtures of these, with added compounds of such nature and quality that, with proper curing, the finished product will comply with this specification.
c. The physical characteristics of the neoprene must meet or exceed ASTM C509, “Standard Specification for Elastomeric Cellular Preformed Gasket and Sealing Materials.”

C. Dense Neoprene Gasketing:
1. All neoprene material shall conform to ASTM D2000M hardness Grade 60. The material shall be homogenous, free from defects, and shall be compounded and cured to meet the requirements specified herein.
2. All neoprene shall be non-staining formulation and shall consist of at least 50% by weight of basic rubber hydrocarbon. Material shall not contain crude or reclaimed rubber.
3. The physical characteristics of the neoprene must meet or exceed the following physical test requirements when tested using the standard ASTM test slab can compression set plug (or approved equal):

PROPERTY	ASTM TEST METHOD	UNITS
a. Shore A Durometer	D2240	55 – 65
b. Tensile Strength (Min.)	D412	1,100 PSI
c. Percent Elongation (Min.)	D412	300%
d. Percent Compression Set (Max.)	D395, Method B,	35% 22 hrs at 212°F
e. Heat Aging, Change from Original Properties	D573	70 hrs @ 212°F
1) Hardness Change (Max.)		+15 Points Shore A
2) Tensile Strength (Max.)		-15%
3) Elongation Change (Max.)		-40%
f. Flame Resistance		Must Not Propagate Flame
g. Temperature Range		-30°C to 100°C
h. Ozone Resistance	D1171, Method A	72 hrs @ 38°C and 50 mPa Ozone
i. Resistance to Oil Aging:	D471	70 hrs @ 212°F Immersion in ASTM Oil No. 3
1) Tensile Strength (Max.)		-70%
2) Elongation (Max.)		-55%
3) Volume Change (Max.)		+120%

PART 3 - EXECUTION

3.01 GENERAL

A. Membrane assembly shop drawings shall include all information necessary for the fabrication by the Subcontractor of the tensile membrane structure. They shall include size and shape of envelope, type and location of shop and field connections, size, type, and extent of all heat-welded seams.

B. The Subcontractor shall take necessary care to plan and assemble the fabricated sections such that the assembly has no shop patches. Splices, if any, shall be patterned into a symmetrical and repetitive geometric arrangement within the assembly, shown on the shop drawings and, where feasible, hidden by structural members.

C. All fabricated joints shall have a minimum of 90% of the total strength of the coated membrane in strip tensile testing. All structural joints shall be fused in accordance with industry standards and shall maintain the integrity of the coating. PTFE-coated woven fiberglass membranes shall be heat-sealed only.

D. Biaxial Test: At least one representative sample of the outer membrane shall be biaxially test loaded. Membrane compensation in patterning shall be based upon the results of the biaxial test loading.

3.02 ERECTION OF MEMBRANE ASSEMBLIES

A. Prior to installation of the membrane assemblies, the Subcontractor shall meet with the General Contractor to review the erection procedure and scheduling. The Subcontractor shall coordinate all work with other trades.

B. Erection of Structural Steel (or other structural supporting elements):
   1. Adequate guy cables shall be used throughout the work and all erection bolts shall be drawn up tight.
   2. All steel shall be accurately aligned before permanent connections are made.
   3. Temporary bracing shall be left in place as required for safety. The bracing shall be located so it does not interfere with the erection of the tensile membrane structure; remove as required during construction.
      a. The structure is to be self-supporting and stable after the building is fully completed. It is the Subcontractor's sole responsibility to determine the erection procedure and sequence and to ensure the safety of the building and its component parts during erection, including the addition of temporary bracing, guys, or tie-downs that may be necessary. Such materials shall be removed by the Subcontractor and remain his property after completion of the project.
   4. Erection tolerances shall be specified in the AISC "Code of Standard Practice for Steel Buildings and Bridges," including those related to placement of anchor bolts, unless otherwise indicated.
      a. Tensile membrane structures (including individual membrane panels) are pre-engineered and prefabricated to fit a specific theoretical dimension. For those primary and secondary structural elements to which the membrane structure (including an individual membrane panel) is connected, the erected position of member working points, including those of cantilevered members, shall not vary from the theoretical model by more than 1 inch (25mm) in any direction, either individually, or cumulatively across a shipping piece. This includes but is not limited to, cable connection points, membrane panel edges, membrane bearing locations, intermediate splice points of field-spliced members, hardware connections, weldments and their anchorages. For arched members, include the three-dimensional location of the member midpoint as a working point for tolerance measurement.

b. The cumulative effect of dimensional steel discrepancies shall be such that the distance between membrane panel support points does not vary more than 1 inch from the theoretical dimension within each membrane panel.
c. All steel structures that support tensioned membrane must maintain an uninterrupted drainage path and a minimum constant slope of 5 degrees from all points of the membrane.

3.03 PROTECTION AND CLEANING

A. Protect work from damage and deterioration during installation.

B. Upon completion of tensile membrane structure installation:
1. The Subcontractor shall clean all surfaces of the system's components in conformance with the membrane manufacturer's recommendations.
2. Inspect the system and repair membrane panels that have become damaged. Repairs shall be executed in such a way that they are visually acceptable.

C. Further protection of the work and final cleaning, if necessary, shall be the responsibility of the General Contractor.

END OF SECTION

SECTION 13501

CASP COMPOSTING SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: A covered bio-layer aerated static pile (CASP) compost treatment system specifically designed to treat unstabilized municipal wastewater solids to meet Class A biosolids requirements as prescribed in Title 40 Code of Federal Regulations (CFR) Part 503 and in Chapter 340 Division 50 of the Oregon Administrative Rules (OAR). The system is to include in-trench aeration, piping and accessories, fans, ductwork, biofilter for odor control, controls, instrumentation, and all appurtenances for a complete and operable composting system.

1.02 SYSTEM DESCRIPTION

A. Design Requirements: The composting system shall be constructed in two project phases. The Phase 1 system provided in this project includes four composting zones and a biofilter to treat foul air. All zones provided as part of the Phase 1 system shall be capable of operating as either primary or secondary composting zones. The Phase 1 aeration and controls are organized into one fan group comprised of air supply and exhaust air. The system shall be designed to continuously monitor and record compost temperatures and adjust aeration fan speed and motorized dampers to maintain operator selected process conditions in individual zones. A future Phase 2 project will expand the compost system adding four additional zones contiguous with the four composting zones constructing during the Phase 1 project. The resulting eight side by side zones will operate as primary composting zones. The Phase 2 project will also include construction of eight separate secondary composting zones served by a separate fan group. Capacity of the fans, air ducts, and control system installed in Phase 1 shall have sufficient capacity for future expansion to eight equal sized primary composting zones without additional fans or changes to motor horsepower, existing duct sizes or the control system.

B. Design Criteria: The Phase 1 CASP system shall meet the following design criteria:

Item	Value
Treatment Capacity, Total Mix Wet TPY[(a)]	5,000
Treatment Capacity, Wastewater Solids, Dry PPD	2,000
System Type	Bio-layer Covered Aerated Static Pile
Number of Zones	4
Zone Dimensions[(b)]	
Length, ft	43
Width, ft	30
Compost Volume, CY per Zone[(c)]	340

Item	Value
Retention Time, Days	22
Aeration Type	Variable Rate, Reversing
CASP Aeration Floor Type	Low Pressure Trench
Aeration Power (max)[d]	
Supply, HP	20
Exhaust, HP	30
Max Aeration Fan Speed, rpm	2,700
Inlet Air Temperature, °F	32 - 90
Biofilter Aeration Floor Type	Pipe on Grade
EBRT[e], Minimum, Seconds	60
Active Biofilter Footprint[f], Minimum, SF	1,200
Biofilter Media[g]	Shredded Wood
Biofilter Media Depth, ft[h]	5

Notes:

(a) Based on total fresh mix of unstabilized municipal wastewater solids and compost amendment with an estimated initial stacked density of 887 lb/yd^3. The dewatered cake solids concentration is 16% and the amendment solids concentration is 60%.
(b) Average compost pile depth is 8 feet of compost mix and 1-foot depth of finished compost cover.
(c) Compost volume is the volume of the initial mix.
(d) Maximum installed fan power.
(e) Empty bed retention time.
(f) An additional 2.5 ft buffer shall be provided between the active biofilter footprint and adjacent vertical walls used to help retain the biofilter media.
(g) The biofilter media is a mix of a fresh shredded trunk wood with finished compost with the fines (less than 2 inches in size) screened out as specified by the manufacturer. Media to be provided by Owner.
(h) Initial bed depth immediately after construction.

C. Performance Criteria: The Phase 1 CASP shall be designed to meet the following performance criteria:

Item	Value
Biosolids regulatory criteria[a]	Class A
Target Compost Pile Temperature Range, °C	40 to 65
Peak Aeration Rate, cfm/cy[b]	6
Nominal Fan Efficiency (Min), cfm/hp[c]	400
Fan Noise, (Max), dBA[d]	
Supply Fan[e]	86
Exhaust Fan	88
Maximum Operating Pressure [f], inches w.c.	10
Nominal Biofilter Inlet Air Temperature, °C	40

Notes:

(a) As prescribed in Title 40 Code of Federal Regulations (CFR) Part 503 and in Chapter 340 Division 50 of the Oregon Administrative Rules (OAR). Ability to meet Class A regulatory requirements are based on an assumed fresh compost mix with sufficient bio-available volatile solids to generate an average heat flux of 3800 BTU/HR per cubic yard at thermophilic composting conditions (55°C material temperature, >12% O_2 by volume) for a continuous period of 7 days.
(b) Minimum peak rate that can be supplied to any one zone, per manufacturer's instructions, in either positive or negative aeration.
(c) For both supply and exhaust fans, fan efficiency is measured at the maximum operating pressure specified.
(d) Free field at 3 feet and at full speed.
(e) With inlet silencer.
(f) Design capacity gauge pressure measured in Supply and Exhaust Plenums.

1.03 SUBMITTALS

A. 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.
   3. Seismic design and certification in accordance with Section 01190.
   4. Certified fan curves from shutoff to free delivery with specified operating-point clearly plotted. Corrections for temperature and altitude where applicable.
   5. Compost system layout including drawings of the aeration system with equipment dimensions and points of connection.
   6. Elementary and connection wiring diagrams clearly showing external connections to other equipment.
   7. Complete list of control system memory locations with descriptions and their respective Modbus TCP/IP addresses for the Owner's use in interfacing to their Modbus converter and ultimately to the Owner's PLC.
   8. Written control narrative of the composting system such that the Owner's Programmer can integrate the composting system into the Owner's SCADA control system.
   9. Field Testing Plan: Provide a detailed plan for conducting the specified Functional and Performance Testing in accordance with this Section and Section 01650. As a minimum, the plan shall include procedures that will be used during the testing, and an outline of necessary coordination with the Owner, Engineer, and Contractor.

B. Performance Testing: Submit certified non-witnessed factory performance test results. Receive favorable review of test results prior to shipping the equipment.

C. Manuals: Furnish manufacturer's installation, lubrication, operation and maintenance manuals, bulletins, and spare parts lists.

D. 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 vendor who has been regularly engaged in the design and supply of aerated static

pile systems for at least 10 years, with at least three aerated static pile installations for composting biosolids in North America. Demonstrate to the satisfaction of the Engineer that the quality is equal to equipment made by those manufacturers named herein.

B. Regulatory Requirements: The composting system must meet Class A biosolids requirements as prescribed in Title 40 Code of Federal Regulations (CFR) Part 503 and in Chapter 340 Division 50 of the Oregon Administrative Rules (OAR) within the system's initial primary zones and a 22-day detention period.

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 Manufacturer will provide a guarantee that the equipment and components furnished will be and remain free from defects in workmanship and materials and perform the general process function intended, for a period of 12 months from completion of installation, start-up or acceptance of the equipment.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Engineered Compost Systems, Inc; no equal.

2.02 MATERIALS

A. Compost system component materials shall be as specified below:

Item	Value
Aeration Ducting	
Above Ground – Exhaust Air	304 Stainless Steel
Above Ground – Supply Air	HDG Steel
Below Ground	HDPE (DR17)
Supports	HDG Steel
Aeration Trench Components	304 Stainless Steel
Temperature Probes Shaft & Tip	316 Stainless Steel
Biofilter Laterals	HDPE (DR17)
Fans	
Exhaust Fan Wheel and Housing	304 Stainless Steel
Supply Fan Wheel and Housing	Mild Steel
Aeration Dampers	304 Stainless Steel

Item	Value
Fasteners	304 Stainless Steel
Anchors	316 Stainless Steel
Pressure Transducer (wetted diaphragm materials)	300 Series Stainless Steel

2.03 EQUIPMENT

A. General: The aerated static pile compost system shall be furnished as an integrated package specifically designed for treatment of unstabilized municipal wastewater solids. It shall be a complete and functional system including fans, aeration floor piping and appurtenances, control panel, instrumentation including temperature probes with sensors and pressure indication transmitters, cables, junction boxes, dampers, biofilter odor control system and required appurtenances. Provide the aeration and control equipment for an aerated static pile system organized into four compost zones designed for primary composting and capable of reversing aeration. The system shall be designed with system components suitably sized for future expansion to eight primary composting zones. The system shall be designed to allow for initial anticipated operations in which two of the composting zones will be operated as primary zones with reversing aeration and two zones operated as secondary composting zones with positive aeration only. The system shall be designed to continuously monitor and record compost temperatures and adjust aeration fans and motorized valves to maintain constant treatment in individual zones. The complete compost system shall be capable of independently controlling the internal temperature of the compost zones within the specified accuracy and range of temperatures. The fans, air ducts, and control system installed in Phase 1 shall be have sufficient capacity to support the future Phase 2 buildout.

B. Fans:
   1. Fans: The aeration system shall be capable of reversing aeration with dedicated supply and exhaust fans capable of automatically and independently providing positive (air forced up through a pile) or negative (air drawn down into a pile) air flow to any combination of composting zones. Fans shall provide the specified capacity and shall be suitable for variable speed operation via Variable Frequency Drives (VFD) provided under Section 16924. In addition, the negative aeration fan shall be capable of drawing in up to 50% additional ambient air and discharge the entire flow through a biofilter. The wheel of the exhaust fans shall be designed to withstand condensing liquid. Both fans will include a sealed shaft. Supply fan shall be provided with an inlet silencer designed to reduce fan noise a minimum of 12 to 15 dbA.
   2. Connections: Provide fans with heavy-duty flexible connectors made from minimum 1/4-inch- thick molded EPDM rubber with flanged, metal backed, mounting connections between the ducting and fan inlets and outlets.
   3. Motors: The fan motors shall meet the requirements of Section 11002 and be 460-volt A.C., 60 Hertz, 3-phase, TEFC, premium efficiency, severe duty, and inverter duty rated and shall be provided with space heaters.

C. Ductwork:
   1. Above ground aeration ducts: Ductwork shall be linear seam welded steel. All ducting will be designed for at least +/- 10 inches of static pressure. All duct to duct connections shall be gasketed.
   2. Supports: Provide duct supports meeting requirements of this Section and Section 01190.
   3. Buried aeration piping: Connections shall be with prefabricated Van-Stone type flanges. Pipe components shall be delivered prefabricated and ready for installation with no cutting or on-site fusing required. Pipe, fittings, connections, and fasteners shall meet the requirements of Section 15050.
   4. Aeration trench system: Provide low pressure loss, covered, in-ground type aeration trenches complete with necessary embeds, covers, and fasteners. Design shall provide removable components and allow for ease of cleaning. The aeration trench system shall connect to a below-grade drainage system designed to prevent air from short-circuiting between different compost zones.
   5. Actuated dampers: Provide separate electrically actuated 24VDC butterfly dampers for each composting zone. These valves shall control aeration flow direction through the compost (positive and negative) based upon the differential temperature of the inner and outer pile temperature probes to achieve and maintain temperatures required for proper composting. Provide an electrically activated louvered 24VDC air damper for adding ambient air prior to the exhaust fan intake to automatically maintain set-point exhaust air temperatures. The butterfly dampers shall feature gasketed damper blades, a travel time from open to closed of no more than 45 seconds and shall be designed for less than 5% leakage at system design pressure. Damper actuators shall be manufactured by Belimo. Dampers shall include position feedback signal.

D. Compost Zone Irrigation: As shown, compost zone irrigation shall connect to a minimum 30 gpm (minimum of 50 psi) water supply at the rear of each compost zone. Irrigation equipment shall include the following:
   1. Solenoid (24 DC) actuated water valves controlled by the compost control system.
   2. Irrigation laterals with adequate spray nozzles to evenly distribute water across the compost pile surface with 90% coverage. Irrigation piping shall meet the requirements of Section 15050.
   3. Irrigation spray nozzles that provide a low angle, large droplet spray pattern to minimize wind driven water loss.

E. Biofilter: The biofilter shall be pipe-on-grade type with the following characteristics:
   1. Ductwork from the exhaust fan shall act as a plenum for the pipe on grade aeration laterals.
   2. Biofilter shall be suitable for construction on asphalt concrete paving as shown on the Drawings.
   3. Media depth shall be determined by the manufacturer but no less than shown on the Drawings.
   4. Design shall permit individual aeration laterals to be disconnected and pulled from beneath the biofilter media to facilitate media replacement.

5. Biofilter shall include top surface irrigation. Irrigation equipment shall connect to a minimum 20 gpm (minimum of 50 psi) water supply as shown on the Drawings. Irrigation equipment shall be designed to evenly distribute water across the biofilter surface with at least 90% coverage of the biofilter surface. Irrigation equipment shall include the following:
    a. Free standing spray nozzles designed to sit on top of the biofilter media that provide a low angle, large droplet spray pattern to minimize wind driven water loss.
    b. UV resistant flexible hose to form lateral assemblies interconnecting spray nozzles.
    c. Solenoid (24 VDC) actuated water valve controlled by the compost control system.

2.04 INSTRUMENTATION & CONTROLS:

A. General: The composting system is comprised of multiple compost zones served by an aeration system containing automatically controlled supply and exhaust fans and aeration dampers. The system shall be automatically controlled by the CASP control system consisting of a Process Control Server, Communication Node, customized software, junction boxes with control hardware and temperature and pressure instrumentation. Fan speed shall be automatically controlled to maintain preset header pressure setpoints. Flow rate and direction in individual compost zones shall be automatically controlled to maintain preset temperature conditions. VFDs shall be provided separately and as specified in Section 16924. All instruments, dampers, solenoids, and valves shall land on Input Output (I/O) in the Owner provided, Contractor installed, Remote I/O (RIO) panel. The VFDs for the supply and exhaust fans shall land in the Owner's existing PLC.

B. Process Control Server and Communication Node:
    1. Process Control Server and Communication Node shall be installed in NEMA 4X enclosures.
    2. The Process Control Server and Communication Node shall communicate to the Owner's existing control system via Modbus TCP/IP over fiber optics. The Owner shall convert Modbus TCP/IP to Ethernet TCP/IP to communicate between the Process Control Server and the Owner's existing SCADA system. Provide Owner with memory addresses to allow for transfer of information between the two control systems (Process Control Server and the Owner's existing Biosolids PLC).
    3. The Process Control Server shall automatically control the composting system transmitting signals to and receiving signals from the Owner's control system. The Owner's Programmer shall develop an HMI screen with adjustable setpoints and status of the composting system. Coordinate setpoint ranges with the Owner. The Process Control Server shall at a minimum provide the following functions for control of the composting system:
        a. Monitoring and recording of the compost temperatures within the composting zones.
        b. Batch tracking throughout the composting process (moving from one zone to another).
        c. Controlling the VFD speed for the composting supply fan to maintain set-point pressures and providing fault clearing of the VFD.

d. Controlling the VFD speed for the composting exhaust fan to maintain set-point pressures and providing fault clearing of the VFD.
e. Controlling the motorized air dampers to maintain set-point temperatures in the compost zones. Temperature setpoints shall be operator adjustable.
f. Monitoring the temperatures in the biofilter, exhaust air and ambient air.
g. Controlling the cooling air damper to maintain set-point exhaust air temperatures.
h. Selection of operating mode (primary or secondary composting) for all composting zones.
i. Controlling the irrigation valves in the composting zones and biofilters using adjustable scheduled timers.
j. Operator overrides (manual control) of all automated functions.
k. Process Control software shall have capability to control the future Phase 2 composting system without any physical changes to system components installed during Phase 1.

4. The Communication Node shall consist, at a minimum, of an Ethernet switch and fiber patch panel per Section 17330.
5. The operator interface with the composting control system shall be via the Owner's SCADA system. The manufacturer shall coordinate data sharing with the Owner's Programmer to facilitate the addition of the CASP system to the Owner's SCADA system. SCADA control displays shall at a minimum include the following:
   a. Show zone temperatures, progress towards meeting regulatory time/temperature goals (PFRP and Vector-Attraction-Reduction), damper status, fan status, and system faults on a graphical display.
   b. Display and record temperatures as a time/temperature graph suitable for proof of regulatory compliance.
   c. Allow operators to inspect, edit, and upload process control parameters. The process control parameters shall include three successive time temperature set-point profiles, minimum aeration damper open times, high and low temperature limits, and duty cycle period selection.
   d. Selection of operating mode (primary or secondary composting) for all composting zones.
   e. Operator configurable settings shall include aeration pressure set-points, and exhaust temperature set-point.
   f. The sequence in which regulatory time/temperature requirements are to be achieved shall be reconfigurable by the manufacturer and the Owner.
   g. Display and print recorded temperatures as a time/temperature graph suitable for proof of regulatory compliance.
6. The Owner shall create a DMZ (demilitarized zone) specifically for remote internet access by the Manufacturer to the Process Control Server. Coordinate with Owner.

C. Junction Boxes for instrumentation devices:
   1. Provide NEMA 4X junction boxes for each composting zone and the fan area and biofilter.
   2. Each junction box shall provide terminations for field devices and convert device signals to 4-20mA signals that will be connected to the Owner's Remote I/O Panel.

D. Temperature Probes:
   1. Provide dual sensor, 60-inches-long, compost temperature insertion probes for composting zones. The probe shafts shall attach to a heavy-duty Type 304 stainless steel handle/platform with molded fiberglass junction box. Probes shall be connected to junction boxes located at each composting zone via a high visibility environmentally rated cable. Number of probes shall be as shown.
   2. Biofilter temperature insertion probes shall be single sensor at tip, 30 inches long, and Type 316 stainless steel. Number of probes shall be as shown.

E. Pressure Transducers: Electric differential pressure transducers shall convert a gauge pressure measurement to a 4-20 mA dc linear electric output signal capable of transmission into a 600 ohm maximum load at 24 Vdc. Signal and power transmission shall be provided by a single pair of wires. Operating ambient temperature shall be at least -18° to +80°C. Overrange protection shall be at least 1-1/2 times span without degradation of accuracy. Reference accuracy shall be ±0.5% of calibrated span or better.
   1. The process connection shall be ¼ inch and stamped with high (H) and low (L) pressure ports.
   2. The transducer shall be provided pre-mounted inside a NEMA 4 rated enclosure. The transducer enclosure shall also include a pre-mounted, thermal switch controlled, 24 Vdc resistive heater capable of providing 30 watts to heat the inside of the enclosure.

2.05 FINISHES

A. Manufacturer’s standard factory applied coating system.

2.06 ANCHORS

A. Provide anchors meeting the requirements of Sections 01190 and 05090.

2.07 SPARE PARTS

A. Manufacturer to provide the following spare parts:
   - (1) spare actuator
   - (2) 60” spare temp probes (compost zones)
   - (1) 30” spare temp probe (biofilter)
   - (1) spare pressure sensor

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install aerated static pile compost system in strict conformance with the manufacturer's installation instructions and at the location as indicated on the Drawings.

3.02 FIELD TESTING

A. Perform start-up and testing for entire CASP system with all units operating in AUTO mode. The Contractor and Manufacturer shall have completed all

programming and electrical/instrumentation and loop testing prior to initiation of Functional Testing.

B. Startup and testing shall meet the requirements of this Section and Section 01650.

C. Functional Testing:
   1. The purpose of Functional Testing is to verify that the CASP Compost System's mechanical, electrical and software is functioning as intended by the Manufacturer and as additionally described in these Specifications and that the control system is automatically operating the equipment and providing the necessary status and alarm functions. Time shall be provided during Functional Testing for the Owner's Programmer to debug and test the Owner's RIO, PLC, and SCADA system.
   2. Functional testing will also verify the communication between the compost Process Control Server and the Owner's PLC and help the Owner verify that all compost system devices are connected and controlled by the PLC as required.
   3. Functional Testing shall demonstrate functionality in both manual and automatic modes of operation.
   4. Functional Testing shall demonstrate suitable automatic control of supply and exhaust fans and air dampers based on compost batch temperature and air header pressure requirements.
   5. Upon successful completion of the Functional testing, the manufacturer will complete the affidavit per Section 01650 and submit per Section 01300.

D. Performance Testing
   1. The purpose of Performance Testing is to verify that the CASP Compost System meets the Design Performance Criteria and Minimum Performance for Acceptance specified herein when operated in accordance with the manufacturer's recommendations.
   2. Prior to starting performance testing, a minimum of four start-up batches will be processed in the primary composting zones to allow for system and control parameter tuning. The 7-day Operation Test and 30-day Acceptance Test specified in Section 01650 may be completed during processing of the four start-up batches. Requirements for continuous operation and restarting of the 7-day and 30-day test periods shall be as specified in Section 01650.
   3. Division of responsibilities for labor, maintenance and materials shall be as specified in Section 01650.
   4. During the performance testing period the Manufacturer will provide the following:
      a. Batch temperature reporting to demonstrate compliance with time-temperature requirements for satisfying Processes to Further Reduce Pathogens (PFRP) and Vector Attraction Reduction (VAR).
      b. Operational support to determine initial feedstock mix requirements and initial system settings.
      c. Ongoing support and monitoring during the performance period to assist with system operation.

5. During the performance testing period the Owner will collect the following data for each compost batch to be tested:
    a. Feedstock characteristics, including total solids, %TS, moisture %, and Feedstock mix analysis as needed (Carbon/Nitrogen ratio, volatile solids, TKN%)
    b. Compost mix ratios (by mass) for biosolids and amendments
    c. Fecal coliform and Salmonella from final compost product (samples will be taken directly from the primary composting piles while they are being broken down, using Manufacturer approved standard sampling methods). Owner will be responsible for sampling and sending samples to an approved lab.
6. Performance testing will be deemed successful if the CASP compost system is shown to treat the biosolids in a manner consistent with the PFRP and VAR and compost test results meet or exceed the CFR 403 Class A Biosolids standards for pathogens in two, independent, sequential, batches produced in separate primary composting zones within the specified detention time.

E. Correction of Non-Acceptable Performance
1. In the case of non-acceptable performance, the Manufacturer may elect to independently test samples of the initial composting mix to ensure heat generation capacity meets specified requirements before taking other corrective measures beyond providing technical advice. If the Manufacturer chooses to test the compost mix, test results shall be provided within 14 days of non-acceptable performance. If tests show that the heat generation capacity of the compost mix does not meet specified requirements, the Manufacturer shall provide recommendations to increase the heat generation capacity at the same time test results are reported. The Owner will modify the mix according to Manufacturer recommendations and performance testing will be repeated.
2. If the heat generation capacity of the composting mix is found to meet specified requirements or the Manufacturer does not choose to test the material, the Manufacturer shall within 2 weeks meet with the Owner on-site to witness operations and identify conditions that may be allowing pathogens to survive the process and/or pathogen vectors to re-infect the product. The design of the Manufacturer supplied system assumes that 72 hours of continuous temperatures at or above 131 degrees F is sufficient to provide a PFRP. If the failure to maintain PFRP time/temperature conditions in the pile are due to a component failure in the electrical/mechanical/software equipment supplied by the Manufacturer, the Manufacturer will correct this issue within 4 weeks at no cost to the Owner. If this problem is not due to a component failure in the Manufacturer's supplied system, the Manufacturer will work with the Owner to develop a systematic and escalating plan to eliminate the conditions believed to cause the non-compliance. Initially this plan will focus on adjusting the aeration and control system, modifications to the operation of the system, and possibly modifications to, and increasing the frequency of, the compost sampling methodology. Carrying out the recommended modifications to operations, sampling, and lab analysis will be the responsibility of the Owner. The first round in the escalation of the recommended adjustments and modifications will focus on those with lowest impact on operations. Subsequent rounds will progressively increase the magnitude of system and operational changes. In each round, the Manufacturer and Owner will select a set of adjustments and

modifications and the performance tests will be repeated. This first round of retesting will be conducted, and results analyzed and reported within a 2-month period to determine if the process has met the Design Performance Criteria and Minimum Performance for Acceptance.

3. If the first round of retesting is not successful, the Manufacturer will again meet the Owner on-site to discuss the findings and plan the implementation of a second round of modifications. Required testing, operational, and Owner supplied component modifications may include: testing biolayer cover material and surface irrigation water for pathogen content; disinfecting wheel loaders between contact with pathogenic materials and post PFRP processed materials, increasing the depth of biolayer cover depths; preventing birds from congregating on top of piles; and modifying the functionality of Owner supplied control system elements. Once these modifications are implemented, the next round of testing will be conducted and completed within a 2-month period to determine if the process has met the Design Performance Criteria and Minimum Performance for Acceptance.
4. If after the second round of testing, the PFRP performance criteria is still not met, the Manufacturer will provide an instrumentation package to continuously measure and record the temperatures in at least 10 locations in the test pile, as well as the aeration rate delivered to pile. Further, the Manufacturer will be on-site for the building of this pile and installation of the instrumentation package, and again when the pile is broken down and sampled to check for compliance with the Design Performance Criteria and Minimum Performance for Acceptance.
5. If results from this third round of testing again fail to meet the PFRP requirements, and if locations within the pile are found that do not reach and maintain the temperatures required for PFRP, despite the feedstock mix providing heat generation as specified and the Owner complying with all of the Manufacturer's modified operational requirements, the Manufacturer shall provide physical modifications to the system requested by the Owner, based on engineering principles, including but not limited to replacement and installation of CASP compost equipment within the scope of supply to bring the system into compliance with specified performance criteria. Correcting non-conforming performance found in this final test shall be at no cost to the Owner.

F. If during the first year of operation nuisance odors are believed to be coming from the composting system, and are not resolved with adjustments to the system or operations, the Manufacturer will provide the Owner with a plan for an odor study to quantify the emissions from the composting system and its impact on the odor flux from the entire site. The Manufacturer will supply the materials and equipment for sampling odor fluxes from the surfaces of compost piles and the biofilter. The Owner will supply labor for all odor sampling, and any other materials required for sampling from other local odor surfaces or volumes. The Manufacturer will coordinate the odor analysis by an odor lab that is compliant with ASTM E679-04. The odor analysis will be paid for by Owner. If the results indicate that Compost System is a significant contributor to the site-wide odor emission, the Manufacturer will provide odor dispersion modeling to identify what level of odor flux from the Compost System would be acceptable. The Manufacturer will then develop a plan with the Owner to modify operations, system settings, or the system itself to meet this odor emission threshold.

3.03 FIELD SERVICE

A. The Manufacturer shall supply a competent field service engineer to thoroughly check and inspect the equipment after installation, place the equipment in operation, make necessary adjustments, calibrate instruments, conduct field tests and initiate system operation. A minimum of two site visits of at least 2 days each shall be provided. One visit shall coincide with initial startup and testing of the composting system. A second visit shall occur during the first year after the system is fully operational.

B. The Manufacturer's field service engineer shall provide a minimum of 2 days (16 hours) of classroom and field training sessions including safety procedures, operating instructions, and preventive maintenance procedures for equipment before operation of the system will be taken over by the Owner. This training may overlap with other Field Service Activities.

C. During the first year following successful completion of the Performance Test, the manufacturer will respond within 24 hours, Monday through Friday, with remote support to any Owner identified technical issue with the CASP system. The Owner will provide reasonable assistance to support the manufacture's efforts to resolve the technical issue. If the issue is not resolved within 7 days following identification, the Manufacturer shall furnish the services of a competent field service engineer to inspect and troubleshoot the system. Services shall include up to four trips with a minimum of one person-day on site for each trip.

END OF SECTION

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SECTION 14400

SCREW CONVEYORS

PART 1 - GENERAL

1.01 SUMMARY

A. The Contractor shall furnish all labor, materials, equipment, and incidentals required and deliver, and place into satisfactory operation, a complete shaftless screw conveying system as specified herein, and as shown on the Drawings. The conveying system shall be designed for conveying dewatered municipal biosolids. The system shall include sludge screw conveyors and supports as required for proper system operation and installation.

B. Related Sections:
   1. Section 01190: Seismic Requirements
   2. Section 01300: Submittals
   3. Section 05090: Structural Metal Fasteners and Concrete Anchors
   4. Section 05100: Structural Metal Framing
   5. Section 09960: High Performance Coatings
   6. Section 11001: General Equipment and Mechanical Requirements
   7. Section 11002: Electric Motor Drives
   8. Section 15050: Piping, Valves, and Accessories
   9. Section 17010: General Requirements Instrumentation and Controls

1.02 SUBMITTALS

A. 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. Seismic design and certification in accordance with Section 01190.
   4. Motor data in accordance with Section 11002.
   5. System layouts showing dimensions, weights, and materials used.
   6. Elementary and connection wiring diagrams clearly showing external connections to other equipment.
   7. List of spare parts to be provided.
   8. Warranty statement.

B. Performance Testing: Submit certified non-witnessed factory performance test results. Receive favorable review of test results prior to shipping the equipment.

C. Manuals: Furnish manufacturer's installation, lubrication, operation and maintenance manuals, bulletins, and spare parts lists in accordance with Section 01300.

D. Affidavits: Submit affidavits from the manufacturer stating that the equipment has been properly installed, adjusted, and tested and is ready for full-time operation in accordance with Section 01650.

1.03 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 8 years. Equipment manufacturers shall provide a list of at least five previous installations, including contact information, of similar size, design, and complying with the requirements as set forth within this Section.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Ship items as complete assemblies except where partial disassembly is required by transportation regulations or for protection of components. All items specified in this Section shall arrive at the jobsite in a single shipment. Pack spare parts in containers bearing labels clearly designating contents and pieces of equipment for which the part is intended.

B. 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.

1.05 WARRANTY

A. The manufacturer shall warrant against any defects in material or workmanship of the sludge conveyance equipment for a period of 12 months following successful completion of startup and performance testing.

B. The manufacturer shall repair or replace any parts of the new conveyance equipment found to be defective in workmanship or materials during the warranty period, provided said equipment is operated in accordance with the manufacturer’s written operating instructions.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. FKC; Jim Myers & Sons, Inc. (JMS); Spirac; or equal.

2.02 SYSTEM DESCRIPTION

A. General:
   1. Schedule of conveyance equipment:

Equipment Number	Name	Motor Power (hp)	Solids Loading		Volumetric Loading (ft^3/hour)
			Dry (lbs/hour)	Total[(a)] (lbs/hour)	
WW1-015M1241	Screw Press 1 Conveyor	7.5	820	5,125	81
WW1-015M1242	Screw Press 2 Conveyor	7.5	820	5,125	81
WW1-015M1251	Cake Conveyor 1	7.5	1640	10,250	161
WW1-015M1252	Cake Conveyor 2	7.5	1640	10,250	161
WW1-015M1253	Cake Conveyor 3	7.5	1640	10,250	161
WW1-015M1254	Cake Conveyor 4	7.5	1640	10,250	161

Note:

(a) Dewatered biosolids have a solids concentration of 16 percent.

2. All screw conveyors shall be 12-inch minimum diameter shaftless flight, U-trough design. The screw conveyors shall operate at a constant speed and be capable of conveying dewatered cake as received from the screw presses for discharge to the Cake Storage Building without exceeding 40% of their maximum capacity.

2.03 SCREW CONVEYORS

A. Shaftless Flighting:
   1. Screw conveyors shall incorporate 12-inch minimum diameter shaftless flighting formed from ¾-inch minimum thickness by 3-inch wide carbon steel with ±240 Brinell Hardness Number minimum. The spiral flights shall be designed with the stability to prevent distortion and jumping in the trough. The torsional rating of the spiral shall be such that, at 150% of the motor nameplate horsepower, the drive unit cannot produce more torque than the torsional rating of the flighting.
   2. Compression and/or elongation: Less than 0.08 inch per 1 foot at maximum loading.
   3. Pitch of spiral flighting shall be as determined by the manufacturer to meet the specified capacities but shall not exceed 12 inches. Where required, the flighting sections requiring field welding will be done by the installation contractor with full penetration welds as recommended by the conveyor manufacturer. The flighting shall include a bolted connection to the drive shaft.

B. Drive:
   1. Motors shall be 460-volt, 3-phase, 1800 RPM, severe duty with 1.15 safety factor and Class F insulation and shall meet the requirements of Section 11002.
   2. Each motor shall be direct connected to an adapter mounted, AGMA Class II, helical gear reducer provided at the conveyor trough end. Gears shall be manufactured and rated for continuous duty in accordance with AGMA Standards, of heat-treated alloy steel. Provide splash type gear lubrication.

3. The gear reducer and drive shall be designed to provide an applied torque adequate to start a full loaded conveyor.
4. Each motor shall provide integral high temperature switches to protect the motor from overheating as shown on the drawings and in accordance with Section 11002.

C. Trough:
1. Conveyor flights shall be housed in 3/16-inch-thick minimum Type 304 stainless steel U-troughs with formed top flanges and integral end flanges. Trough shall conform to CEMA Standards.
2. Troughs shall include a 1/2-inch minimum thickness, replaceable, UHMW-PE liners from roll line to roll line in the trough interior.
3. CEMA standard trough end plates shall be provided with a split gland packing ring consisting of two Teflon coated packing rings. These packing rings shall seal the drive shaft at its penetration through the end plate.
4. Where used, bottom-drop discharge points shall be a minimum of 13 inches x 13 inches.
5. The lowest point of each conveyor trough shall include a 2-inch minimum diameter drain connection. Drain to be connected as shown.
6. Stiffeners shall be placed across the top of the trough and fastened to both sides of the trough to maintain trough shape.

D. Covers:
1. The screw conveyor troughs shall include a minimum 12 gauge Type 304 stainless steel cover with gasketing. Covers shall be bolted in place with stainless steel bolts on 24-inch maximum centers.
2. Screw Press Conveyors 1 and 2 shall include No.12 gauge stainless steel flared skirt extensions to accept loading from the screw presses without spillage.
3. Covers shall not exceed 48 inches each in length.

E. Supports:
1. The screw conveyor shall be supported by structural steel members provided by the manufacturer. The location, sizing, and arrangement of the supports shall be verified by the manufacturer. Supports shall be match marked and shipped to the job site for installation in the field.
2. The supports shall be fabricated from Type 304 stainless steel structural shapes and plates.
3. At a minimum, each conveyor shall be provided with supports at the inlet and discharge end, with intermediate supports at 10 feet on center.
4. Provide base plates at each support leg for anchor bolting.

F. Guards: All exposed, accessible rotating parts shall be covered with an OSHA type guard to prevent accidental injury.

G. Flexible Chute Extensions: The discharge point of the Cake Conveyor 4 (WW1-015M1254) shall include a 10-foot long, flexible chute extension fabricated from rubber impregnated 18 oz/yd minimum canvas.

H. Connections Between Conveyors: Aluminum transition chutes shall be fabricated by the manufacturer to provide connections between the discharge and inlet ends of interconnecting conveyors. Aluminum chutes shall be bolted to the discharge end of the conveyor and shall feed the inlet of the receiving conveyor via a slip joint. The discharge chute shall fully penetrate the inlet of the receiving conveyor with a ½-inch gap between the outside of the aluminum discharge chute and the inlet chute of the receiving conveyor.

I. Screw Press Discharge Chute: 12-gauge stainless steel discharge chutes shall be provided by the conveyor manufacturer. Side slopes of discharge chutes shall have a minimum angle of 60-degrees. Discharge chutes shall be bolted to the discharge flanges of Screw Presses 1 and 2 and shall be designed to allow for independent movement between screw press and screw press conveyor. Coordinate with screw press manufacturer for needed dimensions.

I. Safety Stop Switch: Each conveyor is to be provided with a NEMA-4X, 115 V, safety pull cord stop switch. A continuous orange vinyl coated galvanized cable shall fully surround the conveyor. The cable shall be supported from the conveyor frame on 10-foot maximum centers. The trip switch shall immediately stop all conveyors when the switch is actuated.

J. Zero Speed Switch: Each conveyor is to be provided with a non-contacting probe and relay type zero speed indication switch to indicate lack of spiral flight rotation. The switch shall be a Milltronics ZSS or equal.

2.04 CONSTRUCTION

A. All welding to be in accordance with the latest AWS standards.

B. All component items shall be provided with manufacturer’s standard finish. Shafting and other exposed machined surfaces shall be coated with a rust inhibitive compound.

C. All nuts, bolts, and washers used for assembly shall be furnished by the conveyor manufacturer and shall be stainless steel.

D. All assembled parts and components ready for shipment shall be securely bundled, coiled, or crated and adequately protected from damage and corrosion during shipment and storage.

2.05 WORK COORDINATION

A. Layout and design of conveying systems shall be coordinated with layout of the screw presses and existing equipment.

2.06 INSTRUMENTATION AND CONTROLS

A. All components, assemblies, and wiring shall conform to the requirements of Divisions 16 and 17 of these specifications.

2.07 ANCHORS

A. Provide anchors meeting the requirements of Sections 01190 and 05090.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install equipment in strict conformance with the manufacturer's installation instructions.

3.02 FIELD TESTING

A. Field test all sludge conveyance equipment. For further requirements on performance tests, refer to Section 11001.

3.03 FIELD SERVICE

A. The equipment manufacturer shall supply a competent field service engineer to thoroughly check and inspect the equipment after installation, place the equipment in operation, make necessary adjustments, calibrate instruments, and conduct field tests. The services required shall also include on-the-job training of operators including safety procedures, operating instructions, and preventive maintenance procedures. Furnish a minimum of 4 person-days of field services.

END OF SECTION

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 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.
   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. Pipe couplings and flexible pipe pieces (Product Review).
      c. 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 local requirements. Submit proof of NSF certification for each item.
7. Samples: Solder and flux for copper pipe.
8. Testing data for welded joints. Welds.
9. Submit leak and pressure testing plan in accordance with the requirements in paragraph 3.07.
10. Submit shop drawings for leak and pressure testing apparatus including, but not limited to, temporary bulkheads necessary for testing of new pipelines.

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.
4. Strainers, motorized or automatic washing.
5. Filters.
6. Pressure regulators.
7. Rotameters.

C. Affidavits: Furnish affidavits from the manufacturers for the following equipment:
1. Valves, motorized , hydraulic, pneumatically 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 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.

1.06 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.

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-galling 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 Drawing G-003.

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
N-1	Ductile Iron Bell & Spigot Pipe	B&S	DI
N-2	Ductile Iron Flanged Pipe	Flange or Mech. Groove Coupling	DI
N-3	Cast Iron Soil Pipe	B&S or Mech. Coupling	CI
Q-3	ABS, Drain Waste Vent	Solvent Weld	ABS
T-1	Copper	Solder or Flare	Wrought Copper or Bronze
U-1	High Density Polyethylene	Standard mechanical couplings or fusion welds	Polyethylene
V-1	PVC, Schedule 80	Threaded or Solvent Weld	PVC, Schedule 80
V-5	PVC, SDR 26	B&S	PVC, SDR 26
X-1	Black Steel, Schedule 40	Weld	Steel
Y-1	Galvanized Steel Pipe, Schedule 40	Thread	Galvanized Malleable Iron or Cast Iron

D. Type N-1 Pipe:
   1. Pipe: Ductile iron bell and spigot pipe, AWWA C151.
      a. Minimum Pressure Class: 350
   2. Joints: Push-on, AWWA C111 as modified, except where flanged joints are shown on the Drawings or where making connections to valves.
      a. Gaskets: NBR.
      b. Restrained joints: For all connections provide restrained joints for pipe and fittings capable of deflection after restraint is installed. Joints shall not separate under an internal pressure of 250 psi. For push-on joints use TR FLEX by United States Pipe & Foundry Company; Flex Ring by American Cast Iron Pipe Company; or equal. For mechanical joints use Megalug restraints by EBAA Iron, or equal.
      c. Buried Tee-Head Bolts and Nuts for Mechanical Joints: Type 304 stainless steel.
      d. Buried bolts and nuts for flanged joints shall be Type 304 stainless steel.
      e. Provide insulating flanges with two cathodic test stations for buried ductile iron to steel connections.
   3. Fittings: Ductile iron with push-on joints or mechanical joints, AWWA C110 and AWWA C153.
   4. Lining: Standard thickness cement mortar lining for pipe and fittings, AWWA C104, except where noted otherwise in the Drawings or in the Piping Identification Schedule. Cement mortar linings shall be seal coated.
      a. Ceramic Epoxy lining for pipe and fittings where required in the Drawings or Pipe Schedule:
         1) Pipe and fittings shall be previously unlined. Solvent clean and completely abrasive blast all areas to receive lining.
         2) The ceramic epoxy material shall be an amine cured novalac epoxy containing at least 20% by volume of ceramic Quartz. Ceramic epoxy lining shall meet the following test requirements:
            a) Permeability rating of 0.00 when tested per Method A of ASTM E96, Procedure A with 30-day test duration.
            b) Salt spray (scribed panel) results equal to 0.0 undercutting after 2 years per ASTM B117.
            c) Cathodic disbondment 1.5 volts at 77°F equal to no more than 0.5 mm under cutting after 30 days per ASTM G95.
            d) Immersion testing using ASTM D714:
               (1) 20% sulfuric acid – no effect after 2 years.
               (2) 140°F 25% sodium hydroxide – no effect after 2 years.
               (3) 160°F distilled water – no effect after 2 years.
               (4) 120°F tap water (scribed panel) 0.0 undercutting – after 2 years.
            e) Abrasion resistance of no more than 3 mils loss after one million cycles per European Standard EN 598, Section 7.8.
         3) Lining shall be factory applied to the interior of pipe and fittings to a dry film thickness of 40 mils. Gasket areas and spigot ends shall be coated with 6 to 10 mils of ceramic epoxy joint compound,

which shall also be used for field touchup of any damaged surfaces.

4) Thickness test linings per SSPC-PA-2 using a magnetic film thickness gauge. Test interiors for pinholes with nondestructive 2,500-volt test. Correct all defects before shipment.

5. Coating:
   a. Buried pipe shall receive asphalt coating per AWWA C151.
   b. 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.
6. 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 overlaps at least 4 mils thick and at least 2 inches wide.
7. 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 above ground and bronze or Type 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 can be used.
      3) Manufacturers: Smith-Blair Model 313; equivalent by Mueller; or equal.
8. Field Closure Connections for Restrained Joints: Pipe cut in the field where necessary and when favorably reviewed by the Engineer shall be connected with mechanical joint sleeve and two Series 1100 Megalug restraints by EBAA Iron, Inc.; or equal.

E. 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 125 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: Standard thickness cement mortar lining for pipe and fittings, AWWA C104, except where noted otherwise in the Drawings or in the Pipe Schedule. Cement mortar lining shall be seal coated.
    a. Ceramic Epoxy Lining for pipe and fittings where required in the Drawings or Piping Schedule: See ductile iron push-on joint pipe.
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. Bonding: Bond ductile iron to provide electrical continuity, except that insulating flanges without bonding shall be provided where shown on the Drawings.
9. 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.
10. Flange Bolts: AWWA C115, Appendix A unless stainless steel is required in paragraph 2.02.
11. 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; equivalent by Mueller; or equal.
12. 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. Type N-3 Pipe:
1. Pipe and Fittings: Bell and spigot service weight cast iron soil pipe or no-hub cast-iron soil pipe. (No-hub pipe may not be used under structures.)
   a. Bell and Spigot: ASTM A74.
   b. No-Hub: Cast Iron Soil Pipe Institute Standard No. 301.
2. Bell and Spigot Gaskets: Sewage and oil resistant, ASTM C564.
3. No-Hub Couplings: Cast Iron Soil Pipe Institute Standard No. 301.

G. Type Q-3 Pipe:
1. Pipe and Fittings: Acrylonitrile-Butadiene-Styrene (ABS) drain, waste and vent (DWV), ASTM D2661.
2. Joints: Solvent weld.
3. All products shall bear the seal of a nationally recognized listing or certifying agency.

H. Type T-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; or cast bronze, ASTM B62 for materials and ANSI B16.18 for dimensions.
   b. Flared: AWWA C800 and ANSI B16.26.

I. Type U-1 Pipe:
1. Pipe: High molecular weight, high density, polyethylene pipe, ASTM D3350 or ASTM F714
   a. Cell Classification: 345464C, or 445474C; color material shall be 345464E.
   b. Dimension Ratio (DR): 17 maximum
   c. Pipe shall be ~~ductile iron size~~ iron pipe size.
2. Joints: Butt fusion, ASTM D2657, except mechanical where required to connect with other pipe, valve or equipment materials.
   a. Butt Fusion Joints: The tensile strength of the joint at yield shall not be less than the pipe. Joints shall be made with equipment acceptable to the manufacturer. The equipment operators shall have been trained by certified fusion technicians. Submit description of the equipment and methods for favorable review.
   b. Mechanical Joints: Joint shall consist of a flange adaptor fitting butt-fused to the pipe, a back-up ring of Type 316 stainless steel made to ANSI B16.1 dimensional standards (with modified pressure rating), bolts of Type 316 stainless steel, and chloroprene gaskets.
3. Fittings: Molded fittings to ASTM D3261 required where available of the same material as the pipe, with DR no greater than the pipe, and with a pressure rating at least equal to the pipe. Manufacturer shall conduct X-ray inspection

on samples from each molded fitting production lot. Fabricated fittings shall comply with ASTM F2206 and shall only be used where molded fittings are unavailable. Fitting shall be produced by the same manufacturer as the pipe.

J. Type V-1 Pipe:
   1. Pipe: Schedule 80 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 80, ASTM D2467.
   4. Cement: Solvent weld, ASTM D2564 for non-chemical service, as recommended by the pipe manufacturer for the schedule and size to be joined. For chemical service, ASTM F 493, IPS724 CPVC, no equal.
   5. Pipe Cleaner: As recommended by the pipe manufacturer for the schedule and size to be joined.
   6. Double containment of piping is required for all buried PVC pipe and tubing so indicated in the pipe schedule or elsewhere in the Plans and Specifications.
      a. Size: Provide Schedule 40 PVC containment pipes as follows:

Carrier Pipe	Containment Pipe
1-inch	4-inch
1-½-inch	4-inch
2-inch	4-inch
3-inch	
4-inch	6-inch
6-inch	

      b. Joints: Solvent weld except flanged where required. Use two-piece hinged couplings as specified below where necessary. Do not make-up joints until successful completion of leak tests of primary carrier pipe.
      c. Fittings: Yellow or clear PVC two-piece, hinged, and pre-gasketed (Viton) containment fittings. Termination couplings shall be hubless type of PVC rubber with Type 316 stainless steel clamps. Carrier pipe shall be installed concentrically to the containment using three- or four-legged positioning clips. Fittings shall be Contain-It by Georg Fischer; or equal.

K. Type V-5 Pipe:
   1. Pipe and Fittings: Polyvinyl chloride sewer pipe:
      a. 4-inch through 15-inch nominal size: ASTM D3034, SDR 26.
      b. 18-inch through 48-inch nominal size: ASTM F679.
   2. Joints: Elastomeric gasket joints, ASTM D3212.
   3. Gaskets: SBR rubber or NBR (Nitril or Buna-N).
   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.

L. Type X-1 Pipe:
1. Pipe: Schedule 40 black steel, ASTM A53, Grade B, butt weld or seamless.
2. Joints: Butt welded or socket welded, except where otherwise shown on the Drawings and where screwed or flanged accessories or valves are required.
3. Fittings: Forged steel, butt weld type, same Schedule as pipe conforming to ASTM A234, or 2,000 psi forged steel socket weld fittings conforming to ASTM A105.
4. Flanges: Where required to connect to flanged equipment or valves, shall be slip-on or weld-neck type conforming to ASTM A105 or ASTM A181. Flange drilling and facing shall match that of the flanged valves or equipment to which the pipe connects.
5. Branches two sizes or smaller than pipe main may be made with factory fabricated steel welding saddles manufactured by Bonney; Ladish; or equal.

M. Type Y-1 Pipe:
1. Pipe: Galvanized steel, ASTM A53, Schedule 40.
2. Fittings:
a. Pressure Pipe Service: Galvanized malleable iron, screwed, ASTM A197 for materials, ANSI B16.3 Class 150 for dimensions (rated 300 psig WOG at 150°F).
b. Drain Pipe Service: Galvanized cast iron drainage pattern, ANSI B16.12.
3. Threads: ANSI B2.1.
4. Unions: Galvanized malleable iron, ASTM A197 for materials and ANSI B16.39 for dimensions, with brass seats.
5. Thread Compound: Permatex No. 2; Crane equivalent; or equal, or Teflon tape.

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. 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: NBR (Nitril 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. For steel pipe the joint harness shall conform to the requirements of Chapter 13 of AWWA M-11, Table 13-4 - Tie Bolt Schedule for Harnessed Joints. Anchor studs may be used on flange coupling adapters for pipe up to 12 inches in diameter.

C. Mechanical Groove Couplings:
1. Application: Mechanical couplings (segmental clamp joints) shall be used wherever shown on the Drawings. They may be or flanges on ductile iron pipe to the extent permitted under the ductile iron pipe specification.
2. Type: AWWA C606, pressure rated at least 300 psi.
3. Joints: Cut groove, except shoulder joints may be used for steel pipe where the wall thickness of the pipe is less than that allowed by Table 4 (AWWA C606). Only Type B, Type C, and Type D special ends are acceptable for shoulder joints.
4. Grooves:
    a. Ductile Iron Pipe where Mechanical Groove Couplings are shown on the Drawings: unless otherwise specified, Flexible joint, Table 2 (AWWA C606).
    b. Ductile Iron Pipe where Flanges are shown on the Drawings: Rigid joint, Table 3 (AWWA C606).
    c. Steel Pipe: Table 4 (AWWA C606).
5. Gaskets: EPDM.

D. Flexible Connectors:
1. Up to 12-inch-Diameter:
    a. Type: Built-up, single arch (unless otherwise shown on Drawings) rubber expansion joints with full rubber flanges and retainer rings. Provide filled arch-type or wide flowing arches on sludge service.

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. 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.
3. 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.

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.

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-003
   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.
      d. Swing Check Valves 2-inch through 12-inch:
         1) Rating: 175 psi
         2) Type: Swing, metal seats, outside spring and lever, AWWA C508.
         3) Connections: Flanged, 125-pound ANSI.
         4) Materials: Cast iron, bronze trim.
         5) Manufacturers: M & H Style 259; equivalent by Clow; or equal.

e. Pressure Gauge Assembly:
    1) Complete assembly shall include isolation valve, pulsation dampeners or snubbers. Provide a support plate to the nearest flange.
    2) Pressure gauges shall have a dial size not less than 4-½ inches, phenolic or 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. Gauge case shall be liquid filled with glycerin or silicone. 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); Ashcroft 7004L; Trerice 735 or 740; WIKA Type 910.11.200; or equal.

f. Strainers:
    1) Rating: 125 psi.
    2) Type: Y-type basket strainers, 20-mesh.
    3) Connections: Threaded or flanged.
    4) Materials: Iron body, stainless steel screen.
    5) Manufacturers: Bailey 100A; Hoffman Series 400, 450; or equal.
    6) Installation: Each to be complete with ball valve on blowoff and piping to drain.

g. Solenoid Valves: Valves shall be for 150-psi water pressure, 120-Volt ac service, with a watertight enclosure. Valve body shall be brass, seats Buna-N, with stainless steel plug. Valves shall be normally closed except where noted otherwise. Provide manual override control. Valves shall be ASCO Bulletin 8221; or equal.

h. 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 HP, LP DS for flows to 170 gpm.
        b) Provide strainers with stainless steel screens for each pressure reducing valve unless otherwise noted.
        c) Sizes, capacities and pressures shall be as noted on the on the Drawings.

i. Butterfly Valves:
    1) Standard: AWWA C504, except as modified herein.
    2) Type:
        a) 3-inch through 12-inch: Wafer body, except short body flanged or mechanical joint where shown on the Drawings, or where buried.
        b) 14-inch through 72-inch: Short body flanged or mechanical joint where shown on the Drawings.
        c) Geared operator, resilient seated, 90˚ seating.

3) Pressure Class:
   a) 3-inch through 12-inch: 150 psi.
   b) 14-inch through 72-inch: 150 psi, unless shown otherwise on the Drawings.
   c) Valves shall be leak-tight at rated pressure in either direction.
4) Materials:
   a) Body: Cast Iron; ASTM A126, Class B, or ASTM A48, Class 40.
   b) Disk: Cast or ductile iron with Ni-Chrome or Type 316 stainless steel edge.
   c) Valve Shaft: Type 304 or Type 316 stainless steel.
   d) Seats: Buna-N.
5) Construction:
   a) Seats: Applied to body. Cartridge type seats with retaining rings are not acceptable.
   b) Disk to Shaft Connection: Stainless steel taper pins or torque plug.
   c) Valve Diameter Limitation: Internal diameter of valve at the throat shall be no less than the nominal diameter of the valve less 1-½ inches.
   d) Bearings shall be self-lubricating and corrosion-resistant.
6) Finish:
   a) Exposed Exterior: Shop prime compatible with field applied finish coats. Refer to Section 09960.
   b) Buried Exterior: Shop coat with high-solids epoxy, 12 mils minimum.
   c) Interior: Shop line with two-component, high solids epoxy, AWWA C550.
7) Testing: Test in accordance with AWWA C504, except that leakage test shall be in both directions. Submit certified test results for tests for valves 24 inches and larger.
8) Actuators:
   a) Type: Manual, except where specified otherwise, or shown otherwise on the Drawings. Provide valve position indicators on all actuators.
   b) Manual Actuators: Traveling nut, self-locking, or worm gear above 48 inches.
      (1) Above-ground: Handwheel, provide chainwheel for installations over 6 feet.
      (2) Buried: Designed for buried service, watertight up to 10 psi. Provide 2-inch-square standard AWWA operating nut, with extension stem to reach the ground surface as shown on the Drawings, and with a ground level position indicator.
9) Manufacturer: DeZurik, Pratt, or equal.

2. Valve and Accessory System B: Applicable Service Conditions: Sludge, drainage, sewage and wastewater at working pressures to 100 psig.
   a. Plug valves 2-inch and larger:

1) Rating: 175 psi through 12-inch, 150 psi 14-inch through 36-inch, 125 psi 42-inch and larger.
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. 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, a snubber if over 5 psi operating pressure 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) Diaphragm Seal: Shall be for slurry service with flushing connection. Body shall be stainless or carbon steel. Diaphragm shall be oversized and be removable of Type 316 stainless steel. Complete unit shall be Trerice Series 600, Ashcroft Model 100; or equal.
4) Gauges and Snubbers: Shall be as specified for System A.
5) Installation: All protectors and gauge bourdon tubes shall be evacuated of air, silicone filled at the factory and factory calibrated.

3. Valve and Accessory System C: Applicable Service Condition: polymer.
a. Ball Valves Through 4-inch Size:
1) Rating: 150 psi at 75°F.
2) Type: Double union.
3) Connections: Socket.
4) Materials: PVC body, Teflon seats and Viton O-ring seals.
5) Manufacturers: R&G Sloane, Asahi/America Pro Block, or equal.

b. Check Valves Double Union Type:
1) Rating: 150 psi at 75°F.
2) Type: Ball for horizontal or vertical service.
3) Connections: Union ends for socket weld.
4) Materials: PVC body, Viton O-ring seals and seats.

5) Manufacturers: Chemtrol True Union BC, Plastiline No. 8611, or equal.

c. Strainers:
1) Rating: 150 psi.
2) Type: Wye-type basket strainers. Strainer screen size as recommended by feed pump supplier.
3) Connections: Threaded.
4) Materials: PVC.
5) Manufacturers: Chemtrol, GF, or equal.
6) Installation: Each to be installed with ball valve blowoff and piping to drain.

d. Pressure gauges shall be as specified for System B. Provide protector body and diaphragm and isolation valve materials appropriate for the chemical solutions to which they will be exposed.

e. Plug valves shall be as specified for System B.

4. Valve and Accessory System E:
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 water.
2) Type: Rising stem, solid wedge.
3) Connections: Solder ends for copper pipe.
4) Materials: All bronze.
5) Manufacturers: Jenkins; Crane; 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. Pressure Relief Valves:
1) Rating: 150 psi for valves 2-inch and smaller.
2) Type: Adjustable spring loaded.
3) Connections: Threaded.
4) Materials: Bronze body.
5) Manufacturers: Consolidated 2478; Farris 1400S; or equal.
f. Ball Valves shall be as specified under Valve System A.
g. Strainers shall be as specified under Valve and Accessory System A.

5. Valve and Accessory System J:
a. Applicable Service Conditions: Natural gas.
b. Plug Valves (Buried Service):
1) Rating: 60 psi.
2) Connections: Stub for butt or socket fusion joints.

3) Body Material: Polyethylene.
4) Stops: Provide built-in stops to permit 90 degree turn only.
5) Accessories:
a) Provide operating wrench with fail-safe feature to cause shear in the wrench before the valve can be damaged by over-torque.
b) Provide at least two shutoff rods with ends suitable to operate the underground valve.
6) Manufacturer: Nordstrom 'Polyvalve'; or equal.

c. Ball Valves (Exposed Service):
1) Rating: 1000 psi.
2) Body Material: Stainless steel
3) Type: Three-piece, full port, socket weld with blow-off proof stem.
4) Manufacturer: NibcoKM-590-S6-R-66-FS-LL; equivalent by Apollo; or equal.

d. Gas Cocks:
1) Design: ANSI Z21.15.
2) Pressure Rating: 25 psi, min.
3) Material: Brass.
4) Connections: Threaded.
5) Manufacturers: Conbraco or equal.

e. Flexible Hose Connection: 3/8-inch ID corrugated stainless steel hose with zinc-coated steel end couplings with ½-inch NPT pipe connections. Design shall be certified to ANSI and AGA standards.

f. Polyethylene Steel Pipe Transition Fittings: ASTM D2513 and shall be IAMPO and CSA approved. Steel pipe components shall be epoxy coated Schedule 40 stainless steel pipe.

g. Equipment Service Regulators:
1) Pressure Rating:
a) Maximum Inlet: 125 psig
b) Maximum Outlet: 2.2 psig
c) Outlet Pressure Range: 12.5 to 20 in w.c.
2) Materials:
a) Body: Cast Iron
b) Orifice: Aluminum
c) O-Rings: Nitrile.
3) Manufacturer: Fisher HSR; Invensys; or equal.

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: 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. 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.
4. Floor Boxes (Bushing Type): Cast iron, installed with top set at finish grade. Floor boxes shall be suitable for 150 lb./ft^2 live load. Clow Figure F-5695; equivalent product by Mueller; 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.
8. Chemical Tote Connections: Consist of 1-inch diameter wire reinforced, rubber covered Teflon hose with male barbed fitting on one end and female cam lever hose barb connector on the other for connection to the chemical tote. Band clamps to be stainless steel. Provide mating male cam lever fitting for connection to the chemical tote.
9. Pipe Escutcheons:
    a. Manufactured wall, ceiling, and floor plates; cast brass, polished chrome plated, with set-screw, deep pattern type where required to conceal protruding fittings and sleeves.
    b. Inside Diameter: Closely fit around pipe, tube and insulation of insulated piping.
    c. Outside Diameter: Completely cover opening.
    d. One-piece design for piping to plumbing fixtures and to equipment in finished spaces.
    e. Split concealed hinge type for piping not serving plumbing fixtures or equipment in finished spaces.

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. Cast all metallic pipes and sleeves 6-inch and larger into new concrete walls without blockout. Pipes 5 inches and smaller may be cast in place or installed in a smooth core drilled hole using a link type seal at the Contractor's option. Maintain at least ½-inch clearance between reinforcing steel and metal pipe in penetrations.
   6. Cover polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC) and polyethylene (PE) pipe stored outside for more than two months with canvas or other opaque material. Provide for air circulation under the covering.
   7. Certain installation requirements are contained in Section 15800.

B. General Buried Piping Installation:
   1. Trenching, bedding, and backfill for buried piping shall be as shown on the Drawings.
   2. Where pipe grade elevations are shown on the Drawings, install the pipe with straight grades between the indicated elevations.
   3. 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.
   4. 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.
   5. 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.
   6. Where piping leaves a structure or concrete encasement, provide two joints capable of angular deflection. For pipes 12-inches and smaller, the first joint

shall be within 1 foot of the structure or if concrete encased, the edge of concrete encasement. Distance between joints shall be 2 feet or one pipe diameter, whichever is greatest. Joints for pipes larger than 12-inches shall be provided as shown on the Drawings. Conform to details on the Drawings where such details are shown.

7. Snake buried PVC pressure pipe from side to side in the trench in long sweeps.
8. Concrete Encasements: All piping and conduits except plumbing lines 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.
9. Do not pull bell and spigot, gasketed joints more than *75*% of the maximum deflection permitted by the pipe manufacturer.
10. Coat bolts on buried flanges or other buried appurtenances in accordance with Paint System 8 in 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, flexible hose, 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. Pipe Welding:
   1. General: Unless specified otherwise, shop and field welding of pipe shall conform to ANSI B31.1 as amended by this paragraph.
   2. All field and shop welding shall be done by the electric arc process unless otherwise specified. All field welding shall be done in passes not thicker than ¼-inch. Size and type of electrodes, and current and voltages used, shall be subject to the favorable review of the Engineer. Give particular attention to the alignment of edges to be joined, so that complete fusion and penetration will be effected throughout the bottom of the weld. Welds shall contain no valleys or undercuts in the center or edges of the weld. Thoroughly clean each pass, except the final one, of dirt, slag, and flux before the succeeding bead is applied.
   3. Clean completed field welds of pipe joints of dirt, slag and flux, and then visually inspect. Completely chip out all defects in welds discovered during field inspection in a manner that will permit proper and complete repair by welding subject to the favorable review of the Engineer. Under no circumstances will caulking of defective welds be permitted.
   4. All welding shall be done by experienced, skilled operators familiar with the methods and materials to be used. Hand welding will be done only by welders qualified under the standard qualification procedure of Section IX of the ASME Boiler and Pressure Vessel Code. The Contractor shall conduct tests of his welders, when required by the Engineer, in accordance with that code and in the presence of the Engineer. An independent testing laboratory, favorably reviewed by the Engineer, shall supervise the testing and determine the quality of the test work. Weld specimens in the same positions as those in which the welder is to qualify his work. The Engineer may require test specimens at any time. Any welder whose work is found unsatisfactory shall not remain employed on this Contract, regardless of the quality of his earlier work. Each hand weld specimen shall be plainly marked with the welder's identifying symbol. The Contractor shall furnish all materials required and pay all costs for qualifying welders.
   5. Field welds shall follow as closely as possible to the laying operation. All field welds shall be complete before lining or coating of the joints in steel pipe is begun. Where pipe is fusion epoxy lined and/or coated, follow AWWA C-213 procedures for field welded joints.
   6. A single, continuous, watertight, full fillet weld shall be the minimum required at all field joints. Double welded joints are required on all piping specifically noted to be double welded.
   7. See also installation specifics for welding of pipe.

E. Installation Specifics:
   1. Type N-1 Pipe:
      a. Install buried pipe in accordance with AWWA C600.
      b. Support and brace encased pipe to support the pipe and to prevent movement during testing and placement of the concrete encasement. The braces and supports shall be erected of materials and by methods that will prevent any future contact of the pipe with the environment surrounding the encasement.
      c. Wrap buried pipe with 8 mil polyethylene film in accordance with AWWA C105. Continuously seal seams and overlaps with tape. Seal

circumferential overlaps with two turns of tape, half lapped. Gather excess polyethylene on top of pipe so as not to block backfill material from getting under bottom of pipe. Use caution so as not to rip or cut the polyethylene film. Seal any rips or cuts in the film with tape.

d. Install restrained joints in accordance with manufacturer's instructions. Pull the slack out of restrained joints after they are made up.

e. Wherever a water pipeline crosses over or under a sewer main or house service lateral, center a standard length pipe, 18 foot minimum, on said sewer main or lateral so as to have the pipeline joints as far as possible away from sewer. This may require field cutting of some pipe pieces.

2. 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. Type N-3 Pipe:

a. Bell and Spigot: Fold and insert one-piece rubber gasket into properly cleaned hub. Apply lubricant to gasket and to spigot. Lubricant shall be a type recommended by the pipe and gasket manufacturers. Push or draw spigot into gasketed hub with a pulling tool devised especially for this purpose. Install rubber couplings with stainless steel bands for connections between existing house sewer service lateral and cast iron sewer pipe. Install elastomeric bushings as required to compensate for differences in outside diameters.

b. No Hub: Install in accordance with Cast Iron Soil Pipe Institute Pamphlet No. 100.

4. Type Q-3 Pipe: Comply with ASTM D2661 and F628.

5. Type T-1 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.

6. Type U-1:
a. Handling and laying of pipe and fittings shall be in accordance with the manufacturer's instructions, PPI guidelines, AWWA M55, and as specified herein to line and grades as shown on the Drawings.
b. Pipe and fittings shall not be dropped. All pipe and fittings shall be examined before laying and no piece shall be installed which is found to be defective. Any damage to the pipe shall be repaired as directed by the manufacturer and approved by the Owner. If any defective pipe is discovered after it has been laid, it shall be removed and replaced with a sound pipe in a satisfactory manner at the Contractor's expense. Any pipe with gouges exceeding 5% of the nominal wall thickness will be rejected.
c. All pipe and fittings shall be thoroughly cleaned before laying, shall be kept clean until they are used in the work.
d. The Contractor shall not drag the pipe. Rollers or other such devices shall be used to reduce dragging of the pipe. Damage to pipe caused by dragging is the responsibility of the Contractor and cause for replacement of damaged portion as determined by the Owner. If, in the opinion of the Owner, the pipe may have been dragged to an extent where damage may have occurred to the pipe wall, the Contractor will rotate the pipe in a manner which will facilitate inspection.
e. As much as practicable, the print line on the pipe shall be installed facing upward to facilitate identification of the pipe when initially installed.
f. Pipe fused above ground shall be carefully handled to avoid damage to the pipe. Chains or cable type chokers will not be allowed when lifting sections of pipe. Nylon or other wide fabric slings or other similar lifting apparatus with spreader bars shall be used where necessary.
g. Prior to installing a pipe section, the bedding material shall be brought to grade along the entire length of the section to be installed.

h. The joining method shall be the thermal butt fusion method and shall be performed in strict accordance with these Specifications, PPI guidelines, and the pipe manufacturer's recommendations. Should there be a conflict between these Specifications and the pipe manufacturer's recommendations, the more stringent requirement shall govern. The butt fusion equipment used in the joining procedures shall be capable of meeting all conditions and procedures recommended by the pipe manufacturer, including but not limited to, temperature requirements, alignment, and interfacial fusion pressure and automatic recording of parameters for joining.

i. Heat fusion joining shall be complete, efficient, and match the outer diameter of the two pipes being heat fused. Any offset or mismatch shall not exceed 10% of the minimum wall thickness. In all cases, heat fusion pipe joints shall have a joint weld strength equal to or greater than the tensile strength of the pipe.

j. Submit detailed fusion joint reports as recorded by the heat fusion machine for all joints. Submit a report to the Owner's Inspector the same day the fusion is made. Submit a formal report of all fusions to the Owner's Project Manager on a weekly basis, no later than 4:00 p.m. each Friday. If any joint as indicated by these reports is found to be unsatisfactory, the Contractor shall remove portions of the pipe containing such joint and install a new pipe piece as required and approved by the Owner.

k. The first fusion shall be a trial fusion to be performed in the field in the presence of the Owner. The trial fusion shall be allowed to cool completely, then fusion test straps shall be cut out. The test strap shall be the longer of 12 inches or 30 times the wall thickness in length with the fusion in the center, and 1-inch minimum or 1.5 times the wall thickness in width. Then, the test strap shall be bent until the ends of the strap touch. If the fusion fails at the joint, or if the joint exhibits cracking or crazing, a new trial fusion shall be made, cooled completely and tested. Butt fusion of the pipe to be installed shall not commence until the trial fusion has passed the bend back test.

l. Following the successful initial trial fusion, the bend back test shall be performed once every fiftieth joint.

m. Bending of the pipe to achieve horizontal or vertical changes in direction is allowed. The minimum bending radius, measured along the centerline axis of the pipe is 50 times the nominal pipe size.

n. Flange connections shall be in accordance with the manufacturer’s requirements. Flange bolts shall not be used to draw the connection into alignment. Bolt threads shall be lubricated and flat washers shall be used under nuts. Tighten bolts evenly according to the pipe manufacturer’s tightening pattern and torque step recommendations. Retighten flange connections at least 1 hour after the initial tightening using the pipe manufacturer’s tightening pattern and torque step recommendations.

o. All HDPE pipe must be at the temperature of the surrounding soil at the time of backfilling and compaction.

7. Type V-1 & V-5:
    a. Install pipe in accordance with the manufacturer's instructions.
    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. Clean pipe ends and bells of dirt, grease and other foreign materials prior to making the joint.
    e. 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.
    f. Containment fittings for chemical and chemical solution lines shall be installed and tested in accordance with manufacturers' instructions. Install containment pipe with position clips at 3-foot centers and at fittings during installation of carrier pipe. Do not make joints until after successful leak tests of carrier pipes.
    g. 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.
    h. 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.
8. Type X-1:
    a. Install and weld in accordance with ANSI B31.1.
    b. Threaded joints shall have connections metal-to-metal tight. Remove all burrs from the ends of the pipe and clean threads of all oil and chips. Coat male threads with a joint lubricant.
9. Type Y-1 Pipe: Threaded joints shall have connections made metal to metal tight. Remove all burrs from ends of pipe, and clean threads of all oil and chips. Coat male threads with joint lubricant. Properly tape wrap joints of plastic coated pipe.

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 System 8 in 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 and thermometers 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. All insulated piping passing through walls or slabs shall be sleeved and insulation shall run continuously through the sleeves and shall allow for 1/8-inch annular clearance between outside of insulation and sleeve wall.

L. Provide a suitable chrome plated escutcheon on pipes passing through walls, floors, ceilings and partitions in finished areas.

M. Install link-type seals in cast-in-place metal sleeves or in smooth core drilled holes. Grout both sides flush with non-shrink grout unless otherwise shown on the Drawings.

N. Install butterfly valves in accordance with AWWA C504, Appendix A, Sections A.2 through A.5, inclusive.

O. Install thermometer wells in piping tees in vertical position. Fill with oil. Where wells are in lines 2 inches and smaller, increase line size so that velocity at well section is not increased.

P. Provide test plugs on all closed water systems and condenser water systems located in inlet and outlet of coils, heat exchangers, cooling towers, and where indicated on Drawings. Locate test plugs where they will be easily accessible, have adequate clearance for insertion and removal of gage needles and thermometer stems, and position to allow unobstructed viewing of gages and thermometers.

3.04 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.

3.05 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.

3.06 CLEANING

A. 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.

3.07 FIELD TESTING

A. 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 allowable leakage and test medium shall be as specified and as shown in the following paragraphs. Test pressure shall be as shown on the Piping Schedule shown on the Drawings and 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 City at a fire hydrants designated by the City. At any connection to the City water system, the Contractor shall provide an air-gap or reduced pressure backflow valve system to prevent backflow into the water source.

B. 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.

C. 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.

D. 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.

E. 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.

F. 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.

G. Pneumatic Testing: Piping tested by air or another gas shall show no reduction of pressure during the test period after corrections have been made for changes in temperature in conformance with the following relationship:

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

Where T_1 and T_2 are the absolute temperatures of the gas in the pipe and P1 and P2 are the absolute pressures. The subscript "1" denotes the starting conditions and the subscript "2" denotes the final conditions.

H. Precautions for Pneumatic Testing: Where air or another gas is called for as the test medium, the Contractor shall take special precautions to protect personnel. During the initial pressurization of a pipeline to the specified test pressure, personnel shall be protected by suitable barricades or shall remove themselves to locations where portions of the concrete structure itself are between them and the pipeline under test.

I. 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.

J. Drying: Gas lines tested with water shall be drained and blown dry with air or oil-free nitrogen gas.

K. 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.

L. 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.

M. Testing Specifics:
   1. Type N-1 Pipe:
      a. Duration: 4 hours.
      b. Pressure: See Piping Schedule.

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.

2. Type N-2 Pipe:
   a. Duration: 4 hours.
   b. Pressure: See Piping Schedule.
   c. Medium: Water.
   d. Allowable Leakage: None.
3. Type N-3 Pipe:
   a. Duration: 1 hour.
   b. Pressure: See Piping Schedule.
   c. Medium: Water.
   d. Allowable Leakage: None.
4. Type Q-3 Pipe
   a. Duration: 1 hour.
   b. Pressure: See Piping Schedule.
   c. Medium: Water.
   d. Allowable Leakage: None.
5. Type T-1 Pipe:
   a. Duration: 4 hours.
   b. Pressure: See Piping Schedule.
   c. Medium: Water, except use air for vacuum and operating air systems.
   d. Allowable Leakage: None.
6. Type U-1 Pipe:
   a. Duration: 4 hours.
   b. Pressure: As shown.
   c. Medium: Water, except use air for vacuum and operating air systems.
   d. Allowable Leakage: None.
7. Type V-1 Pipe:
   a. Liquid Service:
      1) Duration: 4 hours.
      2) Pressure: See Piping Schedule.
      3) Medium: Water.
      4) Allowable Leakage: None.
   b. Double Containment for chemical and chemical solution pipes.
      1) Duration: 4 hours.
      2) Pressure: 5 psi.
      3) Medium: Air.
      4) Allowable Leakage: None.

8. Type Y-1 Pipe:
    a. Duration:
        1) Pressure Pipe Service: 4 hours.
        2) Drain Pipe Service: 1 hour.
    b. Pressure: See Piping Schedule.
    c. Medium: Water, except use air for the vacuum and operating air systems.
    d. Allowable Leakage: None.
9. Type X-1 Pipe:
    a. Duration: 4 hours.
    b. Medium:
        1) Liquid Service: Water
        2) Gaseous Service: Air.
    c. Allowable Leakage: None.

END OF SECTION

SECTION 15060

PIPE SUPPORTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes: Provide all pipe supports as shown on the Drawings and described in the Specifications.

1.02 REFERENCES

A. American Institute of Steel Construction (AISC), Manual of Steel Construction

B. American Society of Mechanical Engineers (ASME), ASME B31 Code for Pressure Piping

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

D. ASTM International (ASTM)

E. Manufacturers Standardization Society (MSS):
   1. MSS SP-58: Pipe Hangers and Supports - Materials, Design, and Manufacture
   2. MSS SP-69: Pipe Hangers and Supports - Selection and Application
   3. MSS SP-89: Pipe Hangers and Supports - Fabrication and Installation Practices

F. American National Standards Institute (ANSI)

G. American Water Works Association (AWWA)

H. National Fire Protection Association (NFPA)

I. SMACNA Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Piping Systems

1.03 SUBMITTALS

A. Shop Drawings:
   1. 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).
   2. Submit data to show that the following items conform to the Specification requirements:
      a. Fabricated pipe supports and other pipe supports (Product Review).
   3. Submit certified test reports as required herein and by the referenced standard specifications (Product Information).

B. Provide seismic anchorage design for Contractor-designed pipe supports in accordance with Section 01190, including layout and calculations, signed and sealed by a Professional Civil or Structural Engineer registered in the State of Oregon.

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.

1.05 APPURTENANCES

A. Furnish and install all necessary anchors and assembly bolts, washers and nuts, hangers, and supports; all other appurtenant items shown on the Drawings, specified or required for the proper installation and operation of the pipe supports.

1.06 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 2½ inches and larger and all piping for hazardous chemicals shall be supported with pipe supports designed to resist seismic loads. Hazardous chemical piping includes LPG, chlorine and chlorine solution, fuel, natural gas, hypochlorite, hydrogen peroxide, oxygen, ozone, polymer, potassium permanganate, sodium bisulfite, sulfur dioxide and sulfur dioxide solution, sulfuric acid (concentrated and solution), alum/ferric chloride

(concentrated and solution), steam, compressed air, sodium hydroxide and sludge gas. Piping smaller than 2½ 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: Refer to 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 non-rigid 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 or Steel Copper Plastic Tubing	6 4½ continuous continuous
1¼-inch to 2-inch	Iron or Steel Copper or Plastic	8 5
2½-inch to 4-inch	Iron or Steel Copper or Plastic	10 6
6-inch to 8-inch	Iron or Steel Plastic	12 8
10-inch and larger	Iron or Steel	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).
        2) Building heating hot water (rolling).
        3) Domestic hot water (rolling).
        4) Liquid Oxygen.
        5) Aeration Air, Airwash Air, Compressed Air.
    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 MATERIAL REQUIREMENTS

A. Unless specified otherwise herein bolts, nuts, and other hardware shall be as follows:
    1. Exposed: Electroplated zinc or cadmium steel.
    2. Submerged: Type 304 stainless steel except use Monel or Hastelloy for seawater, 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-galling compound to the threads of stainless steel bolts.

2.02 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.

B. Manufacturers:
    1. Anvil International
    2. Eaton B-Line
    3. Or equal.

C. 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 304 stainless steel. Trays for continuous support of plastic pipe or tubing shall be made of 20-gauge galvanized steel.

D. Insulation Protection Shields:
   1. Provide insulation protection shields at all pipe supports for insulated piping.
   2. The shield shall consist of an insulation layer encircling the entire circumference of the pipe and a steel jacket encircling the insulation layer.
   3. The thermal shield shall be the same thickness as the piping system insulation.
   4. The standard shield shall be used for hot systems and the vapor barrier shield shall be used for cold systems.
   5. Stainless steel band clamps shall be used where specified to ensure against slippage between the pipe wall and the thermal shield.

E. Provide plastic caps with rounded corners on all exposed ends of channels.

PART 3 - EXECUTION

3.01 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.
   4. Adjust hangers and supports to obtain required pipe slope and elevation. Shims made of material that is compatible with the piping material may be used. Adjust stanchions prior to grouting their baseplates.

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.

END OF SECTION

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SECTION 15080

PIPING INSULATION AND HEAT TRACING

PART 1 - GENERAL

1.01 SUMMARY

A. Provide heat tracing, insulation, and accessories for piping systems and designated equipment.

1.02 REFERENCES

A. ASTM International (ASTM) Standards:
   1. B209 Aluminum and Aluminum-Alloy Sheet and Plate
   2. C533 Calcium Silicate Block and Pipe Thermal Insulation
   3. C534 Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
   4. C547 Mineral Fiberglass Insulation.
   5. C552 Cellular Glass Thermal Insulation
   6. E84 Surface Burn Characteristics of Building Materials
   7. E96 Test for Water Vapor Transmission of Materials

B. National Fire Protection Association (NFPA) Standards

C. NEMA ICS 1-88 Industrial Control Systems

D. UL LLC (UL) Publications:
   1. 723 Test Hazard Classification of Building Materials.

1.03 FIRE RESISTANCE

A. Insulation. Smoke-developed ratings per NFPA 255, ASTM E 84 and UL 723 testing requirements to be as follows.
   1. Fiberglass with jacket not to exceed a flame-spread rating of 50.

B. Tape, Adhesives, Vapor Barrier Materials, and Jackets. Flame-spread ratings not to exceed 25.

C. Factory-Applied Items/Materials. Test these items as assembled. Provide Certificates of Compliance from an approved testing laboratory if not UL approved. Flame-proofing treatments which are subject to deterioration are not acceptable.

D. Field-Applied Items/Materials. These items may be tested individually. Provide Certificates of Compliance from an approved testing laboratory if not UL approved; flame-proofing treatments which are subject to deterioration are not acceptable.

E. Exempt Items/Materials. The following are exempt from the fire-resistance ratings:
   1. Nylon duct insulation anchors.
   2. Treated wood insulation inserts.
   3. PVC fittings and valve covers.

1.04 THICKNESS

A. Normal thickness of insulation is defined as the thickness of the basic insulating medium not including finishing coats.

1.05 APPROVED TESTING LABORATORIES

A. Approved testing laboratories include:
   1. UL LLC (UL).
   2. Canadian Standards Association (CSA), where acceptable to local authorities.

1.06 EXPOSED VERSUS CONCEALED INSULATION

A. Exposed is defined as Work exposed to the view of occupants in normally occupied areas and in equipment rooms.

B. Concealed is defined as Work located in ceiling spaces, chases, and other locations not exposed to view.

1.07 SUBMITTALS

A. Shop Drawings and Product Data: Submit the following as a single complete submittal in accordance with Section 01300:
   1. Thermal insulation product data fully describing all items proposed for use to demonstrate that the equipment conforms to the Specifications.

B. Affidavits: Submit affidavits from the manufacturer stating that the equipment has been properly installed, adjusted, and tested and is ready for full-time operation.

1.08 QUALITY ASSURANCE

A. Qualifications: Materials and equipment furnished under this Section shall be supplied by 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 named herein, if an alternate manufacturer is proposed.

PART 2 - PRODUCTS

2.01 THERMAL INSULATION AND HEAT TAPE FOR PLUMBING AND PIPING

A. General:
   1. Delivery: Deliver insulation materials to the job in original packages with manufacturer's "R" values clearly shown. Provide certification of compliance.
   2. Warning: The Contractor is warned that working with fiberglass or rock wool materials may constitute a serious health hazard. The Contractor shall take all necessary precautions to ensure the safety of the workers.
   3. Shields: Insulation protection shields are required per Section 15060.

4. The following table summarizes the insulation system by use and service:

System	Location	Service	Insulation System	Insulation Thickness (Inches)
2W	Exposed outside building	E	A	1-inch

For Service: E = Exposed including concealed space

B. Insulation System A:
   1. Material: Insulation shall be a pre-molded fiberglass with a maximum "K" factor of 0.25 at 70°F and having a factory-applied foil scrim kraft jacket with adhesive laps and butt straps.
   2. Fittings shall be insulated with insulating cement or mitered section of pre-molded fiberglass. Fittings shall be covered with PVC or aluminum jackets; Zeston, Childers, or equal.
   3. Pipe insulation shall be Johns Manville "Micro-Lok" ; Owens Corning Fiberglas SSL II with ASJ Max; or equal
   4. Insulation exposed to the weather shall have, in addition, a waterproof UV resistant PVC or aluminum jacket (alloy 3003 (0.024-inch)); Zeston, Childers, or equal.

C. Electric Heat Tape:
   1. Heating cables shall be self-regulating heating cable to be applied directly to the surface of piping. Cable shall be braided and protected from exposure with a fluoropolymer outer jacket. Heating cable and components must be UL approved and rated for installation in a NEC Class 1, Division 1, 2 location.
      a. For piping 4 inches or less: Cable shall be 5 watts per foot capacity using 120 volt, single-phase electrical wiring.
      b. For piping greater than 4 inches: Cable shall be 10 watts per foot capacity using 120 volt, single-phase electrical wiring.
      c. For Tanks. Cable shall be 10 watts per foot capacity, approximately 2,000 watts total, using 120 volt, single-phase electrical wiring.
      d. Maximum loading per heat trace controller shall not exceed 16A unless otherwise specified in this Section. Conform to manufacturer's recommendations for maximum thermal rating and maximum amperage per heat trace controller where these recommendations are less than those specified in this Section
   2. Operation of the heating cable shall be line sensing and be sized to maintain a minimum temperature of 40°F.
   3. System shall include all necessary components including power connection kits, integral line sensing and ambient sensing thermostats, end seals, pipe straps, and labels. Power connection kit shall at a minimum include a signal light and a NEMA 4X enclosure. End seals shall be lighted to indicate power on/off. Pipe straps shall be either nylon straps or fiberglass tape.

4. Circuits and power supply locations for the heat trace system are identified on the Drawings. Provide any additional conduit, wire, or other accessories required to provide the required heat tracing.
5. Heat cable and accessories shall be Chromalox; Raychem; or equal.

PART 3 - EXECUTION

3.01 INSTALLATION OF INSULATION

A. General: Apply insulation material, accessories, and finishes according to the manufacturer's printed instructions.
   1. Apply insulation only after piping has been tested and certified as ready for operation, and after heat tracing elements have been installed where applicable.
   2. Seal joints and seams to maintain vapor barrier.
   3. Seal penetrations for hangers, supports, and anchors.
   4. Keep insulation material dry during application.
   5. Apply vapor barrier on seams, joints, over staples, and at end butt to fittings.
   6. Install with all joints tightly butted.
   7. Tuck and tuft all edges of insulation.
   8. Install insulation to allow easy access to piping or equipment for inspection and repairs.
   9. Carefully bevel and seal insulation around unit or equipment nameplates.
   10. Remove all loose dirt, rust, all other loose foreign material, moisture, and frost from surfaces prior to installing insulation.
   11. Seal all raw edges of insulation at unions, flanges, etc.

B. Roof Penetrations: Apply insulation for interior applications to a point even with the top of the roof flashing. Seal with vapor barrier coating. Apply insulation for exterior applications butted tightly to interior insulation ends. Extend metal jacket for exterior insulation outside roof flashing at least 2 inches below top of roof flashing. Seal metal jacket to roof flashing with vapor barrier coating.

C. Interior Walls and Partitions Penetration: Apply insulation continuously through walls and partitions, except fire-rated walls. Apply aluminum jacket with factory-applied moisture barrier over insulation. Extend 2 inches from both surfaces of wall on partition. Secure aluminum jacket with metal bands at both ends. Seal ends of jacket with vapor barrier coating. Seal around penetration with joint sealer.

D. Whenever possible, slip insulation on pipe before making connections. Seal joints with adhesive. Where the slip-on technique is not possible, cut one side longitudinally and apply to the pipe. Seal seams and joints with adhesive.

E. Cover exterior insulation, except for metal-jacketed insulation with PVC fitting covers and seal circumferential joints with butt strips. Metal jackets shall be secured with bands. Screws, rivets, or other devices capable of puncturing underlying vapor barriers are not acceptable. Paint all exterior PVC covering.

F. Provide insulation protection shields at all pipe supports for insulated piping. Refer to Section 15060.

3.02 INSTALLATION OF HEAT TRACING

A. Install in accordance with the manufacturer's instructions.

B. Fasten heat tracer tape to pipe and valves as recommended by the manufacturer at intervals not exceeding 1 foot. Spiral winding is only permitted around vertical piping.

C. The cable must be capable of being cut in field without affecting heat output of the finished installation.

D. Insulation shall be installed after heating cable is in place and deemed functional.

E. Affix labels on surface indicating heat-traced pipe.

END OF SECTION

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SECTION 15800

HEATING, VENTILATING, AND AIR CONDITIONING

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Furnish all labor, materials, equipment, services, and incidentals required to provide complete, integrated, and operating Heating, Ventilating, and Air Conditioning (HVAC) Systems for the buildings and structures in this project. Materials and equipment to be supplied shall be new, of the best quality as specified, and as shown on the Drawings.

B. Work included in this Section:
   1. Ductwork and ductwork support systems
   2. Dampers
   3. Registers
   4. Fans
   5. Testing, adjusting, and balancing
   6. HVAC controls descriptions
   7. Gas-fired makeup air units

1.02 REFERENCE STANDARDS

A. Air Movement and Control Association International, Inc. (AMCA):
   1. AMCA 99 Standards Handbook
   2. AMCA 210 Laboratory Methods of Testing Fans for Rating Purposes
   3. AMCA 300 Test code for Sound Rating Air Moving Devices
   4. AMCA 301 Method of Calculating Fan Sound Ratings from Laboratory Test Data

B. ASTM International (ASTM):
   1. ASTM E84-69 Standard Test Method for Surface Burning Characteristics of Building Materials

C. National Electrical Manufacturers Association (NEMA):
   1. NEMA MG-1 Motors and Generators

D. Sheet Metal & Air Conditioning Contractors' National Association, Inc. (SMACNA):
   1. SMACNA HVAC Duct Construction Standards
   2. SMACNA Thermoset FRP Duct Construction Manual
   3. SMACNA HVAC Systems – Testing, Adjusting, and Balancing

E. UL LLC (UL):
   1. UL 181 Standard for Factory-Made Air Ducts and Air Connectors

1.03 SUBMITTALS

A. Provide shop drawings and technical literature covering all equipment and accessories being furnished under this Section and in accordance with Sections 01300 and 11001. The data shall include information to demonstrate compliance with all the requirements of these Specifications.

B. Provide seismic anchorage design for equipment, including layout and calculations, signed and seal by a Professional Engineer registered in the State of Oregon, and conforming to the requirements of Section 01190.

C. Manuals: Furnish manufacturer's installation, lubrication, and maintenance manuals, bulletins, and parts lists. Furnish separate list of recommended spare parts.

D. Affidavits: Furnish affidavits from the manufacturers stating the equipment has been properly installed and tested, and each is ready for full-time operation.

E. Submit fabrication drawings for ductwork, including duct supports.

1.04 QUALITY ASSURANCE

A. Codes: Comply with all rules and regulations of authorities having jurisdiction over the work specified herein.

B. Permits and inspection shall be in accordance with the Standard Construction Specification.

C. All equipment furnished under this Section shall 1) be of a design and manufacturer who has been regularly engaged in the design and manufacture of the equipment and 2) be demonstrated to the satisfaction of the Engineer that the quality is equal to equipment made by those manufacturers specifically named herein.

D. The Drawings shall be taken in a sense as diagrammatic. Size of ducts and pipes including 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.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site, properly store, and protect under applicable provisions of Section 11001.

1.06 SEISMIC PROTECTION

A. Equipment specified in this Section is classified as essential for seismic protection as specified in Division 1. Conform to the seismic requirements in Section 01190.

PART 2 - PRODUCTS

2.01 DUCTWORK

A. Ductwork for the Dewatering Building shall be Type 304 or 316 stainless steel of the gauge and fabrication that conforms to SMACA "HVAC Duct Construction Standards."

B. Flexible Duct Connections: Flexible connections in ducts shall be made of neoprene fiberglass cloth, installed in folds, and of sufficient length to accommodate the maximum deflection resulting from vibration and contraction without causing strain. Minimum length in folded position shall be 4 inches. Flexible

duct connections shall be Ventfabrics Inc. “Ventglas”; Duro-Dyne Corp.; “Neoprene”; or equal.

C. Vent piping for gas-fired makeup air unit: 24-gauge or heavier galvanized Type B in accordance with NFPA 211 and Appendix C of the Oregon Mechanical Specialty code.

D. Duct sealant (for sealing joints) shall be Arabol and Canvas; Hardcast; or equal.

E. Turning vanes shall be 2-inch blades for ducts up to 18 inches in either dimension and shall be 4½-inch blades for larger ducts. All turning vanes shall be constructed of double thickness vanes. Turning vanes shall be constructed of materials matching the ductwork in which they are installed.

F. Duct Supports: Duct support details and spacing shall conform to SMACNA “HVAC Duct Construction Standards.” The specific support detail utilized shall be as appropriate for each duct and location, except as otherwise shown. Duct supports shall be Type 304 stainless steel.

G. Insulation:
   1. General: Insulation shall be exterior wrap or internal duct lining as specified. Insulation shall have a maximum flame spread of 25 and smoke developed of 50.
   2. Exterior Wrap: Fiberglass wrapping, where specified, shall be the flexible blanket type and shall be made of flame attenuated glass fibers bonded with a thermosetting resin. The facing shall be constructed out of reinforced foil kraft. Insulation shall be 1½-inches thick or of minimum thickness to meet the requirements of the Oregon Mechanical Specialty Code and Oregon Zero Energy Ready Commercial Code, ¾ pound per cubic foot density, and have a maximum thermal conductivity or 0.30 Btu-inches/hour/sq ft/°F. Adhesive use in securing insulation to the ductwork shall meet the requirements of the SMACNA. Owens-Corning “Fiberglas All Service Duct Wrap”; Johns-Manville "Microlite"; or equal.
   3. Internal Duct Lining: Duct lining, where specified on the Drawings, shall be fiberglass of 3 pounds per cubic foot density; Owens-Corning Fiberglass "Duct Liner Board," Johns-Manville, or equal, 1-inch thickness, installed using pins spot welded to ductwork. Insulation shall be installed in strict conformance with the manufacturer's installation requirements and SMACNA. Duct dimensions shown shall be net inside clear after lining.

2.02 DUCTWORK – FIBERGLASS REINFORCED PLASTIC

A. Ductwork for the Cake Storage Building odor control system shall be fiberglass reinforced plastic (FRP) and shall be fabricated in accordance with the SMACNA “Thermoset FRP Duct Construction Manual.”
   1. The fabricating firm shall be experienced in the fabrication of FRP ductwork.
   2. Prior to fabrication, the fabricator shall provide certification to the Engineer from an independent testing laboratory of the following:
      a. The fabricated duct will have a flame spread of 25 or less when tested in accordance with ASTM E84-69.
      b. The fabricated duct will meet UL Standard 181.

c. The test shall be based on the same material to be used in the fabrication of the ducts.

3. The resin shall be a biphenyl A polyester that provides high chemical resistance. A certificate from the resin manufacturer listing the nomenclature, composition, and characteristics of the resin being used in the ductwork shall be provided by the Contractor. This certificate shall also indicate the expected resistance to acids, alkalines, organic compounds, and UV exposure.
4. The FRP ductwork shall be rated to withstand a minimum of 10-inch water vacuum using the same safety and design factors and minimum properties of the duct materials as listed in the SMACNA “Thermoset FRP Duct Construction Manual.”
5. The FRP duct shall be flanged where required to mate with devices, equipment, or to provide flanges for supporting the ducts. Provide chlorine-resistant flange gaskets to make ductwork air-tight. Gaskets shall be Viton.
6. All duct joints shall be of the butt-type where not flanged.

B. Flexible FRP duct shall be used for Screw Press Room Exhaust. Flexible duct shall be UL listed and fabricated in accordance with SMACNA “HVAC Duct Construction Standards.”

C. Duct Joining: ‘Butt-weld’ type joints shall, in general, be used in FRP duct assemblies. Flanged joints shall be used where specifically noted on the Drawings and where ductwork is to be joined to flanged equipment. Joints shall be formed according to the duct manufacturer’s specifications, and in accordance with the latest version of the SMACNA “Thermoset FRP Duct Construction Manual.”

D. Duct Hangers and Supports: FRP ductwork shall be supported in accordance with the latest version of the SMACNA “Thermoset FRP Duct Construction Manual.”

E. FRP Duct Accessories:
1. Flexible Connections and Expansion Joints:
a. Rating: -2 to 2 psi.
1) Type: Molded single arch (unless otherwise shown on Drawings) with full rubber flanges and retaining rings. Flanges to match pattern of adjoining ductwork.
2) Materials: EPDM, unless ammonia is present, then BUNA-N.
3) Manufacturers: Proco Series 530; Garlock; or equal.

2.03 VOLUME DAMPERS

A. All dampers shall be made of material similar to the ductwork in which the damper is located. Dampers shall be two gauges thicker than the duct in which the damper is located. Each damper shall have an operator with indicator handle and a locking mechanism. Damper operator shall be Young Regulator Company "Valcalox" No. 403B; Ventfabrics Inc. "Ventloc" No. 637; or equal.

2.04 FRP VOLUME DAMPERS

A. Construction: Volume dampers shall be balancing type, manufactured in accordance with the SMACNA “Thermoset FRP Duct Construction Manual” in addition to the following:

1. Blade shall be of molded FRP construction with stiffeners, as directed by the manufacturer.
2. Shaft: Stainless steel.
3. Bearings: Fiber reinforced thermoplastic.

B. Dampers shall be provided with manual operators. Operator shall provide visual indication of valve position.

C. Dampers shall be supplied with flanged connections for mating to connecting FRP ductwork. See Drawings for more information.

D. Manufacturer: Hartzell Model FCO or equal.

2.05 REGISTERS

A. Supply diffusers shall be stainless steel with air patterns and size as indicated on the Drawings. Diffusers shall be double deflection with individually adjustable bars that allow 45° adjustable spread. Bars shall be on ¾-inch centers, with horizontal face bars and vertical rear bars. Provide integral volume dampers where indicated on the Drawings. Diffusers shall be Titus Model 300FL; Price Model 620 series; or equal.

B. Exhaust registers shall be stainless steel with sizes as indicated on the Drawings. Provide integral volume dampers where indicated on the Drawings. Registers shall be return Titus Model 50F; Price Model 80; or equal.

2.06 FANS

A. In-Line Centrifugal Fans: In-line centrifugal fans shall be factory fabricated assemblies having fan, fan motor, and housing. Fans shall be of aluminum construction. Fan capacities, electrical characteristics, special features, and accessories shall be as indicated in the fan schedules on the Drawings. Fans shall bear the AMCA seal.
1. Fans shall be Greenheck Type BSQ; Loren Cook Model SQN-B; or equal.

B. Utility Set Fans:
1. General: Belt-driven, centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories, having weathertight fan assembly and vented motor housing when installed outside the building. Fan housing fabricated of heavy-gauge steel with side sheets fastened airtight to scroll sheets by welding or deep lock seams, equipped with round duct collar inlet, having slip-joint duct connection discharge, adjustable to eight positions. Fan wheel shall be aluminum construction, non-overloading, backward inclined airfoil centrifugal type, statically and dynamically balanced in accordance with AMCA 204-05, with blades securely riveted or welded to a heavy gauge back plate and wheel cone. Fan shaft shall be ground and polished solid steel with anti-corrosive coating, equipped with pre-lubricated and sealed, self-aligning, pillow-block type ball bearings.
2. Provide weather cover.
3. Mounting: Provide equipment support frame and mount fans on vibration isolators in compliance with this Specification. Provide flexible duct connections on suction.

4. Manufacturers: Utility sets shall be Greenheck Model USF; Loren Cook CF; or equal.

C. Where indicated, corrosion-resistant, factory applied epoxy coatings shall be used per the manufacturer's instructions.

D. See Fan Schedule on the Drawings for specific requirements.

2.07 GAS-FIRED MAKEUP AIR UNIT

A. Gas-Fired Makeup Air Unit: Gas-fired make-up air unit shall be indirect-fired, factory-fabricated assembly suitable for 100% outside air, and natural gas fuel as shown on the Drawings. Make-up air unit shall consist of an insulated metal cabinet, sensors, filter assembly for intake air, supply air blower assembly, control unit with motor starter, and indirect-fired gas furnace. All specified components and internal accessories factory installed and tested and prepared for single-point power connection.
   1. Cabinet: Formed, insulated metal cabinet, fabricated to permit access to internal components for maintenance.
      a. Outside casing: 18-gauge, galvanized (G90) steel meeting ASTM A653 for components that do not receive a painted finish.
      b. Base rail: 12-gauge, galvanized (G90) steel.
      c. Internal assemblies: 24-gauge, galvanized (G90) steel except for motor supports which shall be minimum 14-gauge galvanized (G90) steel.
      d. Cabinet Insulation: Interior of entire unit shall be insulated. Comply with NFPA 90A and NFPA 90B and erosion requirements of UL 181. Insulation shall be minimum 1-inch thickness with a maximum flame spread rating of 25 of smoke development rating of 50 when tested in accordance with ASTM C411.
      e. Access Panels: Unit shall be equipped with insulated access panels to provide access to all major components. Access panels shall be fabricated of 18-gauge galvanized (G90) steel.
      f. Corrosion-resistant, factory applied coatings shall be Hi-Pro Polyester applied in strict conformance with the paint manufacturer's instructions.
   2. Fan: Fan shall be a forward curve centrifugal fan. Assembly shall be mounted on heavy gauge galvanized rails mounted on spring vibration isolators. Fan assembly shall be statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and horsepower.
   3. Motors: Motors shall be in accordance with Section 11002 for the type identified in the Make-up Air Unit Schedules. Motors shall be heavy-duty, permanently lubricated type to match the fan load and furnished at the specified voltage, phase, and enclosure. Drives shall be sized for a minimum of 150% of driven horsepower and pulleys shall be fully machined cast-type, keyed, and fully secured to the fan wheel and motor shafts. Electric motors of 10 horsepower or less shall be supplied with an adjustable drive pulley.
   4. Indirect Gas-Fired Furnace:
      a. UL or ETL listed for installation downstream of a cooling coil, electronic modulating gas control with integral combustion gas blower.
      b. 24-volt modulating gas controls with minimum 8-to-1 turndown including main, operating, pilot safety, and pressure regulating valves.

c. Furnace shall have 3-pass tubular heat exchangers constructed of 409 stainless steel. Heat exchanger tubes shall be supported by a minimum of two fabricated assemblies that support the tubes and permit tube expansion and contraction.
d. Furnace shall be encased in a weather-tight metal housing with intake air vents. Provide hinged access door.
e. Provide kit for outdoor mounting with vertical stack venting.

5. Filters: Unit shall have 2-inch disposable filters located in the outdoor air intake and shall be accessible from the exterior of the unit.
6. Electrical: Electrical requirements shall be as indicated in the equipment schedules on the Drawings. Provide for single connection of power to unit with NEMA 4X rated remote control station including disconnect switch, control circuit transformer with built-in circuit breaker, starters, step down transformers, and other elements required for the control of the units. Unit wiring to comply with NEC requirements with applicable UL standards. Electrical components to be UL recognized where applicable.
7. Instrumentation and Controls: Provide all instrumentation required for complete control and monitoring of the units as shown on the Drawings. Instrumentation to be provided with the unit includes but is not limited to the following:
   a. Room/Space override temperature sensor
   b. DPDT air differential pressure switch for fan status
   c. Supply air temperature sensors
   d. Dirty filter sensor
   e. Heating inlet air sensor
   f. Auxiliary exhaust starter contacts
   g. Airflow proving monitoring contract.
8. Spare Parts: Provide one extra set of filters and one set of fan belts for each unit.
9. Makeup air unit shall be Greenheck IGX series or equal.

B. See the Makeup Air Unit Schedule on the Drawings for specific requirements.

2.07 HVAC INSTRUMENTATION

A. Differential Pressure Switches: UL listed and FM Approved, SPDT snap-acting rated for 15 Amps at 120 VAC; enclosure as required for location; scale range and differential suitable for intended application; setpoint adjustable with operating ranges as indicated below.
   1. For makeup air unit: operating range of 0.07 to 0.15 inches W.C. Dwyer Model 1910-00, or equal.
   2. For fans: operating range of 0.15 to 0.5 inches W.C. Dwyer Model 1950-0, or equal.
   3. For odor control unit: operating range of 3 to 11 inches W.C. Dwyer 1950-10, or equal.

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.

C. 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.

D. All FRP ductwork shall be erected in a first class and workmanlike manner and shall be in accordance with the SMACNA “Thermoset FRP Duct Construction Manual”, and as specified above. No ductwork shall be fabricated or installed until it has been carefully coordinated with other trades. Connection of new ductwork to existing ductwork, repairs, or other modifications shall be in accordance with SMACNA guidelines. Duct dimensions shown are "net" inside clear.

E. Testing and Adjusting Equipment and Controls:
   1. The equipment and controls of this Section shall be completely tested, adjusted, and placed in operating condition.
   2. 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.
   3. Supply the testing apparatus and make all necessary connections for applying the tests.
   4. 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.

F. Testing, Adjusting and Balancing of Heating, Ventilating, and Air Conditioning Systems:
   1. Exhaust fans (FAN-0001, FAN-0005) shall be adjusted as needed in relation to the makeup air unit (AHU-0001) to maintain a slightly negative pressure (0.05 in. WC) in the Screw Press Room and the Polymer Pump Room. Fans shall be balanced in accordance with SMACNA “HVAC Systems – Testing, Adjusting, and Balancing.”
   2. 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.

3. 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.
4. 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.

3.02 CONTROLS DESCRIPTION

A. The Screw Press Room is ventilated via makeup air unit (AHU-0001) and exhaust fan (FAN-0001) at a continuous rate of 6 air changes per hour (ACH). Duct-mounted differential pressure switches connected to the PLC monitor both fans and will generate an alarm in the event of low differential pressure (low airflow). Visual alarms (located near each entrance/exit to the space) shall have one GREEN and one RED light. The GREEN light indicates sufficient airflow while the RED light indicates insufficient airflow. Audible alarms shall be located with the indoor visual alarms, with an alarm indicating insufficient airflow.

B. The Polymer Pump Room and Mezzanine are ventilated via makeup air unit (AHU-0001) and exhaust fan (FAN-0005) at a continuous rate of 6 ACH. Duct-mounted differential pressure switches connected to the PLC monitor airflow for both fans and will generate an alarm in the event of low differential pressure (low airflow). Visual alarms (located near each entrance/exit to the space both on the inside and outside) shall have one GREEN and one RED light. The GREEN light indicates sufficient airflow while the RED light indicates insufficient airflow. Audible alarms shall be located with the indoor visual alarms, with an alarm indicating insufficient airflow.

C. Heating is provided to the Screw Press Room, Polymer Pump Room, and Mezzanine via the gas-fired makeup air unit (AHU-0001) and existing unit heaters.

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SECTION 15850

ODOR CONTROL EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Complete, tested, and operating packaged radial flow dry media odor control system complete with blower and accessories as specified herein.

B. Work included in this Section: Odor control system and all appurtenances described within this Section are to be provided and installed by the General Contractor.

1.02 REFERENCE STANDARDS

A. ASTM International (ASTM):

1. ASTM D2563 Standard Practice for Classifying Visual Defects in Glass Reinforced Plastic Laminate Parts
2. ASTM D2584 Standard Test Method for Ignition Loss of Cured Reinforced Resins
3. ASTM D2854 Standard Test Method for Apparent Density of Activated Carbon
4. ASTM D2867 Standard Test Method for Moisture in Activated Carbon
5. ASTM D3299 Standard Test Method for Filament-Wound Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks
6. ASTM D3467 Standard Test Method for Carbon Tetrachloride Activity of Activated Carbon
7. ASTM D3802 Standard Test Method for Ball-Pan Hardness for Activated Carbon
8. ASTM D4097 Standard Specification for contact-molded glass-fiber-reinforced Thermoset Resin Corrosion-Resistant Tanks
9. ASTM D3982 Standard Specification for Contact Molded “Fiberglass” (Glass Fiber Reinforced Thermosetting Resin) Ducts

B. National Bureau of Standards (NBS):

1. NBS PS 15-69 Custom molded reinforced polyester for chemical resistant process equipment

1.03 SYSTEM DESCRIPTION

A. Design Requirements: Foul, odorous air within the Cake Storage Building is to be treated prior to discharging to atmosphere. The odor control system shall include insulated FRP radial vessel, media, fan and motor assembly, instruments, interconnecting ductwork, prefilter, fan acoustic enclosure, and all appurtenances necessary for a complete and operable system.

1.04 PERFORMANCE AND DESIGN REQUIREMENTS

A. The odor control system shall be designed to operate at 99% gas removal efficiencies and conform to the following operational requirements:
   1. Air Flow: 9,000 cfm
   2. Maximum H_2S concentration: 0.05 ppm
   3. Percent Removal: 99%
   4. Percent Nuisance Odor Removal: 90%

B. Odor Control System Fan:
   1. Capacity: 9,000 cfm @ 10-inch w.c.
   2. Fan Speed: Variable
   3. Maximum Horsepower: 25 HP
   4. Maximum noise level at 3 feet: 68 dbA (with sound enclosure)
   5. Number: 1
   6. Electrical: 460/60/3.

C. Odor control system shall be suitable for installation in a NEC Class 1, Division 2 environment.

1.05 SUBMITTALS

A. 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, including performance and design requirements, installation and design details, and catalogue cut-sheets. Include a list of materials of construction for all components.
   2. Motor data.
   3. Odor reduction system layouts and dimensions and operating Data Sheets including odor reduction efficiency, air residence time through the media, blower motor performance, and other operational data conforming to the requirements herein.
   4. Fan performance curve and sizing based upon supplied inlet duct losses.
   5. Shop Drawings: Submit signed and sealed structural calculations by a Professional Engineer registered in the State of Oregon and detailed drawings for the attachments and anchorage to the structure of the equipment and appurtenances in this Section: Calculations shall conform to the requirements of Section 01190.
   6. Submit certification from the manufacturer that the equipment can resist seismic loads. Loading shall be as described in Section 01190.

B. Performance Testing: Submit certified non-witnessed factory performance test results. Receive favorable review of test results prior to shipping the equipment.

C. Manuals: Furnish manufacturer's installation, lubrication, operation and maintenance manuals, bulletins, and spare parts lists.

D. Affidavits: Submit affidavit from the manufacturer stating that the equipment has been properly installed, adjusted, and tested and is ready for full time operation.

1.06 QUALITY ASSURANCE

A. 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.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The odor reduction system shall be ECS VX-9000; Perry Fiberglass; or equal.

2.02 EQUIPMENT

A. Pre-Filter: A prefilter shall be provided to remove moisture/particulate and direct airflow into the fan. Housing shall be FRP construction, with access door, drain and ball valve, and capable of withstanding 12-inch w.c. positive and negative pressure. Flange dimensions shall match connecting ductwork. Particle removal efficiency shall be 99% particles 10 microns and larger.

B. Adsorber Vessel:
   1. Vessel shall be cylindrical with vertical media bed, FRP construction, have multiple inner corrosion layers, and internally sloped bottom for drainage. The bed shall be grounded to prevent static electricity accumulation. Tie down lugs and lifting lugs shall be stainless steel.
      a. Media bed shall have access ports and one access manway so man-entry of vessel is not required.
      b. The top of the housing shall be flanged to allow complete removal of internal components, and capable of withstanding 12-inch w.c. of positive pressure.
      c. Media shall be provided for removal of ammonia, volatile organic compounds (VOCs), and hydrogen sulfides (H_2S):
         1) The VC Plus media consists of manufactured coconut derived pellets composed of activated carbon for 99% ammonia removal.
            a) Moisture content: 4% max by weight
            b) Maximum ash content: 7% by weight
            c) Minimum hardness number: 99
            d) Apparent density: 0.46-0.52 g/cc
            e) Nominal pellet diameter: 4mm

C. Fan:
   1. Belt driven, centrifugal FRP fan sized to deliver rated airflow through adsorber vessel. All parts of fan exposed to airstream shall be corrosion resistant. Fan base should be stainless steel; epoxy coated components not allowed.
      a. The fan shall be balanced at the factory to operate without vibration throughout the full operating range specified.
      b. Fan shall bear the AMCA rating seal.

c. Fan shall be furnished with inverter duty motor for operation with variable frequency drive. Refer to Section 11002 for specific requirements.

D. Sound Attenuation Enclosure: FRP sound enclosure shall be provided to house fan. Trim shall be identical to adsorber vessel. Enclosure shall be easily removable for maintenance with a split centered on the fan outlet. Enclosure shall produce 20 dB loss at 3 feet.

E. Differential pressure gauge to permit local read-out of pressure drop through the adsorber vessel.

2.03 FINISHES

A. Painting: Where applicable, apply manufacturer’s standard factory paint finish.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install the Odor Control System in strict conformance with manufacturer's installation instructions. The skid shall rest on a level, even base of concrete. Check fan and motor alignment after complete system has been installed at the site.

3.02 FIELD TESTING

A. Field test the system to guarantee compliance with these specifications. Fan shall be field adjusted to provide airflows indicated on the Drawings.

3.03 FIELD SERVICE AND TRAINING

A. The equipment manufacturer shall supply a competent field service engineer to thoroughly check and inspect the equipment after installation, place the equipment in operation, make necessary adjustments, calibrate instruments, conduct field tests, and perform operator training.

END OF SECTION

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 11001: General Equipment and Mechanical Requirements – equipment supports and foundations

2. Section 11002: Electric Motor Drives - providing electric motors
3. Division 17: Providing instruments and other process control equipment.

C. 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. UL LLC (UL)
9. Factory Mutual (FM)
10. Institute of Electrical and Electronics Engineers
11. ASTM International (ASTM)
12. Local Telephone Company requirements
13. Local Utility Company requirements

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 in accordance with Section 01300 and 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 pull boxes.
3. Conductor sizes and conduit fills.
4. Panelboard Schedule(s).
5. Control Wiring Diagram(s).
6. Underground raceway and duct bank routing including manhole/handhole locations.
7. 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. 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.

B. Inspection 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.

1.06 DEMOLITION AND RELATED WORK

A. General:
   1. Perform electrical demolition work as indicated.
   2. The Contractor is cautioned that demolition work may also be indicated on non-electrical Drawings.
   3. Coordinate with all trades regarding electrical de-energization, disconnection and removal, and the overall sequence of construction.

B. Electrical Requirements for Removed Equipment:
   1. Remove dedicated wiring and exposed conduits back to the source.
   2. Abandon in place wiring that shares conduit with other equipment wiring, except power wiring.
   3. Remove power wiring from the power source to the first pull box or manhole remote from the panel and abandon in place the remaining wiring.
   4. Abandon in place wiring routed through encased conduits and cut encased conduits flush to the floor and grout flush with the floor.
   5. Remove remote mounted starters, disconnect switches, circuit breakers, sensors, and transmitters

C. Where new lighting and receptacles are installed in existing structures, remove old lighting, receptacles, switches, wiring, and conduits.

D. Junction Boxes:
   1. Wiring and conduits indicated to be extended shall be terminated in a new junction box with terminal strips.
   2. Provide a junction box with a NEMA rating in accordance with the area in which it is located and sized as required by the NEC.
   3. Properly identify wires and terminals before disconnection.

E. Removed materials and equipment not indicated to be returned to the Owner shall, upon removal, become the Contractors property and shall be disposed of off-site.

F. Identification:
   1. Where switchgear, motor control centers, switchboards or panelboards are indicated to have components, assemblies or circuits removed and/or reconnected, provide the affected equipment compartments with new engraved nameplates matching the existing. Modify panelboard schedule(s) to indicate revised circuits.
   2. Pencil or magic marker markings directly on equipment will not be acceptable.

1.07 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. Modifications:
   1. Perform modifications or alterations to existing electrical facilities as required to successfully install and integrate the proposed electrical equipment as indicated.
   2. Perform modifications to existing equipment, panels and cabinets in a professional manner. Repair coatings of existing equipment to match existing.
   3. The costs for modifications to existing electrical facilities that are required for a complete and operable system shall be included as part of the Work.

G. 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.

H. 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 Contractor shall be responsible for identifying available existing circuit breakers in lighting panel for the intended use as required.
   4. The Contractor shall be responsible for field verifying the available space in switchgear, switchboards, and/or motor control centers to integrate new overcurrent protective devices meeting the requirements of these Specifications.
   5. The cost for the above field verifications shall be included as part of the Work.

I. Installation of Temporary Power:
   1. To facilitate the continuous operation of existing equipment, provide temporary equipment as indicated.
   2. Submit installation and connection details for favorable review and acceptance by the Engineer.
   3. Costs associated with these temporary installations shall be included as part of the Work.
   4. Temporary wiring and equipment shall remain the property of the Contractor unless indicated otherwise.
   5. Temporary power circuit breaker is available at the existing Influent Pump Station Building in Switchgear 10B, see contract drawings.
   6. The Dewatering Building process shall be bypassed to a Biosolids Dewatering Trailer that requires 100A, 480V three phase service.

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 75ºC conductors. Wire sizes in the Contract Documents are based on NEC ampacity tables using the 75ºC 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 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.

2.04 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 inches wide.

C. Protective matting shall be as manufactured by Rhino or approved equal.

2.05 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 incidentals 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, Sitework, 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 ¼ 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 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.

3.10 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

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. TC 2 Electrical Polyvinyl Chloride (PVC) Conduit
3. TC 6 PVC and ABS Plastic Utilities Duct for Underground Installation
4. TC 14 Reinforced Thermosetting Resin Conduit (RTRC) and Fittings

D. UL LLC (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 ¾-inch minimum trade size and encased conduit of 1-inch minimum trade size.

C. The use of short sections of ½-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 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 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 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 equal.

E. Fiberglass conduit shall be manufactured using the single circuit filament winding process. The resin shall be epoxy-based, with no fillers. All additives for increasing flame spread and lowering smoke density shall be halogen free. Conduit shall be manufactured in accordance with NEMA TC 14. Manufacturers shall be Champion Fiberglass, United Fiberglass, or 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 five 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 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 aluminum shall be cast aluminum with less than 0.40 percent copper content, and suitable for use with aluminum conduit. Manufactures shall be O.Z. Gedney, Appleton, Crouse-Hinds, or equal.

D. 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.

E. 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 equal. If such are not available, then the Specification for PVC coated galvanized rigid steel fittings shall apply.

F. Fittings for flexible conduit shall be Appleton Type ST, O.Z. Gedney Series 4Q, or equal.

G. Fittings for use with fiberglass conduit shall be fiberglass and as recommended by the conduit manufacturer.

H. 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 equal.

I. Expansion fittings with internal grounding shall be installed wherever exposed raceway cross building expansion joints. Expansion fittings shall be Crouse Hinds Type XLGSA or equal.

J. Union couplings for conduits shall be the Erickson type and shall be Appleton Type EC, O.Z. Gedney 3-piece Series 4, or equal. Threadless couplings shall not be used.

K. 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 equal.

L. 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 equal.

M. Conduit seals in areas where chlorine, ammonia, sulfur dioxide and/or hydrofluosilicic areas shall be Link Seal or 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 equal.

C. NEMA 4X Areas: NEMA 4X terminal boxes, junction boxes, pull boxes, etc. shall be Type 304 or 316 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 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 NEMA 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 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 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 all existing conduit sizes and new 2-inch and larger conduits runs, snake conduits with a cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of the conduit. This procedure requires that the mandrel be pulled out and returned to the starting point.
   1. For PVC conduits, use a spring mandrel as required to ensure full inside diameter at all bends are cleaned. This procedure requires that the spring mandrel be pulled out and returned to the starting point.
   2. When conductors required lubricate to loosen, start with smaller diameter brush and work up to the standard mandrels.

G. 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.

H. 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.

I. 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.

J. 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.

K. Damage to PVC coating of coated conduits or fittings shall be repaired with factory-approved PVC patching material to the original factory condition.

L. Install fiberglass conduit in accordance with the manufacturer's instructions. Connections between sections of conduit may be either glued or threaded, at the Contractor's option.

M. 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.

N. 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-inch-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 equal. Application shall follow manufacturer's recommendation.

O. 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.

P. All conduit penetrations through interior walls and floors shall be sealed with fire retardant type conduit sealant.

Q. Conduit Identification: In each handhole, pull box, 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.

R. 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.

S. Aluminum conduit shall not be installed underground or encased in concrete. If necessary to run through concrete, install in a non-metallic conduit sleeve or use PVC coated conduit.

T. 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	PVC Coated GRS	GRS	GRS	PVC-40	PVC-40
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.

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

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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. ASTM International (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. UL LLC (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 90ºC 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, two 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 conductor, stranded copper, PVC jacketed, shielded type, tray cable (TC) rated 600 volts with three symmetrical ground conductors. The individual conductors shall be UL listed as Type XHHW-2 or RWH-2 rated for 90ºC 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. 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
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. Wrap all cables in manholes with fireproofing tape. Extend tape 1 inch into ducts.

J. Cable bending radius shall be per applicable code. Install feeder cables in one continuous length unless splices are favorably reviewed.

K. 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.

L. 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.

M. 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 pull boxes, 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 pull box, 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 TESTING

A. As specified in Section 16950 - Electrical Tests for all cable testing requirements.

END OF SECTION

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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. Section 17010: Instrumentation and Controls, General Requirements

1.02 REFERENCE STANDARDS

A. ASTM International (ASTM):
   1. B8 Concentric Lay Stranded Copper Conductors, Hard, Medium-Hard, or Soft, Specification for

B. Institute of Electrical and Electronic Engineers (IEEE):
   1. 383 Shielded Instrumentation Cable, Specifications for

C. UL LLC (UL):
   1. 13 Power Limited Circuit Cable Class 2, Specifications for (Bulletin)
   2. 83 Thermoplastic Insulated Wires and Cables

1.03 SUBMITTALS

A. Submit material or equipment data in accordance with the submittal requirements of Section 16010.

PART 2 - PRODUCTS

2.01 TWISTED SHIELDED PAIRS (TSP)

A. Cable shall conform to IEEE 383, UL 13, and UL 83 and shall be type PLTC cable suitable for direct burial. Each TSP shall consist of two #16 AWG, 7 strand copper conductors per ASTM B8 with 15 mils PVC insulation. Conductors shall be twisted with 2 inch or shorter lay, with 100% foil shielding and tinned copper drain wires. Each pair shall have a 35-mil-thick outer jacket. Cable shall be rated at 90°C and for operation of 600 volts, as noted on the Drawings. Provide Alpha 5616B1601, Dekoron 1852 6860R, or equal.

2.02 MULTIPLE (TWISTED) SHIELDED PAIR (MSP) CABLES

A. Each MSP cable shall conform to IEEE 383, UL 13, and UL 83 and shall consist of the number of pairs shown on the Drawings, of #20 AWG, 7 strand copper conductors per ASTM B8. Conductors shall have 15-mil PVC insulation and shall be twisted in 2 inch or shorter lay. Each pair shall have a 100% foil shield and a tinned copper drain wire. The MSP cable itself shall have, in addition, an overall foil shield, tinned copper drain wire, and an outer PVC jacket. Thickness of the jacket

shall be 50 mils for 8 or fewer pairs, 60 mils for 10 to 16 pairs, and 70 mils for 18 or more pairs. Provide Alpha 5620B20XX, Dekoron 1874 XXX80, or equal.

2.03 ETHERNET (TCP/IP) CABLE

A. Industrial use, unshielded:
   1. Provide UL listed, Category 6 unshielded twisted pair (UTP) Ethernet cable conforming to ANSI/TIA-568-C.2 and suitable for use in harsh environments.
   2. Conductors: 4 pairs of #23 AWG solid bare copper.
   3. Conductor insulation: Fluorinated Ethylene Propylene, minimum thickness 0.01 inches.
   4. Jacket material: Fluorinated Ethylene Propylene, factory marked at regular intervals indicating verifying organization and performance level. Minimum thickness 0.03 inches.
   5. Insulation shall be 300 volt class.
   6. Insulation temperature range: -55 to +150 degrees C
   7. Electrical Characteristics: Cable shall have a maximum attenuation of 20 dB per 100 meters at 100 MHz and 33 dB per 100 meters at 250 MHz.
   8. Terminations/Connectors: Cables shall terminate in Category 6 RJ-45 crimp connectors with strain-relief boots, or at Category 6 punch down blocks at both ends.
   9. Cable shall be plenum-rated for flammability in accordance with NFPA 262, and suitable for use as riser cable.
   10. Ethernet cable installed in underground conduits shall be rated as suitable for the application.
   11. Industrial, unshielded Ethernet cable shall be Belden 7931A or equal.

2.04 FIBER OPTICS

A. Fiber optic cable shall be Gigabit Single Mode 12 strand fiber conductor, rated for outdoor, heavy duty. Optical fibers shall be loose tube construction and shall not adhere to the inside of the buffer tube. Fibers and buffer tubes shall be color coded with distinct and recognizable colors in accordance with EIA/TIA-598-B.

B. Fiber Jacket:
   1. Chlorinated Polyethylene (CPE) Color: Yellow or Black. Mark the exterior sheathing with the manufacturer's name, month and year of manufacture, and sequential meter or foot markings for easily determining the length of the cable at all points along the cable run.
   2. Provide a telecommunication handset symbol as required by Section 350G of the National Electrical Safety Code® (NESC®), fiber count, and fiber type.

C. Fiber Type:
   1. OFNR with industrial cable tray rating and IEEE flame test rated: 802.3Z.
   2. Clad Diameter: 125 ± 0.7 µm.
   3. Coating Diameter: 245 ± 5 µm Core Diameter: 8.2 µm.
   4. Attenuation: ≤ 0.35 db/km @ 1310 nm≤ 0.25 db/km @ 1550 nm.
   5. Operating Temperature Range: -40 to +70 Deg C Maximum Tensile Loading: 600 lbf.
   6. Minimum Cable Bending Radius: 10 x diameter.

D. Provide Markers for labeling each end of a fiber optic cable. Fiber optic markers must have space for typed or machine printed text.
   1. Provide Markers for Individual fiber optic strands, jumpers, and patch cables. Fiber optic markers must have space for typed or machine printed text. Fiber optic markers shall be attached to the fiber using tie wrap or other approved method of securing the marker listed.

E. Fiber Optic Connectors: Active and spare fiber optic cables fibers shall be provided with a breakout kit, and terminated with SC type terminations.

PART 3 - EXECUTION

3.01 CABLE INSTALLATION

A. Signal cable shall be installed by personnel who have had a minimum of 3 years' experience in terminating and splicing twisted shielded conductors and co-axial 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 O.D.

C. Cables shall be continuous from initiation to termination without splices except where specifically indicated.

D. 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.

E. Heat shrinkable sleeving shall be installed on all cables to insulate shielding at the ungrounded cable terminations.

F. 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.

G. Install and ground Ethernet cable in accordance with IEEE 802.3. Attach trunk cable to walls and ceilings with PVC clamps with clamp backs at 4-foot intervals

H. Manufacturer's cable pulling tension shall not be exceeded.

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 cables as follows:
   1. Watertight Splices: Splices in concrete pull boxes, for any type of cable or wire, shall be watertight. Make splices in low voltage cables using epoxy resin splicing kits rated for application up to 600 volts.
   2. Terminal Cabinets:
      a. When splices are permitted by the Engineer, install terminal cabinet per Section 17510. Terminal system shall include insulated, crimp-type connectors and barrier-type terminal boards. Coordinate the lug and boards for correct fit. All terminations shall include marker sleeves.

b. Shields shall be handled as a separate conductor. Use manufacturer's compression sleeve and insulated pigtail. Keep pigtail as short as possible. Terminate pigtail with marker sleeve and tug.

3. No splicing is acceptable for coaxial cables.

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 (TC) 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. Use manufacturer's recommended solder. The Contractor shall prevent misapplication of solder and termination.

3.03 CONDUCTOR IDENTIFICATION

A. Identify each wire or cable at each termination, in each pull box, 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 Section 17010.

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. As specified in Section 16950 - Electrical Tests for all cable testing requirements.

END OF SECTION

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

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 Requirements for Wiring Devices
2. WD 6 Wiring Devices - Dimensional Requirements

D. UL LLC (UL) Standards:
1. 20 General-Use Snap Switches
2. 498 Electrical Attachment Plugs and Receptacles
3. 514 Electrical Outlet Boxes
4. 943 Class A Ground Fault Receptacle Interrupting Requirements

1.03 SUBMITTALS

A. Submit material or equipment data in accordance with the submittal requirements of Section 16010.

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 5362; Daniel Woodhead 5262DW; or equal.

C. Special Purpose Receptacles: Receptacles shall be of the amperage, voltage, and NEMA configuration indicated on the Drawing. Compliance to standards and tests shall be as listed in Item B above.

D. GFI Receptacles:
   1. Device shall be rated 20 ampere, 2 pole, 3 wire, 120 volt, conforming to NEMA WD1.10 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 5362, Daniel Woodhead, or equal.

E. 480V RECEPTACLES: Receptacles shall be 100A, Type 3R, IP54/IP55. IP55 on the receptacle when the lid is latched closed. Receptacle shall be Hubbell 4100 R7W pin/sleeve with latch cover and angle mount.
   1. Provided complete with angle adapter, gaskets, and a gasketed screw-type, weathertight cap with chain fastener.
   2. Provide each receptacle with one plug. Coordinate with Portable Mixer with Conveyor manufacturer to assure equipment comes with matching pin/sleeve.

F. Corrosion Resistant Receptacles: Units shall comply with standards listed in Item B above, but shall also have tin-nickel plated brass connecting equipment and stainless steel hardware. Receptacle face color shall be yellow to identify the device as having these special qualities. Provide Hubbell Catalog No. 52CM62 and 53CM62; Daniel Woodhead; or equal.

G. Explosion Proof Receptacles: Devices shall be UL listed for use in Class 1, Division 1 or Division 2, or for Class 2, Division 1 areas as indicated on the Drawings. Units shall be factory sealed types where available and shall contain disconnecting mechanisms which must function prior to plug withdrawal or after insertion.

1. All 20 amp, 120 and 240 volt, 2 pole, 3 wire receptacles shall be NEMA 5-20R and NEMA 6-20R. Receptacles shall be UL classified as interchangeable with male plugs of other manufacturers. Provide Killark Receptacle No. UCR520231, 20 amp, 125 volt feed through 3/4-inch hub; Killark Receptacle No. UCR520232, 20 amp, 250 volt feed through 3/4-inch hub; Crouse-Hinds; or equal.
2. For 30 amp and above devices shall be Killark copper-free aluminum KR Series for Class 1, Division I and Division II C and D; Crouse-Hinds; or equal.
3. For corrosive areas devices shall be Killark CES Series 8575, 8578, and 8579 non-metallic plugs and switched receptacles suitable for Class 1, Division II Groups A, B, C, D; Class 2, Division I and II E, F, G; and Class 3, NEMA 3, 3R, 3S, 7, Division II and NEMA 9; Crouse-Hinds; 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. Sierra Electric, Monumental Grade, Catalog No. 5721; Daniel Woodhead 1900 Series; or equal.

B. Low Voltage Types: Switches shall meet all of the requirements listed in Item A above except to be rated at 15 amperes for switching 24 Volts dc. Devices shall be three-position, momentary contact, spring return, center "off" configuration.

C. Explosion Proof Types: Units shall conform to the standards listed in Item A above, but in addition shall have UL listings for use in hazardous areas classified as Class 1, Division I or II, and Class 2, Division I. Units shall be factory sealed devices. Material shall be copper-free aluminum for metallic types. Provide Killark FSK, Seal X Series; Crouse-Hinds; or equal. Provide fiberglass or polyamide for non-metallic types.

D. Dimmer Switches: Dimmer switches shall be single pole or 3 way types employing solid state components. The solid state control shall be true voltage compensated to give square law dimming operation without dead spots. Device shall be a toroid filter choke to reduce RFI. Incandescent dimmers shall be equipped with heat sink cover plates and shall employ full wave rectification. Fluorescent dimmers shall control up to 24 lamps without auxiliary equipment. Provide Lutron Series, Leviton Series, 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 ½ 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. Blank Plates Cover plates for future telephone or television outlets shall match adjacent device wall plates in appearance.

G. Damp or Wet and Corrosive Locations: Plates shall have weather protective double doors. Material of manufacture shall be die-cast aluminum for metallic plates or nylon for non-metallic plates.

PART 3 - EXECUTION

3.01 INSTALLATION OF WIRING DEVICES

A. 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.

B. Damp or Wet Exterior Locations Install only wiring devices approved for outdoor service in these locations.

C. 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 ¼ inch. Boxes shall be adjusted so that they do not project beyond the finished wall. Height above finished floor shall be as follows:

	Inches From Floor
Duplex Receptacles - Office Areas	12
Receptacles - Industrial Areas	46
Toggle Switches	46

D. Damp or Wet Interior Locations: Install only wiring devices approved for outdoor service. Adjust boxes so that front edge will be ¼ 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.

E. 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.

D. Future Locations: Install blanking cover plates on all unused outlets.

3.03 TESTS

A. As specified in Section 16950 – Electrical Tests. Test Requirements.

END OF SECTION

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SECTION 16155

MOTOR STARTERS

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.

C. NEMA Enclosed Combination Starters, with Thermal Solid State Electronic Overload Relays. Starters may be of the full voltage non-reversing or full voltage reversing type.

D. Related Work Described Elsewhere:
   1. Section 16955: Control Devices

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 1 Industrial Control & Systems, General Requirements
   2. ICS 2 Industrial Control and Systems Controllers
   3. ICS 6 Industrial Controls and Systems: Enclosures
   4. 250 Enclosures for Electrical Equipment (1,000 Volts Maximum)

C. Federal Specification (FS):
   1. W-C-375 Circuit Breakers, Molded Case, Branch Circuit and Service

D. UL LLC (UL) Standard:
   1. 50 Enclosures for Electrical Cabinets
   2. 508 Industrial Control Equipment
   3. 508A Industrial Control Panels

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 submittal requirements of Section 16010.

1.04 LOCATIONS

A. Refer to Section 16010 for definitions of types of locations.

PART 2 - PRODUCTS

2.01 COMBINATION MOTOR CONTROL

A. Each motor starter shall be NEMA rated and consist of a manually operated circuit protective device and a magnetically operated motor starter mounted in a common enclosure, complete with control power transformer and auxiliary devices for control of the circuit as indicated. Starters designed to IEC ratings or with dual IEC/NEMA ratings will not be accepted either as part of a Motor Control Center, as remote starters or as part of an equipment package.

B. Contactor contacts shall be silver alloy, double break, and shall allow for inspection on NEMA Sizes 1 through 4 without the use of tools. Size 5 and larger shall allow for inspection utilizing standard tools. They shall be replaceable without removing the line, load, or control wiring from the starter, and replaceable without removing the starter from the enclosure.

C. Contactor coils shall be the encapsulated type and shall be replaceable on NEMA Sizes 1 through 4 without the use of tools. Size 5 and larger shall be replaceable with standard tools. They shall be replaceable without removing the line, load, or control wiring from the starter, and replaceable without removing the starter from the enclosure.

D. Solid-State Electronic Overload Relay
   1. Provide a solid-state overload relay for protection of the motors.
   2. The overload relay shall provide high accuracy through the use of state-of-the-art microelectronic packaging technology. The relay shall be suitable for application with NEMA Size 1 through Size 5 motor starters.
   3. The overload relay shall be modular in design, be an integral part of a family of relays to provide a choice of levels of protection, be designed to directly replace existing electromechanical overload relays, and be listed under UL Standard 508.
   4. The relay should have the following features:
      a. Self-powered.
      b. Manual or automatic reset.
      c. Supply with 24 VDC and 120 Vac Electronic reset.
      d. Selectable (On/Off) Phase loss protection. The relay shall trip in 10 seconds or less under phase loss condition.
      e. Selectable (On/Off) Phase Imbalance protection. The relay shall trip in 10 seconds or less under phase imbalance condition.
      f. Visible trip indication.
      g. One normally open and one normally closed isolated auxiliary contact.
      h. Test button that operates the normally closed contact.
      i. An LED that provides self-diagnostic information.
      j. An LED that aids in commissioning by indicating running current is too high compared to the FLA dial.
      k. EtherNet TCP/IP with I/O with webserver Communication shall be provided.
      l. Additional digital Inputs and Outputs 4 in and 2 out additional shall be supplied as shown on the drawings or as required by the Drawings.

E. Operating handle of the circuit protective device shall physically indicate "on", "off" and "tripped" positions. Handle shall accept three padlocks with heavy duty, industrial type shackles. Cover shall be interlocked with the operating handle to prevent opening when in the "on" position. A method shall be provided for releasing the interlock for inspection purposes when the switch is "on."

F. Motor circuit protectors shall have adjustable magnetic trips by a single dial with a moveable plug stop.

G. Starters shall be NEMA rated and no smaller than Size 1. Each shall be equipped with an overload element in each phase and auxiliary contacts as indicated on the Drawings, with a minimum of two normally open and two normally closed auxiliary contacts.

H. Each starter unit shall have its own control power transformer with a grounded secondary. Transformer shall have fused protection (2 primary and one secondary) sized to accommodate the control devices presented on the Contract Drawings, plus 100VA of spare capacity.

I. Starters shall be equipped with a local red “run” indicating light and a green “off” indicating light to indicate the presence of control power when the motor is not energized. Provide push buttons, selector switches, and indicating lights as shown on the Drawings and in compliance with Section 16955.

J. Enclosures shall suit the location per Section 16010.

K. Nameplates: Provide an engraved plastic nameplate for each combination starter identifying the motorized equipment it controls.

L. An externally operable manual "reset" button shall be provided. Automatic restart after overload shall not occur.

M. Provide Allen-Bradley E300/E200 or equal Allen Bradley solid state overload.

2.02 FULL VOLTAGE NON-REVERSING

A. Unless otherwise specified, contactors shall be full voltage, 3-pole, 600 volt AC, NEMA size 1 minimum. Contacts shall be double break, silver-cadmium oxide, and weld resistant. Contacts shall be isolated to prevent arcing.

B. Disconnecting means shall be provided with an external operating handle mounted in the flange of the enclosure which has a means to lock the handle in the off position. Mechanism shall prevent enclosure door from opening when handle is in the on position.

C. Short circuit current rating of the combination starter shall be 65,000 RMS amperes symmetrical, but in no case less than the values presented from the short circuit study provided under Section 16961.

2.03 MANUAL MOTOR STARTERS

A. Manual motor starters shall be horsepower rated. Provide nameplates and ambient compensated thermal overload protection. Enclosures shall suit the location per Section 16010.

B. For corrosive locations, provide Crouse-Hinds NMM, or equal. For all other locations, provide Allen-Bradley Bulletin 600; Allen Bradley Bulletin 609; or equal Allen Bradley component.

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 Construction Manager's instructions.

B. Contractor shall adjust motor circuit protector devices to the instantaneous trip setting position recommended for the actual horsepower and full load amps of the motor.

C. Contractor shall verify that the overload devices are proper for equipment installed.

D. Contractor shall make the necessary changes in overload devices as required for any motors having power factor correction capacitors.

E. Contractor shall touch up any scratches after the equipment has been installed.

3.02 GROUNDING

A. Grounding shall be installed in compliance with Section 16450 of these Specifications and as shown on the Contract Drawings.

3.03 FIELD TESTING

A. As specified in Section 16950 – Electrical Tests, low voltage motor starter 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. UL LLC (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 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 rated 480 VAC shall have short circuit ratings not less than 22,000 amperes RMS symmetrical or as indicated by the Short Circuit Study, whichever is greater.
    d. 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. 480V panelboards shall accommodate double branch mounting of circuit breakers up to 600A.
7. 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. 480V: Eaton Pow-R-Line 3a, Schneider Electric I-Line, or equal.
   2. 240V and below: Eaton Pow-R-Line 1a/2a, Schneider Electric NQ/NF, or 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. UL LLC (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 submittal requirements of Section 16010.

1.04 LOCATIONS

A. Refer to Section 16010 for definitions of types of locations.

PART 2 - PRODUCTS

2.01 FUSIBLE SWITCHES

A. Fusible 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 horsepower rated. Auxiliary contacts shall be provided as indicated on the Drawings. Stationary contacts shall be equipped with arc chutes. Fuse clips shall accept only Class J current limiting cartridge fuses. Where indicated on the Drawings, units shall have service entrance labels and shall be equipped with an insulated neutral lug. Switches shall be Square D, Type HD; Westinghouse Type H600; or equal.

B. Enclosures shall be as follows:
   1. Dry Locations: NEMA Type 1.
   2. Corrosive Locations: NEMA Type 4X.
   3. Wet locations: NEMA Type 4.

C. Nameplates: Provide an engraved plastic nameplate for each disconnect switch identifying the equipment it protects.

D. Fuses:
   1. General: Provide one complete set of fuses of each ampere rating shown on the Drawings plus one spare set for each size shown.
   2. Fuse Type: Units shall be Class J current limiting, 700 volt, in the ampere ratings shown. Plug fuses are unacceptable. Barrels shall be non-hygroscopic with brass knurled ferrules.
   3. Fuses shall conform to FS W F 1726 and UL 198B, and shall carry labels showing UL class, interrupting rating, time delay characteristics, and voltage rating.

2.02 ENCLOSED CIRCUIT BREAKERS

A. Units shall be thermal-magnetic molded case circuit breakers in surface mounted non-ventilated enclosures conforming to the appropriate articles of NEMA 250, as follows:
   1. Indoor, Dry, Clean Locations: NEMA Type 1.
   2. Outdoor, Unprotected Locations: NEMA Type 3R/12.
   3. Wet Locations: NEMA Type 4.
   4. Corrosive Locations: NEMA Type 4X.

B. Each unit shall have an external operating handle with a cover interlocking mechanism which will prevent opening of the enclosure when the operating handle is in the "ON" position. The handle shall be capable of being padlocked in either the "ON" or the "OFF" position. A breaker "tripped" position shall be clearly indicated between the "ON" and the "OFF" position.

C. Where indicated on the Drawings, enclosed breakers used as service entrance equipment shall be so labeled for such service and shall contain an insulated neutral lug. The complete unit shall conform to UL 489.

D. The circuit breakers shall be of the voltage, number of poles, frame size, and ampere rating shown on the Drawings. Units shall be manually operated, trip-free, thermal-magnetic, molded case, front mounted circuit breakers.
   1. Frame sizes larger than 100 amperes shall have adjustable instantaneous magnetic elements. Minimum interrupting rating shall not be less than 10,000 amps asymmetrical and the breaker shall conform to FS W C 375. Multiple breakers shall have a common trip single operating handle with three positions of indication. Circuit breaker shall be calibrated at 40°C (104°F).
   2. Each breaker shall be completely enclosed in a molded case with the calibrated sensing element factory sealed to prevent tampering.

2.03 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 4X

C. Nameplates: Provide an engraved plastic nameplate for each disconnect switch identifying the motorized equipment it controls.

2.04 MOTOR RATED CONTROL STATIONS

A. Control station shall be of zinc electroplate and aluminum lacquer 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; Eaton 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 MOUNTING HEIGHTS

A. Fusible switches and enclosed circuit breakers shall be centered 5' 0" above the floor.

3.03 FIELD TESTS

A. As specified in Section 16950.

END OF SECTION

SECTION 16280

SURGE PROTECTIVE DEVICES

PART 1 - GENERAL

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. UL 1449 Third Edition 2014 - Transient Voltage Surge Suppressors

B. UL 1283 - Electromagnetic Interference Filters

C. ANSI/IEEE C62.41.1-2002 - IEEE Guide on the Surge Environment in Low Voltage (1000 V and Less) AC Power Circuits;

D. C62.41.2-2002 - IEEE Recommended Practice on Characterization of Surge Voltages in Low Voltage AC Power Circuits; and C62.45-2002 - IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits.

E. NEC 2017, Article 285.

PART 2 - PRODUCTS

2.01 GENERAL

A. SPD shall be Listed in accordance with UL 1449 Third Edition 2014 and UL 1283, Electromagnetic Interference Filters.

B. SPD shall be Component Recognized in accordance with UL-1449 Third Edition 2014 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-1.2/50μs, 10kA-8/20μs).

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. Also, this distribution equipment shall be fully tested and certified to the following UL standards:
   1. UL 67 - Panelboards
   2. UL 845 - Motor Control Centers

3. UL 857 - Busway
4. UL 891 - Switchboards
5. UL 1558 - Low Voltage Switchgear.

2.02 SPD RATINGS

A. Minimum surge current rating shall be 160 kA per phase (80 kA per mode) for service entrance and 80 kA per phase (40 kA per mode) for distribution applications.

B. UL 1449 clamping voltage must not exceed the following:

VOLTAGE	L-N	L-G	N-G
240/120	800/400V	800/400V	400V
208Y/120	400V	400V	400V
480Y/277	800V	800V	800V

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 of one self-contained suppression module per phase.

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. A push-to-test button shall be provided to test each phase indicator. Push-to-test button shall activate a state change of dry contacts for testing purposes.

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. The output of the dry contacts shall indicate an end-of-life condition for the complete SPD or module.

I. SPD shall be equipped with dry contacts (normally open or normally closed) to allow connection to a remote monitor or other system. The output of the dry contacts shall indicate that the SPD has operated to protect the equipment from a surge.

J. Terminals shall be provided for necessary power and ground connections.

2.03 MANUFACTURERS

A. 480 Volt Connections
1. ASCO series 560 SPD
2. Eaton Clipper CPS Series
3. Or equal

B. 120/208 or 120/240 Volt Connection
   1. ASCO series 440 SPD
   2. Or equal

PART 3 - EXECUTION

3.01 INSTALLATION

A. The installing Contractor shall install the parallel SPD units with short and straight conductors as practically possible. The Contractor shall twist the SPD input conductors together to reduce input conductor inductance. The Contractor shall follow the SPD manufacturer's recommended installation practices as found in the installation, operation, and maintenance manual and comply with all applicable codes.

B. 480 volt SPD units shall be provided for Motor Control Center.

C. SPD units shall be provided at all panelboards that provide power to the control panels/remote I/O panels.

3.02 FIELD ACCEPTANCE TESTS

A. Test per Specification 16950.

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. ASTM International (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
      f. C150 Portland Cement
      g. C478 Precast Reinforced Concrete Manhole Sections
      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)

1.03 SUBMITTALS

A. Submit material or equipment data in accordance with 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 Sections 16120 and 16124.

2.02 CAST-IN-PLACE AND PRECAST MANHOLES

A. Cast-in-place concrete manholes shall have a smooth trowel finish for floors and horizontal surfaces. Concrete shall conform to Division 3, Section 03300. Precast concrete manholes, risers and tops shall conform to ASTM C478, except that the spacing of manhole steps or ladder rungs shall not exceed 16 inches. Precast units (ACI 318) shall be the product of a manufacturer regularly engaged in the manufacture of precast concrete manholes and handholes. Manholes shall be the type noted on the Drawings and shall be constructed in accordance with the applicable details as indicated. Top, walls, and bottom shall consist of reinforced concrete. Walls, bottom and top of manholes shall be of monolithic concrete construction; sectionalized construction is not acceptable. Duct entrances and windows shall be located near the corners of structures to facilitate cable racking. Doors shall fit the frames without undue play. Steel and iron shall be formed to shape and size with sharp lines and angles. Castings shall be free from warp and blow holes that may impair their strength or appearance. Exposed metal shall have a smooth finish and sharp lines and arises. Provide all necessary lugs, rabbets, and brackets. Set pulling-in iron shall be installed in the wall opposite each duct line entrance. The words "ELECTRICAL" shall be cast in the top face of all manhole covers. Cable racks, including rack arms and insulators, shall be adequate to accommodate the cable. Cable racking hardware shall be non-metallic and corrosion resistant as manufactured by Pacific Utilities Supply, or equal.

B. Metal Frames, Doors and Gratings: Provide steel or malleable iron frames, doors and gratings conforming to Federal Specification RR-G-661, Type I.

C. Manhole Doors:
   1. Manhole doors shall be hot-dipped galvanized steel after fabrication with spring operated hinged doors. Traffic doors shall be rated for HS 20-44 wheel loading as given in AASHTO HB-13, with I-beam removable base supports.

2. Covers: Prior to galvanizing, the covers shall have words applied, "Electrical" plus manhole number shown on the Drawings for power manholes and "Signal" plus the manhole number shown on the Drawings for signal manholes. Letters shall be not less than 5 inches high formed by means of a welding bead in the center of the cover.

2.03 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. 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. Traffic doors shall be HS20-44 as given in AASHTO HB-13.

2.04 EXISTING MANHOLE

A. Provide traffic-rated doors, HS20-44 to replace existing doors/covers, per the Drawings.

PART 3 - EXECUTION

3.01 EARTHWORKS

A. See Section 02300.

3.02 WIRE AND CABLE INSTALLATION

A. See Sections 16120 and 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 four 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, pull boxes, etc., at minimum rate of 3 inches per 100 feet unless indicated otherwise on the 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. Connections to Existing Ducts: Where connections to existing duct lines are indicated, excavate the lines to the maximum depth necessary. Cut off the lines and remove loose concrete from the conduits before new concrete encased ducts are installed. Provide a reinforced concrete collar, poured monolithically with the new duct line, to take the shear at the joint of the duct lines. Remove existing cables that constitute interference with the work. Abandon in place those used ducts and cables that do not interfere with the work.

C. Removal of Ducts: Where duct lines are removed from existing manholes, close the openings to waterproof the manhole. Chip out the wall opening to provide a key for the new section of wall.

D. 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 MANHOLES AND HANDHOLES

A. Installation of Cable in Manholes and 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.

B. Fireproofing (Arc Proofing) of Cables in Manholes, 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 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. ASTM International (ASTM) Publication:
   1. B228 Copper Clad Steel Conductors Specification
   2. D178 Specifications for Rubber Insulating Matting

B. National Fire Protection Association (NEPA):
   1. 70 National Electric Code (NEC)

C. International Electrical Testing Association (NETA) Publication:
   1. ATS Acceptance Testing Specifications for Electrical Equipment for Power Systems

1.03 SUBMITTALS

A. Submit material or equipment data in accordance with 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 and structural steel 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 ASTM B228. The welded copper encased steel rod shall have a conductivity of not less than 27% of pure copper. Rods shall be not less than ¾ inch in diameter and 8 feet long, unless otherwise indicated. Rods longer than 8 feet shall be made up of 8-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 #2/0 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 3/16 inch by 3/4 inch and of lengths as shown on the Drawings. Bus shall be predrilled and tapped to accept 8-32 brass machine screws on 12-inch centers.

2.03 RUBBER MATS

A. Provide corrugated rubber mats, which conform to ASTM D178 Type II, oil resistant. Mats for low voltage switchboards and switchgear and motor control centers shall be rated for protection for 1,000 volts minimum to ground. Mats for medium voltage switchgear shall be rated 17,000 volts.

B. Mat shall be a minimum of 1/4 inch thick and black in color with beveled edges. Mats shall extend the full width of the equipment with a minimum width of 30 inches. Mats shall be 4 feet deep in front of low voltage equipment and 6 feet deep in front of medium voltage equipment.

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 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.

C. Where ground rods must be driven to depths over 8 feet, increase rod diameter used, sufficiently to prevent the rod from bending or being damaged.

D. 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.

E. Provide a ground wire in every conduit carrying a circuit of over 150 volts to ground.

F. Make embedded or buried ground connections, taps, and splices with exothermic welds. Coat ground connections.

G. Effectively bond structural steel for buildings to the grounding system using exothermic welds.

H. Install rubber mats in front of low voltage switchboards and switchgear, medium voltage switchgear, and motor control centers.

3.02 TESTING

A. As specified in Section 16950.

END OF SECTION

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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. UL LLC (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. ASTM International (ASTM):
   1. D635 Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position

1.03 SUBMITTALS

A. Submit material or equipment data in accordance with 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").

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 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 Specification 16950.

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SECTION 16500

LUMINAIRES

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. UL LLC (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 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 EXTERIOR LIGHTING POLES

A. General: Provide lighting poles with pole cap and the necessary fixture mounting hardware.

B. Type: Poles shall be square, galvanized steel, bronze, with hand holes.

2.03 LED LUMINAIRES (LED)

A. LED luminaires shall be a complete functioning unit with all components including light source, lamps, power supply, control interface and any additional components needed for operation shall be assembled by the luminaire manufacturer.

B. Luminaires shall comply with ANSI chromaticity standard for classifications of color temperature. Luminaire shall be UL or ETL listed and labeled.

C. Luminaire testing shall be per IESNA LM-79 AND LM-80 procedures.

D. Useful Life Requirements: The useful life of the luminaire in terms of lumen output must be specified by one of the following two methods:
   1. Simplified L70 threshold: A minimum of 50,000 operating hours before reaching the L70 lumen output degradation point, accounting for individual LED lumen depreciation and catastrophic failures. Fifty percent of the sample population must reach the 50,000 hour point – this is known as B50. Only 10 percent of the LED lamps can have failed in a conventional sense – this is known as F10.

E. Provide shop drawings showing illumination levels with LED systems based on lumen output at 70 percent lumen depreciation for white LEDs and 50 percent for colored LEDs. Initial lumen output for all LEDs shall be listed individually.

F. LED drivers
   1. Drivers shall have reversed polarity protection, open circuit protection and require no minimum load.
   2. Drivers shall operate at a minimum 85 percent efficiency and have a Class A noise rating.
   3. LED driver shall be solid state unit mounted within fixture and shall be adequately ventilated and match the LED fixture rating in watts and voltage.

G. Where LED systems are required to be dimmable, the LED system shall be capable of full and continuous dimming.

2.04 PHOTOELECTRIC CELL

A. Photoelectric cell shall have adjustable turn on range from 2- to 50-foot candles. Cell shall operate from 120 Vac, 60 Hertz. Switched contacts shall be single pole, single throw and tungsten rated 1,800 watts minimum at 120 Vac. Housing shall be

weatherproof with threaded conduit fitting suitable for mounting to a junction box. Cell shall be Tork 2101; Intermatic K4121; or equal.

2.05 TIME SWITCH

A. Time switch shall be equipped with astronomical (24 hour, seasonally adjusting) dials and reserve power springs for a 10 hour minimum carry-over in the event of a power outage. Units shall be complete with a manual bypass switch.

2.06 LIGHT CONTROL RELAYS

A. Units shall be mechanically held with contacts rated 30 Amperes to 600 Volts. Number of poles and operating coil voltage shall be as shown on the Drawings.

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. Mount lighting poles and lighting standards plumb and make free of dents or other damage.

C. Underground and outdoor wire splices shall be in accordance with Sections 16010 and 16120.

D. 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.

END OF SECTION

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SECTION 16721

FIRE ALARM SYSTEM

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 manual pull stations, visual/audible devices, auxiliary relays, and modifications at the existing Simplex 4005 fire alarm control panel to provide a complete fire alarm detection system.
   1. HVAC system is being modified and Fan/AHU shutdown contacts shall be revised and connected to the new HVAC system.
   2. Manual pull station and visual/audible device are required at the Cake Storage Building to meet NFPA 820.
   3. Review existing Dewatering Building device layout to meet NFPA 820.

C. System Design: Drawings show the minimum system requirements. Complete system design shall be performed by qualified personnel as indicated in paragraph 1.05.

1.02 REFERENCE STANDARDS

A. American National Standards Institute (ANSI) Publication:
   1. C2 National Electrical Safety Code

B. National Fire Protection Association (NFPA) Publications:
   1. 70 National Electrical Code
   2. 72A Local Protective Signaling Systems
   3. 72D Proprietary Signaling Systems
   4. 72E Automatic Fire Detectors

1.03 SUBMITTALS

A. Submit material or equipment data in accordance with Sections 01300 and 16010

B. Shop Drawings: Shop drawings shall include wiring diagrams, elementary diagrams, and complete descriptions of components

C. As-Built Diagrams and Manuals: Upon completion of work and prior to final testing and inspection, furnish as-built drawings showing the exact sequence of all initiating devices as they were installed in the circuits.

1.04 PERSONNEL QUALIFICATIONS

A. Complete Fire Alarm System plans shall be developed in accordance with NFPA 72 by persons who are experienced in the proper design, application, installation, and testing of the systems.

B. Design personnel shall be certified by a nationally recognized certification organization acceptable to the authority having jurisdiction.

C. The system designer shall provide evidence of their qualifications and/or certifications with the submitted design documents.

PART 2 - PRODUCTS

2.01 GENERAL

A. All equipment shall be listed by the State Fire Marshal, UL listed, FM listed, and tested by a nationally recognized fire test laboratory.

2.02 COMPONENTS

A. Manual Pull Station: Stations shall be non-coded, dual-action type. Station shall be red in color and fabricated from high impact LEXAN. The station shall provide mechanical indication of operation until reset with the proper key. Station operating lever shall be recessed to prevent accidental operation of the station. The station shall be surface mounted in a red backbox. Unit shall contain one set of normally open contacts.

B. Horn/Strobe Audio-Visual Signaling Device: Unit shall have a red surface mounting enclosure containing a horn and a xenon flash tube operating on 24 Vdc. Sound level shall be 90 to 94 decibels at 10 feet distance. Strobe shall be enclosed in a white translucent lens having the words "FIRE" imprinted on three sides. Strobe flash rate shall be 2 to 3 times per second. Unit shall have a surface mounting red enclosure.

C. Existing Fire Alarm Control Panel:
   1. Add Simplex 4005 I/O modules for new devices.

D. End-of-Line Device: Unit shall consist of a 6,000-ohm resistor mounted on the back of an ABS white plastic cover plate. Included shall be a standard single gang surface mounting box.

E. Auxiliary Shut Down Relays: Relays shall be a miniature plug-in sealed enclosure unit with a 24 Vdc operating coil. Relays shall be equipped with four SPDT contacts rated 5 amperes at 120 volts. One relay shall be used to signal the PLC in the Main Control Panel.

F. Conduit and Wire: All conduit and wire required for the fire alarm system shall be coordinated and provided under this Section. Provide all conduit and wire required for a fully operational system. All conductors shall be suitable for installation in conduit. Provide grounding and ground wires as necessary; conduit shall not be used as a ground return path. All conductors shall conform to the requirements of Sections 16120 and 16124. All conduit shall conform to the requirements of Section 16110. All conductors shall be labeled according to their function in the circuit. All exposed conduit and junction boxes shall be painted red.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Installation shall not begin until the State Fire Marshal Listing for all equipment and Drawings and Specifications have been approved by the Fire Marshal's office in Linn County and the State Oregon Fire Marshal's Office

B. Installation of wiring and equipment shall conform to Article 760 of NFPA 70 and Article 210 of NFPA Standard No. 72.

C. Minimum conductor size shall be #16 AWG for the alarm initiating circuits and #14 AWG for output circuits to audio/visual annunciators.

D. All wiring shall be in conduit. Terminations in control panels shall be made on terminal strips with a separate point for each conductor.

E. Mount all end-of-line resistor boxes where they will be readily accessible at all times and at 54 inches above the finished floor.

F. Install no automatic detection equipment on its ceiling mounting plate until the associated room has been painted and cleaned. A minimum of 2% or two (whichever is larger) automatic detection elements shall be given to the Owner as spares.

G. Fire alarm systems installation personnel shall be qualified or shall be supervised by persons who are qualified in the installation, inspection, and testing of the systems. Installation personnel shall be certified by a nationally recognized certification organization acceptable to the authority having jurisdiction.

3.02 PERFORMANCE TESTING

A. A factory trained representative of the manufacturer shall supervise final testing of the complete system. This test of each component of the total system shall be made in the presence of the Engineer and in the presence of the enforcing fire agency. Upon completion, the Owner's maintenance staff shall be instructed in the testing and operation of the system by the manufacturer's representative. Training shall be conducted in accordance with Section 01650.

B. Any equipment proving defective shall be immediately replaced with new equipment at no additional cost to the Owner.

3.03 FIRE ALARM SYSTEM DEVICE LIST:

A. List shall be created by FA Contractor including new and existing devices for both Cake Storage Building and Dewatering Building. Table shall include Device Type tag, Type of Device, and Location. All tags shall have a prescript of WW1-015, for example Fire Alarm Control Panel WW1-015FACP0001.

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SECTION 16920

MOTOR CONTROL CENTERS

PART 1 - GENERAL

1.01 SUMMARY

A. Scope: This Section specifies freestanding, factory assembled 600 volt motor control centers (MCC).
   1. Final location of MCCs shall be set over existing conduit floor penetrations, interception of existing overhead conduits, and new conduits. Contractor shall field verify wiring diagrams and control connections for equipment to remain prior to submitting motor control center submittal.
   2. The MCC arc flash hazard energy level shall be less than or equal to 8cal/cm². Prior or during submittal process, Contractor shall conduct an arc flash analysis. Contractor shall be responsible for any mitigation to achieve arc flash hazard risk category 2 or less.

B. Provide a motor control center, complete, at each location shown on the Drawings.

1.02 QUALITY ASSURANCE

A. Reference Standards:
   1. This Section incorporates by reference the latest revisions of the following documents. They are part of this Section insofar as specified and modified herein. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.

Reference	Title
ANSI/NEMA ICS 1	General Standards for Industrial Controls and Systems
ANSI/NEMA ICS 2	Industrial Control Devices, Controllers and Assemblies
ANSI/NEMA ICS 2-322	AC General-Purpose Motor Control Centers
ANSI/NEMA ICS 4	Terminal Blocks for Industrial Control Equipment and Systems
ANSI/NEMA ICS 4	Enclosures for Industrial Controls and Systems
JIC EMP 1	Electrical Standards for Mass Production Equipment
UL 845	Motor Control Centers

B. Factory Tests:
   1. Prior to delivery to the site, each motor control center shall be tested by the manufacturer, all control devices shall be operated and the MCC shall be powered with rated incoming voltage for at least 1 day.
   2. The testing shall include, but not be limited to, operation of all input and output (I/O) points, control devices and motor controllers.

1.03 SUBMITTALS

A. Procedures: Section 01300

B. Action Submittal Items for This Section:
   1. Manufacturer’s data including product literature, materials of construction, construction details of equipment, installation instructions, wiring diagrams (elementary and connection), dimensions and weight of equipment.
   2. Time-Current Curve diagrams showing coordination between the main circuit breakers and feeder breakers.
   3. Time current curves for all protection devices.
   4. List of starters and feeder tap compartments indicating the size and type of circuit protection.
   5. Manufacturer's certification that the following items are capable of interrupting and/or withstanding the specified short circuit condition:
      a. Bus bars
      b. Feeder tap units
      c. Starter units
      d. Main incoming units
   6. Due to the nature of construction, show housekeeping pad in building
   7. Manufacturer's certification and calculations that the equipment complies with the seismic requirements of Section 01190.
   8. Letter of coordination from the MCC manufacturer stating that the Surge Protective Device selected for the MCC has been coordinated with and will not adversely affect the active harmonic filters.
   9. Factory and field test reports.
   10. Applicable operation and maintenance information per Section 01300.
   11. Conduit entrance provisions.
   12. Custom elementary schematic ladder diagrams for each compartment including remote devices.

PART 2 - PRODUCTS

2.01 MANUFACTURERS/PRODUCTS

A. Manufacturers and models of Low Voltage Intelligent Motor Control Centers are listed below. To conform with specified requirements, the manufacturer’s standard product may require modification.
   1. Allen Bradley Centerline 2100 Intellicenter.

2.02 SERVICE

A. Motor control centers shall be rated 600 volts, 60 hertz, 3 phase, 3-wire, as shown on the Drawings, 65,000 AIC, with ampacities as specified and shall be suitable for operation at the specified voltages and short circuit capacities.

2.03 STRUCTURE AND CONSTRUCTION

A. Structure:
   1. Each MCC shall be of dead front construction and shall consist of one or more vertical sections bolted together to form a rigid, free-standing assembly.

The systems shall be designed to allow for the addition of future sections at either end and to permit the interchanging of units.

2. Motor control centers shall be made of No. 14 gauge steel minimum and each section shall be 90 inches high by 20 inches wide by 20 inches deep. When required for larger motor starters, panelboards, or VFDs, wider sections shall be allowed. Provide an additional 12”H x 20”D factory designed wireway running atop of and the length of each MCC for raceway and cable penetrations from above. Front of wireway shall have hinged covers that open down. The interior of the wireway shall have easily removable sectionalizing plates. The individual unit compartments shall be a minimum of 13 inches high. There shall be 72 inches available for stacking starter units. Compartments shall have pan-type doors with a minimum of two quarter-turn hold-down latches; and neoprene gaskets. All doors shall be gasketed.
3. A full height vertical wireway, 4 inch wide minimum, shall be provided for each vertical motor control center section. The vertical wireway shall be isolated from the vertical and horizontal buses. The wireway shall contain full height hinged doors and secure doors. Wireway tie bars shall be provided.
4. Horizontal wireways shall be provided top and bottom, extending the length of motor control centers. Horizontal wireways shall be 6 inches in height and extend the full depth of the vertical section to allow maximum flexibility in locating conduit for MCC feeds and loads. The horizontal wireways shall have removable covers held in place by captive screws.
5. Bottom channel sills shall be mounted front and rear of the vertical sections extending the full length of the motor control center lineup. A removable lifting angle shall be mounted on top and shall extend the width of the motor control center lineup.

B. Construction:

1. Motor control centers located indoors shall be rated NEMA 1 gasketed with drip tops when fire sprinkler system is present.
2. Starter units, size 4 and smaller, and breaker feeder tap units less than 225 amperes shall be drawout plug-in construction with hardened, plated copper free-floating stabs, steel spring backups. The door shall have a defeatable mechanism to allow the door to be opened when the unit’s breaker is closed. The door shall have interference tabs which prevent door closure if unit is improperly installed. Units shall be latched in the position to assure proper bus contact. The unit disconnect device shall be interlocked to prevent removal or reinsertion of a unit when the disconnect is in the "ON" or "TRIPPED" positions.
3. Circuit breaker disconnect operators shall be capable of accommodating three padlocks for locking in the "OPEN" position.
4. Hardware for mounting future starter and feeder tap units shall be provided at compartments specified as "FUTURE” and “SPACE”.

2.04 FINISH AND COLOR

A. Unless otherwise specified, electrical equipment shall be painted by the manufacturer as specified in Section 09900 – Coating Systems.

1. MCC interior shall be primed high-visibility gloss white.
2. MCC color shall be light gray ANSI 61 or similar gray.

2.05 BUS

A. General: Bus shall be 100% rated tin-plated copper with bolted connections between vertical and horizontal bus bars. Access for tightening these connections shall be from the front, without the need for tools on the rear of the connection. Insulated horizontal and vertical bus barriers shall be provided. Barriers shall be fabricated from high-strength, glass-filled polyester resin. Unless otherwise specified, the bus shall be braced to withstand a minimum fault current of 65,000 amperes, RMS, symmetrical.

B. Horizontal Bus: Unless otherwise specified, the main horizontal bus shall be rated a minimum 800 amperes continuous. Provide for continuation/addition of additional MCC sections at ends of the horizontal bus with removable end plates as indicated on the drawings for future MCC sections.

C. Vertical Bus: Unless otherwise specified or required, the vertical power bus shall have an effective rating of 600 A. If a center horizontal bus construction is utilized, then the rating shall be 300 A above and below the horizontal bus for an effective rating of 600 A. If a top or bottom mounted horizontal bus is utilized, then the full bus must be rated for 600 A.

D. Neutral Bus: Where specified, a neutral bus shall be provided. The neutral bus shall have the same rating as the main horizontal bus.

E. Ground Bus: A 1/4-inch by 2-inch tin-plated copper ground bus shall be provided the full length of the motor control center.
   1. Ground bus shall be located at the bottom of the motor control center.
   2. Provide a lug to terminate a bare 4/0 AWG copper ground conductors at each end of the ground bus.
   3. Provide a pressure-type mechanical lug mounted on the ground bus in the incoming line section.

2.06 WIRING

A. General:
   1. Provide wiring and terminals in MCC buckets in accordance with the wiring diagrams provided with the contract drawings.
   2. Motor control centers shall be provided with NEMA Class II, Type B wiring. All starter units shall have terminal blocks for control wiring. Terminal blocks shall be provided for power wiring for starters size 2 and smaller. Motor control centers shall be provided with all necessary interconnecting wiring and inter- locking. Provide elementary and connection diagrams for each starter unit and an interconnection diagram for the entire motor control center including all field devices. Provide a drawing pocket in each unit.

B. Power Wire: Power wire shall be copper 90 degrees C "THWN-2" insulated, sized to suit load; minimum power wire size shall be No. 12 AWG copper stranded.

C. Control Wire: Control wire shall be No. 14 AWG stranded copper wire, rated 90ºC and UL listed for panel wiring.

D. Terminations And Cable Connections:
   1. Terminals: Provide crimp type terminals made from electrolytic copper, tin-plated. Provide cable termination connectors to match cable size and quantities as indicated on the drawings.

E. Conductor Markers:
   1. All internal wiring in MCC buckets shall be numbered with a basic wire numbering scheme. Wires which terminate on a terminal shall have the terminal number. Wires that leave the MCC shall be labeled in accordance with Sections 16010 and 16120.
   2. Markers used for identification shall meet the requirements of Section 16010.

2.07 MAIN, FEEDER, AND BRANCH CIRCUIT PROTECTION

A. General:
   1. Main and feeder tap units shall consist of circuit breakers, as specified. Main breaker shall be 100% rated, with frame size, solid state trip unit, rating plug, and the following fully adjustable (dynamic) trip functions: Long Time delay, Short Time Pick-up, Short Time delay, Instantaneous, Ground Fault Pick-up, and Ground Fault delay. Minimum short circuit capacity shall be 65,000 amps symmetrical.
   2. Feeder breakers 250A and greater shall include solid state trip unit, rating plug, and fully coordinate with the main breaker. Minimum short circuit capacity shall be 65,000 amps symmetrical.

B. Circuit Breakers (Thermal Magnetic): Thermal-magnetic circuit breakers shall be molded case equipped with toggle type handle, quick-make, quick-break over center switching mechanism that is trip-free so that breaker cannot be held closed against short circuits and abnormal currents. The tripped position shall be clearly indicated by breaker handle maintaining a position between "ON" and "OFF." All poles shall open, close, and trip simultaneously. Minimum short circuit capacity shall be 65,000 amps symmetrical, refer to Specification 16180.

C. Circuit Breakers (Magnetic Only): Magnetic circuit breakers shall be molded-case equipped with toggle type handle, quick-make, quick-break over center switching mechanism that is trip-free so that breaker cannot be held closed against short circuits and abnormal currents. The tripped position shall be clearly indicated by breaker handle maintaining a position between "ON" and "OFF." All poles shall open, close, and trip simultaneously. Minimum short circuit capacity shall be 65,000 amps symmetrical.

2.08 MOTOR STARTER UNITS

A. General: Motor starter units shall be combination type with contactor and motor circuit protector as specified on the drawings or the MCC schedule. The starter units shall have a minimum combination UL listing of 65,000 amps RMS, symmetrical or as specified in the schedule.

B. Motor Circuit Protectors: The molded case motor circuit protector (MCP) shall operate on the magnetic principle with a current sensing coil in each of the three poles to provide an instantaneous trip for short circuit protection. The trip setting shall be adjustable from 700 to 1300 percent of the motor full load amperes from

the front of the breaker. The motor circuit protector shall be set at its lowest position at the factory. The Contractor shall size the MCP based on the specific motor supplied. Minimum short circuit capacity shall be 65,000 amps symmetrical.

C. Control Transformers:
   1. Each control transformer shall be rated 480/240-120V, single phase, 2 wire, 60 Hz. The transformer shall be sized for the load it feeds and shall be increased in capacity for significant loads such as condensation heaters. Minimum ratings shall not be less than the following:

NEMA starter size	Minimum transformer volt-ampere rating
1	150
2	150
3	200
4	300

   2. Each control transformer shall be provided with time-delay, slow-blow secondary fuse rated to interrupt 10,000 amperes short circuit at 250 volts AC. Two primary fuses rated to interrupt 200,000 amperes at 600 volts shall be provided on all starters.
   3. All fuses shall be provided with blown fuse indicators.

D. Contactors:
   1. Unless otherwise specified, contactors shall be full voltage, 3-pole, 600 volt AC, NEMA size 1 minimum. Contacts shall be double break, silver-cadmium oxide, and weld resistant. Contacts shall be isolated to prevent arcing. Coils and magnets shall be capable of being removed or replaced without special tools.
   2. Reversing, multispeed, and reduced voltage starters shall have additional contactors, overload relays, and auxiliary relays as required, and shall have mechanically interlocked contactor coils to prevent simultaneous engagement.

E. Transient Surge Suppressor:
   1. Provide a factory selected transient surge suppressor rated for each motor starter and power contactor encapsulated in a small module and mounted directly to the starter or contactor coil.

F. Motor Auxiliary Contacts: Contactors shall be equipped with auxiliary contacts, rated 10 amperes at 120 volts AC. Unless otherwise specified on the Drawings, each contactor shall be equipped with a minimum of one normally open and one normally closed electrically isolated auxiliary contacts. Auxiliary contacts shall be wired out to terminal blocks if shown on the Drawings. If auxiliary contacts are not shown on the Drawings, then the contacts shall still be provided but shall not be wired out to terminals. Refer to the Drawings for actual quantities required.

G. Overload Relays:
   1. All motor starters shall include fully programmable electronic overload relays. Overload relays shall monitor all three phases individually for current and voltage.

2. Overload Relay shall have a normally open dry contact, rated 1 amp at 120 VAC for remote alarming of overload trip.
3. Manual reset functions shall be accessible without opening the cubicle door.
4. The overload shall provide the following protective functions at a minimum:
    a. Overload/underload/jam
    b. High/low voltage
    c. Phase unbalance and reversal (voltage and current)
    d. Ground fault
    e. Rapid cycling
5. The overload shall provide the following diagnostic and operational information at a minimum:
    a. Error and trip Indicators
    b. Ground fault, L1, L2, L3 and three-phase average currents
    c. L1-L2, L2-L3, L1-L3 and three-phase average voltages
    d. Voltage and current unbalance
    e. Power factor
    f. Fault history (last four faults)
    g. Run timer value
6. A data port shall be accessible on the door of the cubicle to retrieve overload data. Provide (2) cables and necessary software to access data via a portable computer.

H. Wiring/Terminals:
1. The motor control center shall be suitable for operation on 480 volts, three-wire, 60 Hertz. Wiring shall be NEMA Class II, Type B. Each unit shall be completely prewired with all control wiring numbered and terminated on terminal strips. Terminal's numbering shall be coordinated between units such that like devices shall have the same terminal numbers. Wiring within one bucket shall be labeled with a basic wire numbering scheme. Field wiring or wiring between buckets shall conform to the requirements of Section 16120.
2. Provide a drawing pocket in each unit; provide an individual wiring diagram and arrangement diagram in each bucket
3. Provide terminals for the load wiring. Auxiliary components such as HOA selector switches, indicating lights, elapsed run time meter and other indicating and/or recording devices shall be mounted on the compartment door or cover. All control power leads into and out of each unit shall pass through auxiliary contacts of the circuit breaker or be equipped with their own disconnecting device or disconnecting terminal strips, appropriately labeled.

2.09 ETHERNET/IP COMMUNICATION

A. The Electrical Schematics are based on Ethernet/IP wiring between the MCC and the remote I/O cabinets. Provide a single Ethernet/IP network in each MCC as shown on the Drawings.

B. The MCC shall have Ethernet wiring incorporated into its design that allows control, monitoring and configuration of Intelligent Motor Control units across the network by personnel and higher level control systems using Ethernet/IP (Industrial Protocol) network topology and protocol. MCC devices will include motor starters with electronic overload relay, AC drives, and soft starters.

1. The MCC shall have factory installed industrial Ethernet cabling incorporated throughout the vertical section across the entire lineup.
2. Each Intelligent Motor Control unit in the MCC shall be supplied with a means to communicate via EtherNet/IP network.
3. Plug-in units should be able to move around without impacting the network.
4. Maintenance activities should be able to be performed without impacting the network.
5. The Ethernet/IP cable shall be routed through the center of the MCC line-up, behind barriers that isolate the cables from the unit space and wireways to prevent accidental mechanical damage during MCC installation.

C. Ethernet/IP Industrial Managed Switch:
1. The MCC shall have managed industrial Ethernet switch(es) with Ports to connect each EtherNet/IP enabled device. The use of unmanaged switches shall not be allowed.
2. The managed industrial Ethernet switch shall deliver optimal network security, network resiliency (if needed), and flexibility. The functionality should include port based control/prioritization, switch-level ring support, VLAN segmentation, and other Layer-2 switch features based on Cisco Managed Switch architecture and protocol.
3. The managed industrial Ethernet switch shall have the ability to include, if needed, Gigabit ports, CIP Sync functionality, Network Address Translation (NAT), and an Industrial SD Card.
4. The managed industrial Ethernet switch shall include redundant terminal blocks for customer supplied/connection of an external 24V DC UPS.
5. Ethernet Switches shall be provided with spare ports to accommodate network expansion and future plug-in unit inserts.
6. Managed switches shall be installed in the motor control center bucket centered around three sections. Managed switches shall not be installed in the upper or lower wireways.
7. Managed switches shall be Strattix, no substitute.

D. Industrial Ethernet Cabling;
1. Industrial Ethernet Cable Ratings
   a. The industrial Ethernet cable shall be 600V UL Category 5e PLTC (Power Limited Tray Cable) rated including a Vertical Flame Test. Cables that do not provide UL listing as PLTC shall not be used, and the use of a 300V rated cable is not acceptable
   b. Ethernet Switch-to-Device cable labels shall be located on both ends of the cable to specify where the cable is connected to on both ends
   c. A detailed Ethernet network table and Ethernet network diagram specifying IP addresses, subnet masks, device locations, cable label details, and 24V DC capacities shall be included in the MCC documentation.

E. Ethernet Network Power Supplies:
1. Power supplies shall provide 24V DC for the devices that require it, including the Ethernet Switches and any Intelligent Motor Control devices that require separate power.

2. The MCC manufacturer shall check the user's design to confirm that adequate power supplies have been specified to conform with network requirements.
3. Power supply output shall be rated 8 A, 24V DC, proving 2 separate Class 2 circuits (4A each).
4. Power supplies unit shall be provided with a buffer module to provide a minimum of 500 ms ride-through at full load.
5. Two (2) 24V DC adapters allowing four (4) power connections shall be provided:
    a. In each vertical wireway of standard sections to simplify installation, relocation and addition of plug-in units.
    b. Each 24V DC adapter in the vertical wireway shall be connected to the power supply.
6. The power supplies units shall be provided with a door mounted external 120V AC connection for laptop power and Ethernet network connection.

F. EtherNet/IP Interface for Motor Starter Units:
1. Solid State Overload relay unit shall be provided are required as indicated on the individual starter unit drawings.
    a. Built-in EtherNet/IP communication.
    b. Selectable trip of NEMA Class 5 to 30. Unless indicated, the trip class shall be set for NEMA Class 20 operation.
    c. Overload relay separately powered by 24V DC from integrated 24VDC power bus in the Intelligent MCC.
    d. Status indicators for status indication and a Test/Reset button.
    e. Up to six (6) inputs and three (3) outputs of direct I/O. Additional I/O can be provided with an add-on module to the overload relay. Input voltage shall match the overload relay power voltage.
    f. Protective functions shall provide a programmable trip level, warning level, time delay, and inhibit window.
        1) Protective functions shall include Thermal overload, Phase loss, Stall, Jam, Underload, Current imbalance, and Remote trip
        2) Optional Ground fault protection is required when indicated on the unit drawings, range shall be 20 mA to 5 A
        3) Optional PTC Thermistor input is required when indicated on the unit drawings
        4) Optional Voltage protection is required when indicated on the unit drawings
    g. Current monitoring functions shall include phase current, average current, full load current, current imbalance percent, percent thermal capacity utilized, and ground fault current (if required).
    h. Voltage, energy, and frequency measuring capabilities shall be included when voltage protection or kW monitoring is required.
    i. Diagnostic information shall include device status, warning status, time to reset, trip status, time to overload trip, and history of last five trips.
    j. Preventive maintenance information shall include Allowable starts per hour, required Time between starts, Starts counter, Starts available, Time until next start, total operating hours, and elapsed operating time.

k. The overload relay shall support the following CIP messaging types: Polled I/O messaging, Change-of-state/cyclic messaging, Explicit messaging, Group 4 offline node recovery messaging, and Unconnected Message Manager (UCMM).
l. The overload relay shall provide the following functions to minimize network configuration time: Full parameter object support, Configuration consistency value, and Add-on Profile.
m. Optional Add-On Expansion Inputs and Outputs shall be provided where indicated on the unit starter diagrams, including Digital Inputs, Relay Outputs, Analog Inputs and Outputs as indicated. All expansion I/O shall be addressable via the Ethernet/IP communications link.
n. Overload relay shall include an on-board logic processor to allow basic logic to be performed within the overload relay based on network data and the status of the inputs to the overload relay. Programming of this logic shall be available via DeviceLogix Programming Software in the PLC programming package or through a Web page interface built into the unit for connection via the Ethernet link. Any custom programming used in individual starter units, including that of Expansion I/O, shall be retained by the connected PLC control system using ADC for use in being automatically downloaded into any units that are subsequently replaced in the field, so long as the replacement units have the same I/O configuration.

2. Solid State OL relay shall be Allen-Bradley E300 model or equal Allen Bradley solid state OL.

G. Ethernet/IP Interface for other units
1. Provide an Ethernet/IP interface for other units as indicated on the contract drawings.
2. Refer to the contract drawing wiring diagrams for points to be monitored.

H. Programming and Testing
1. The MCC manufacturer shall load the IP Address and Subnet Mask into each unit and Ethernet switch. The IP Address shall be provided by the Contractor.
2. The MCC manufacturer shall test and verify the MCC and Ethernet wiring to ensure that each unit communicates properly prior to shipment. A test report shall accompany the MCC.
3. Each unit shall have a label showing the IP Address for the devices within it.
4. The MCC manufacturer shall provide a disk containing applicable electronic data sheet (EDS) files for the Ethernet/IP devices.
5. The IP Address shall be visible on the unit Nameplate for any units containing an Ethernet/IP enabled.

2.10 MISCELLANEOUS

A. Operating and Indicating Devices: Operating and indicating devices minimum rating shall be NEMA 13.

B. Selector Switches: Allen-Bradley 800H or Allen Bradley equal.

C. Push Buttons: Allen-Bradley 800H or Allen Bradley equal.

D. Indicating Lights: Allen-Bradley 800H or Allen Bradley equal, All lights shall be LED type and push-to-test.

E. Power Monitor:
   1. Provide a power monitor that will monitor the three input phases at all times and calculate voltage levels, voltage tolerance, phase unbalance, peak power demand for 30 days, peak power demand for 1 year.
   2. The phase monitor shall be door mounted to allow viewing display and access to power monitor pushbutton and keys. Exposed wiring is not acceptable.
      a. Provide a clear plexiglass cover over power phase monitor with a cutout that allows an operator access to all the buttons with his fingers without opening door and without exposure to line voltage.
   3. Provide an Allen Bradley PowerMonitor 1000 unit. Power Monitor protocol shall be converted to Ethernet TCP/IP.

F. Control Relays: Relays for general purpose use shall be DPDT or 3PDT, 10-amp contacts with 24 VDC or 120 VAC coil voltage as specified. They shall have an 8-pin base, matching socket, and contact status indicator.

G. Time Delay Relays: Time delay relays shall be multi-function, multi-range with plug- in base, pin style terminations timing and timed out LED indicators, and calibrated scales. Relays shall have minimum .5 seconds to 60 minutes, 8 selectable timing ranges, 5-amp contacts. Select coil voltage for the application. Minimum accuracy requirements (plus or minus) shall be as follows: 1) Repeat accuracy 1/2% 2) Timing change over full voltage range 1/2% change over full temperature range 2% 3) Scale tolerance 5%. Appropriate relay shall be selected based on application from the control wiring diagrams.

H. Terminal Blocks: Terminal blocks shall be 600-volt modular terminal blocks with tubular screw and pressure plate. Terminal shall be sized to accept 2-#14 wire minimum. Provide not less than five (5) spare terminals in each bucket.

I. Nameplates:
   1. Each motor control center compartment shall have a nameplate designating the equipment and its identifying number and size or rating. Data shall be as shown on one-line diagrams. Nameplates shall be made of 1/16-inch-thick machine engraved laminated phenolic having black letters not less than 3/16 inch high on a white background. Nameplates shall have name, number and/or function as is applicable for clear identification. Nameplates shall be fastened using self-tapping stainless-steel screws. The use of adhesives will not be permitted on the outside of enclosures.
   2. Provide one large nameplate for each motor control center identifying the motor control center name and number with 1-inch lettering. Include power source using ½-inch lettering in the following format, “fed from (source)”.
   3. Equipment titles and numbers shall be completely spelled out on nameplates or as shown on the drawings.
   4. Nameplates shall also be provided for identifying all relays and devices that are located inside the panels and shall be of the sandwich phenolic described above or approved equal.
   5. Nameplates shall be mounted in a manner or location such that other equipment or devices do not block them so they are easily viewed.

J. Surge Protection Device:
   1. An integrally mounted Surge Protection Device, (SPD), shall be included in each motor control center per Section 16280.
   2. SPD type selection shall be coordinated with active harmonic filter installation to prevent active harmonic filter mis-operation due to SPD capacitors.

K. Current Transformers And Transducers:
   1. Where shown on the Drawings (P&IDs) provide split current transformers (CTs) with a primary current rating that is at least 3.0 times the load current. Secondary of the CT shall be terminated on shorting terminal strips with the circuit extended to a current transducer with a 4-20ma DC signal output. Transducers shall be 24 VDC and powered by a #24 TSP run from the local PLC cabinet to the MCC bucket. Phoenix Contact MCR series, no equal.
   2. Provide programming adapter and current software version for each MCC line-up.
   3. Operating Mechanisms: All circuit breakers in motor control centers shall be provided with external "thru-the-door" operating handles.

L. Spare Parts: In addition to spare parts mentioned elsewhere in this section, the Contractor shall supply the following set of spare parts for each motor control center for use by the Owner:
   1. 100% spare LED lamp type used for indicating lights.
   2. One spare control, time delay phase fail, etc. relay of each type used, or 20% whichever is the greater number.
   3. One spare lens of each color used for indicating lights.
   4. Two spare fuses for each fuse provided under 10 amps and one spare fuse for each fuse provided over 10 amps.
   5. One spare overload relay for each type and size provided.
   6. Spare parts shall be provided with the motor control equipment when shipped to the site

PART 3 - EXECUTION

3.01 GENERAL

A. It is the Contractor’s responsibility to verify that the motor starters, protection equipment, and other components, etc. provided are suitable (correct phase, voltage, starter type, correct breakers, and overload relays) for the motors and equipment loads being served.

B. Operator interface devices such as metering and devices with control and displays shall be installed between 5’ and 5’-8” above finished floor. Operator interface devices on full height sections shall be installed between 4’-6”and 6’ above finished floor.

C. Motor control centers shall be assembled per the contract documents. Each motor control center shall be completely inspected by the Owner and tested in the manufacturer’s shop and delivered to the site ready for external connections to field equipment.

D. Conduit installation shall be coordinated with the manufacturer’s as-fabricated drawings such that stub-ups are within the area allocated for conduit.

E. Conduit shall be stubbed up in the section that contains the devices to which conductors are terminated.

F. All assembly and wiring not completed by the manufacturer or Integrator, due to shipping sections, multiple suppliers, etc. shall be the responsibility of the Contractor.

G. Provide wire and terminal numbering on all wires and terminals.

H. Provide schematic and layout drawings for each individual unit.

3.02 INSTALLATION

A. Receive, store, set, and assemble the shipped section of each motor control center and install and connect any breakers, relays, meters, or other miscellaneous devices shipped separately. Make all internal wiring interconnections necessary for a complete assembly of each motor control center.

B. Make all bus joints at shipping splits. All bus conductor joints and taps shall be carefully made and insulated in strict accordance with manufacturer's instructions. All bolted connections between sections of current-carrying bus shall be tightened down to torque values recommended by the manufacturer.

C. Take all necessary precautions to exclude moisture and foreign material from the equipment at all times during storage and installation. Care shall be taken to prevent corrosion of silver-plated contact surfaces and damage to relays and control devices. The motor control centers shall be erected in accordance with the recommendations of the manufacturer and with the details specified herein.

D. Field wiring shall meet the requirements of section 16120. Cables larger than No. 6 AWG which hang from their vertical connections shall be supported within 2 feet of the connection.

E. The setting of the overload relays shall be by the Contractor and adjusted based on the actual full load amperes of the motor connected to the starter.

F. The motor circuit protectors shall be adjusted by the Contractor to the lowest setting not causing false tripping.

G. MCCs shall be labeled for arc-flash in accordance with Section 16961.

3.03 FACTORY TESTS

A. Factory Tests: Provide Manufacturer's Standard Electrical and Mechanical production Tests and inspections for motor control centers and their components. Tests shall include continuity check, dielectric tests for each circuit and inspection for proper functioning of components including controls, protective devices, metering and alarm devices.

3.04 FIELD TESTS

A. Motor control centers shall be tested in accordance with the requirements of Specification 16950 Electric Tests.

B. The power monitors shall be tested for verification of correct amps, volts, hertz, power factor, and harmonics by comparison of the signal into the plant's power monitoring system with a high accuracy hand held meter.

3.05 MANUFACTURER'S SERVICES

A. Provide a combination of 5 hours class and field calibration for Owner's designated personnel for the motor control centers. Manufacturer's representative shall present training at the job site.

B. Inspection, Startup, Field Adjustment
   1. The Service Representative shall supervise the following items, and shall certify that the equipment and controls have been properly installed, aligned, and readied for operation:
      a. Installation of the equipment.
      b. Inspection, checking and adjusting of the equipment.
      c. Startup and field testing for proper operation.
      d. Performance of repairs to correct any discrepancies or problems revealed during startup and testing.
      e. Performance of field adjustments to ensure that equipment installation and operation comply with the indicated requirements.
      f. Preparation and submittal of a report covering startup and testing, including a listing of equipment settings and parameters at the end of startup and testing.

END OF SECTION

SECTION 16924

VARIABLE FREQUENCY DRIVES

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 so 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 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 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 during both utility services. 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. 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. 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. Allen-Bradley Powerflex 755, no 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.
   7 Suitable for use with constant torque loads and having a 150% overload capacity for one minute.

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: Limited to less than 100% of motor full load current for centrifugal loads and as required to start motor, for constant torque loads.
   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 volt-microseconds 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. 120 volt 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. Drive Output dv/dt Filter
   1. Provide a drive dv/dt filter mounted within the drive system enclosure when indicated on the contract documents or as required by the VFD manufacturer per motor insulation and distance between drive and motor. Dv/dt filters shown on contract documents are based on Allen Bradley Powerflex 723 and requirements of Section 11002 inverter duty motors with insulation values at 1600V.
   2. The dv/dt filter shall meet the following specifications:
      a. The construction shall be iron core with an impedance of 5 percent.
      b. The winding shall be copper or aluminum wound.
      c. The insulation shall be Class H with a 115 °C rise over 50 °C ambient.
   3. The unit shall be rated for system voltage, ampacity, and frequency.
   4. Install a Trans Coil Inc., Sinegarad or equal on the output side of the drive, in the drive cabinet.

I. Construction:
   1. VFD shall be mounted within an MCC, or within packaged system, as shown on the Drawings.
   2. 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) HMI
         2) Manual-Off-Auto selector switch.
         3) 0-100%Speed potentiometer.
         4) Speed Indicator calibrated in percent of full speed.
         5) Motor Run indicating light.
         6) VFD failure indicating light.
         7) Reset
         8) External operating handle for the incoming line circuit breaker.
      b. Provide finish as specified in Section 16920. Provide control components as specified in Section 16955.
      c. Components: Mount components on circuit cards or modules which can be adjusted or replaced in the field without the use of special tools.
      d. Cooling fans as required.

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 (2017 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 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.

D. Test per Specification 16950.

3.03 TRAINING

A. Service technician shall instruct operating personnel in the operation, maintenance and adjustment of the system and installation.

END OF SECTION

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. 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 panel-board 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.

C. 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. 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.
    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.

D. 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. Verify that cooling fans operate and that fan motors have correct overcurrent protection.
   g. 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.
   h. Perform specific inspections and mechanical tests required by the manufacturer.
   i. Verify that as-left tap connections are as specified.
   j. Verify the presence of surge arresters, if applicable.
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. Perform power-factor or dissipation-factor tests on all windings in accordance with the test equipment manufacturer's published data.
   d. Perform turns-ratio tests at all tap positions.
   e. Measure core insulation resistance at 500 volts dc if the core is insulated and the core ground strap is removable.
   f. Verify correct secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.
   g. Test surge arresters in accordance with Sections 2.03.O, as applicable.
3. Test Values – Visual and Mechanical
   a. Control and alarm settings on temperature indicators shall operate within manufacturer's recommendations for specified settings.
   b. Cooling fans shall operate.
   c. 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.
   d. 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.

e. 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. CH and CL power-factor or dissipation-factor values will vary due to support insulators and bus work utilized on dry transformers. The following shall be expected on CHL power factors:
      1) Power transformers: 2.0 percent or less
      2) Distribution transformers: 5.0 percent or less

      Consult transformer manufacturer's or test equipment manufacturer's data for additional information.
   d. Power-factor or dissipation-factor tip-up exceeding 1.0 percent shall be investigated.
   e. Turns-ratio test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio.
   f. The typical excitation current test data pattern for a three-legged core transformer is two similar current readings and one lower current reading.
   g. Temperature-corrected winding-resistance values shall compare within one percent of previously obtained results.
   h. Core insulation-resistance values shall not be less than one megohm at 500 volts dc.
   i. AC dielectric withstand test voltage shall not exceed 75 percent of factory test voltage for one-minute duration. DC dielectric withstand test voltage shall not exceed 100 percent of the ac rms test voltage specified in ANSI C57.12.91, Section 10.2 for one-minute duration. 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.
   j. Phase-to-phase and phase-to-neutral secondary voltages shall be in agreement with nameplate data
   k. Test results for surge arresters shall be in accordance with Sections 2.03.O, as applicable

E. 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. 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.

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. 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.

H. 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.

I. 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.

J. 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.

K. Low Voltage Motor Starters:
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 contactors.
        1) Verify mechanical operation.
        2) Verify contact gap, wipe, alignment, and pressure are in accordance with manufacturer's published data.
    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 appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   b. Perform insulation-resistance tests on each pole, phase-to-phase and phase-to-ground with starter closed, and across each open pole for one minute. Test voltage shall be in accordance with manufacturer's published data or NETA ATS Table 100.5.
   c. 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.
   d. Test motor protection devices in accordance with manufacturer's published data.
   e. Test circuit breakers in accordance with Section 2.03.J.
   f. Perform operational tests by initiating control devices.
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 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.
   c. Insulation-resistance values of control wiring shall not be less than two megohms.
   d. Motor protection parameters shall be in accordance with manufacturer's published data.
   e. Circuit breaker test results shall be in accordance with Section 2.03.J.
   f. Control devices shall perform in accordance with system design requirements.

L. 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.J for appropriate inspections and tests of the motor control center circuit breakers.

3. Refer to Section 2.03.Q for appropriate inspections and tests of the motor control center starters.

M. 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.J.
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.P.
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.

N. Voltage Field Test:
1. Check and record voltage at point of termination of *Pacific Power* 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.

O. Low Voltage Surge Arresters:
   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 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. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
   2. Electrical Tests
      a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
      b. Perform an insulation-resistance test on each arrester, phase terminal-to-ground. Apply voltage in accordance with manufacturer's published data.
      c. Test grounding connection in accordance with Section 2.03.P.
   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 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. Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm and in accordance with Section 2.03.P

P. Test 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.

2.04 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 □T. In the absence of consensus standards for □T, 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	DC High Potential (Medium Voltage Cable) Test Record
4	Ground Electrode Testing Test Record
5	Neutral Grounding Resistor Test Record
6	Bonding Resistance Readings (Nonelectrical Equipment/Structures) Test Record
7	Bonding Resistance Readings (Electrical Equipment) Test Record
8	Insulation Resistance (Transformer) Test Record
9	Insulation Resistance (Equipment) Test Record
10	Insulation Resistance (Rotating Equipment) Test Record
11	Equipment Absorption Ratio and Polarization Index Test Record
12	Medium Voltage Circuit Test Record
13	Electric Motor Run-In Test Record
14	Thermographic Inspection Test Record
15	Ethernet Cable 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 _____

DC HIGH POTENTIAL (MEDIUM VOLTAGE CABLE)
TEST RECORD

CIRCUIT NUMBER: _____ REF. DWG.: _____

CABLE SIZE: _____ (SQ.MM.) _____ (MCM) FROM: _____ TO: _____

NUMBER OF CONDUCTORS: _____ NO. OF SPLICES: _____

CABLE LENGTH: _____ MANUFACTURER: _____

INSULATION TYPE: _____ THICKNESS: _____

JACKET MATERIAL: _____

WEATHER: _____TEMP:_____ºC_____ºF % HUMIDITY: _____DATE: _____

TEST EQUIPMENT USED: _____

NOTES:
1. The test voltage shown below shall be reached in 10 equal voltage increments.
2. After each voltage increase, the leakage current shall be allowed to stabilize during a 1-minute interval. If 1-minute intervals are insufficient to stabilize the current, the cable shall be discharged, and the test repeated with new time intervals of greater, but still equal duration.
3. Record the stabilized leakage current, in microamps, at the end of each time interval.
4. Allow the voltage to remain constant at the full test voltage and record the leakage current for 5 minutes for unshielded cables and 15 minutes for shielded cables.
5. Read test equipment instruction manual prior to testing cable.
6. When the plotting of test results is specified, attach the second sheet with separate plot for each phase. Note leakage current, in microamps, on “y” axis. Note step-voltage increase on “x” axis, followed by time, in minutes, for the dielectric absorption portion of the test.
7. All other phases and shields to be grounded.

Voltage hold time at each step _____ sec.	___kV	___kV	___kV	___kV	___kV	___kV	___kV	___kV	___kV	___kV
ØA[7]										
ØB[7]										
ØC[7]										

RECORD LEAKAGE CURRENT IN MICROAMPS

Time at _____Kv	SEC 30	MIN 1	MIN 2	MIN 3	MIN 4	MIN 5	MIN 6	MIN 7	MIN 8	MIN 9	MIN 10	MIN 11	MIN 12	MIN 13	MIN 14	MIN 15

CABLE-RATED VOLTAGE (kilovolts) TEST VOLTAGE (kilovolts)

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 _____

MEDIUM VOLTAGE CIRCUIT
TEST RECORD

EQUIPMENT DESIGNATION			
CIRCUIT DESCRIPTION TAG NO. MANUFACTURER KW/HP FLA	 _____ _____ _____ _____	 SERIAL NUMBER. SERVICE FACTOR. RATED VOLTAGE.	 _____ _____ _____
BREAKER DESCRIPTION MANUFACTURER CONTACTOR RATING RATED CURRENT FUSE SIZE.	 _____ _____ _____ _____	 C.T. RATIO TYPE RATED VOLTAGE O/L RELAY SETTING	 _____ _____ _____ _____
CONDUCTOR SIZE	POWER	CONTROL	GROUND

1. Check circuit breaker for cleanliness. _____
2. Check nameplate data and tagging of circuit components for conformance to approved submittals. _____
3. Check conduits and/or cables for correct tagging. _____
4. Check equipment and installation for conformance to area classification. _____
5. Check installation for seals, breathers, and drains. _____
6. Check main and auxiliary contacts of breaker and contactors. _____
7. Check mechanical operation of breakers, contactors, and relay and O/L reset devices. _____
8. Check continuity of power and control cables. _____
9. Verify calibration and setting of protective relays. _____
10. Check wiring to surge arrestors, capacitors, stator RTDs and current transformers. _____
11. Complete functional operation check of the motor control circuit using the contract drawings and approved submittals. Close and open the starter using all control devices. _____

GENERAL COMMENTS

_____

_____

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 _____

THERMOGRAPHIC INSPECTION
TEST RECORD

EQUIPMENT: _____

THERMAL AND ELECTRICAL INFORMATION

THERMAL DATA (°F/°C) AND RISE				MANUAL READINGS			
A Phase	____/____	Reference	_____°F	A Phase	_____ A	A/ B Volts	_____V
B Phase	____/____	Temperature	_____ °C	B Phase	_____ A	B/C Volts	_____V
C Phase	____/____	ΔT	_____°F	C Phase	_____ A	A/C Volts	_____V
Neutral	____/____	or Rise	_____ °C	Neutral	_____ A	A/N Volts	_____V
ANOMALY TEMP(°F/°C)							
PROBLEM DESCRIPTION:							
RECOMMENDATION:							

ANOMALY PRIORITY

CRITICAL - IMMEDIATE ATTENTION SUGGESTED

SEVERE - PROBABLE FAILURE, PROMPT ACTION RECOMMENDED

INTERMEDIATE - MONITOR PROBLEM, SCHEDULE MAINTENANCE

MINOR - SCHEDULE ROUTINE MAINTENANCE AT NEXT OPPORTUNITY

DISTRIBUTION:

CONTRACTOR/Date _____

CATEGORY 6 ETHERNET CABLE ASSEMBLY
TEST RECORD

Date/Time: _____ Operator: _____

Cable Type: _____ Test Equipment Model: _____

Cable ID: _____ Test Equipment Calibration Date: _____

Cable Length (ft):		
Propagation Delay (ns):	[Worst Pair]	Pass/Fail
Delay Skew (ns):	[Worst Pair]	Pass/Fail
Insertion Loss (dB): Frequency (MHz):	[Worst Pair]	Pass/Fail
Return Loss (dB): Frequency (MHz):	[Worst Pair]	Pass/Fail
Wire Map	1 2 3 4 5 6 7 8 | | | | | | | | 1 2 3 4 5 6 7 8	Pass/Fail
Worst Pair NEXT (dB): Frequency (MHz):	[Worst Case Margin] [Worst Case Value]	Pass/Fail
Worst Pair PSNEXT (dB): Frequency (MHz):	[Worst Case Margin] [Worst Case Value]	Pass/Fail
Worst Pair ELFEXT (dB): Frequency (MHz):	[Worst Case Margin] [Worst Case Value]	Pass/Fail
Worst Pair PSELFEXT (dB): Frequency (MHz):	[Worst Case Margin] [Worst Case Value]	Pass/Fail

END OF SECTION

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 Centers
   2. Section 16924: Variable Frequency Drives
   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 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: Allen-Bradley Bulletin 700; or equal.
4. Analog or Digital Signal Switching (SR) Relays: Provide plug-in style indicating type relays with gold plated silver contacts for switching low level currents (less than 100 mA). Provide relay sockets screw-type barriered terminals.
5. Timing Relays (TR)
    a. General: Relays designated TR shall be machine tool industrial 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; or equal Allen Bradley relay.
6. 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.

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 ALTERNATOR RELAYS (ALT)

A. Alternator relay shall alternate the state of its contacts in response to impulses applied to its coil. Contacts shall be rated 5 amperes minimum at 120 Vac, 60 Hz. Coil shall be rated 120 Vac, 60 Hz. Provide stud terminals for all wiring. Alternator shall be Autocon 7101AA; Struthers Dunn B11AXA; or equal.

2.06 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 Eaton (Cutler-Hammer) HT series control devices.

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. 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.

2.07 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 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; 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.

B. Test per Specification 16950.

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 and 208/120 VAC 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 medium voltage equipment
   3. All medium voltage to low voltage transformers
   4. All 480 VAC transfer switches, switchboards, panelboards, distribution, power conditioning, motor control, and motors
   5. All 480-208 VAC and 480-240 VAC transformers feeding panelboards
   6. All 208 VAC and 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 208/120 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 an Oregon 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.

1.06 MANUFACTURERS' SERVICES

A. The Motor Control Center manufacturer shall furnish the services of a qualified field engineer and necessary tools and equipment in order to test, calibrate, and adjust the protective relays and circuit breaker trip devices as recommended in the Protective Device Coordination study.

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. Second Utility 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, 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 and distribution switchgear.
   3. Medium and 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. 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.
   8. Transformer excitation current.
   9. Motor and cable damage curves in accordance with the manufacturer's recommendations.

10. 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.
11. Provide recommended settings for protective devices, such as relays and circuit breakers, to achieve the best selectivity to minimize system disturbances during fault clearing.
12. 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.
13. 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 and 208 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.

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SECTION 17010

GENERAL REQUIREMENTS INSTRUMENTATION AND CONTROLS

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 Instrumentation and Controls System as shown on the Drawings except for wire specifically specified in Division 16. See Section 16010, paragraph 1.01.

B. Work Specified in Other Divisions:
   1. Process piping, installation of inline instrumentation and other mechanical work and equipment as specified in Divisions 11 and 15.
   2. Instruments and controls which are not directly used for process control, i.e., those provided as part of a package system, such as a boiler, air compressor, etc. as specified in Divisions 11, 15, and 16.
   3. Division 16 work, including all instrumentation and controls conduit, and only that wire specified in Division 16. Refer to Section 16010 for specific requirements for wire, conduit, and other electrical equipment.
   4. Final control elements as specified in Section 15050.
   5. General mechanical requirements as specified in Section 11001.

1.02 REFERENCE STANDARDS

A. American National Standard Institute (ANSI) Publications:
   1. Y14.15 Drafting Practice
   2. C62.1 Surge Arrestors

B. Instrumentation Society of America (ISA) Publications:
   1. S5.4 Instrument Loop Diagrams
   2. S20 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves

1.03 SYSTEM RESPONSIBILITY

A. General: The I&C equipment as specified in this Division shall be considered an integrated system. Entire system installation including calibration, verification, startup, operation testing, and training shall be performed by qualified personnel,

possessing all the necessary 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 to meet the design conditions stated.

1. Refer to Specifications 01010, the Owner shall perform programming of the existing Biosolids Building PLC and existing SCADA screens.

B. Compatibility: The Contractor shall be responsible to see 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 cost to the Owner.

C. Coordination: For control components, devices, and systems specified in Divisions 11, 15, 16, and 17, or shown on the Instrumentation Drawings, the Contractor shall:

1. Provide technical advice to mechanical and electrical subcontractors as necessary regarding their installation of instruments.
2. Verify the correctness of installation of all instruments.
3. Verify that the proper type, size, and number of control wires with their conduits are provided.
4. Verify that the proper type, size, and number of pneumatic tubes with their conduits are provided.
5. Verify that proper electric power circuits provided for all components and systems.
6. Supervise final signal connections, both electric and pneumatic, to all process instrumentation and control equipment.
7. Adjust, startup, and test all process instrumentation and control equipment.
8. Provide specified documentation and training.

1.04 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.

B. All electrical equipment and materials, including their installation, shall conform to Division 16 of these Specifications unless specified otherwise in this Division.

C. UL Label: Each control panel and terminal cabinet shall bear the UL label except as noted in the following paragraph. 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.

D. Control panel enclosures containing instruments mounted through the enclosure walls or door shall meet all requirements for UL labeling as above, but no UL label is required. This exception applies only if UL Recognized instruments are used.

1.05 INSPECTIONS

A. The Engineer may inspect the fabricated equipment at the factory before shipment to job site. Provide the Engineer with enough prior notice so that an inspection can be arranged at the factory.

B. Inspection 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.

1.06 DRAWINGS

A. Drawings: The Instrumentation Drawings are diagrammatic; exact locations of instrumentation products shall be determined in the field by 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 favorable review.
   4. Resolution of varying interpretations of the Contract Documents shall conform to the Special Provisions.

B. The Contractor shall be responsible for implementing the I&C scheme indicated by the Drawings.

1.07 SUBMITTALS

A. Shop Drawings: Submit shop drawings 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. Schematics shall be complete with device tag numbers, wire numbers and terminal board numbers. Submit fabrication details, nameplate legends, and control panel internal wiring schematic drawings. Submit panel graphic drawings where applicable. Include material specifications lists where applicable.

B. Provide logic diagrams and narrative description of operation for devices and equipment containing programmable logic controllers.

C. Loop and Interconnection Diagrams: Prior to installation of wire, 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 which Division in which it is specified. For the format of these diagrams, see below under As-Built Drawings.

D. Show schematically a "single-line" representing each conduit run, with wirefill noted for each run.

E. Show conduit pull boxes with appropriate tag names and/or numbers.

F. Elementary Diagrams: Provide:
   1. Number for each rung (1, 2, 3, etc.).
   2. Number for each contact and device (101 CR, 104 TR, etc.)
   3. Rung cross reference numbers for all relay contacts associated with each relay coil. Underline rung numbers for each normally-closed contact (5, 7, 9, 11, etc.).
   4. Functional annotation below each contact ("Pump 1 Call," "Sump High Level," etc.).
   5. Functional annotation to the right of each coil, light, and other device ("Pump 1 Call," “Sump High Level," etc.).

G. Record Drawings: Submit "As-Built" process and instrumentation diagrams for all work included in Division 17, in accordance with Section 01700. Submit complete schematics, loop diagrams, and wiring diagrams or drawings to 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.

H. 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 as specified. Obtain distribution method instructions from the Owner or his representative. Provide Operation and Maintenance Manuals.
   1. Schedule: Deliver at least two (2) copies of manuals in 3-ring binders (8½-by 11-inch format) not later than the equipment shipment date.
   2. Contents: Include in manuals not less than the following information, as applicable, for each instrument, equipment, subsystem and/or control loop:
      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 spare parts recommendations.
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.

3. Format: 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.
4. 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.
5. 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.
6. 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 in standard three ring binders and include system name and subcontractor's name on binding.

I. Accessory and Maintenance Materials: Furnish the following items:
1. Special Tools and Accessories: Furnish 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.
2. Maintenance Materials and Spare Parts: Provide a list of recommended spare parts for all devices in this Division.

J. Demonstration and Final Operation Test Plan and Results: Submit, for approval, a document that outlines all procedures to be used in final operational testing of instrument and control systems. Include a description of each system, 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. Following final operating testing, submit three copies of witnessed test results and records for review by the Engineer.

1.08 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. 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.

C. 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 ELECTRONIC EQUIPMENT

A. If the equipment is electronic in nature, provide solid state equipment to the extent practicable. Select components of construction for their suitability and reliability. Employ adequate component derating to preclude failures because of transients and momentary overloads reasonably expected in normal operation. Design units for operation without forced cooling, unless such cooling is an integral part of the device.

B. All instrument and control equipment mounted outside of protective structures (field mounted equipment) shall be equipped with suitable surge arresting 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.

2.04 EQUIPMENT OPERATING CONDITIONS

A. All equipment shall be rated for normal operating performance with varying operating conditions over the following minimum ranges:

B. Electrical Power: 120 volts ac ±10%, 60 Hz, unregulated, except where specifically stated otherwise on the Drawings or in the Specifications, or when two-wire, loop-powered devices are specified.

C. Field Instruments:
   1. Outdoor Areas:
      a. Ambient Temperature: +15°F to +104°F

b. Ambient Relative Humidity: 5% to 100%
c. Weather: Rain, sleet, snow and ice.

2. Indoor Unheated Areas:
   a. Ambient Temperature: +15°F to +120°F
   b. Ambient Relative Humidity: 5% to 95%, non-condensing.

2.05 EQUIPMENT LOCATIONS

A. Provide equipment and materials suitable for the types of locations in which they are to be installed as defined under Division 16. All equipment specified for field mounting shall be weatherproof and splash proof at a minimum. If electrical or electronic components are contained within the equipment, they shall be housed in NEMA 4 cases.

2.06 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%, unless noted otherwise on the Drawings.

2.07 SIGNAL TRANSMISSION

A. Analog:
   1. Signal transmission between electric or electronic instruments shall be 4-20 milliamperes and shall operate at 24 volts dc. 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.
   2. Nonstandard transmission systems such as impulse duration, pulse rate, and voltage regulated will not be permitted except where specifically shown on the Drawings. When transmitters with nonstandard outputs do occur, their output shall be converted to 4-20 milliamperes prior to transmission.

B. Discrete: All alarm and status signals shall be 24VDC unless specified otherwise on the Instrument Schedule. PLC inputs/outputs shall be 24VDC.

2.08 POWER SUPPLIES

A. For each two-wire transmitter, provide a 24 Vdc regulated 30 W 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. 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: Idec Model No. PS5R-VE24 or PS5R–VC12.

2.09 GO/NO-GO STATIONS

A. Go/No-Go Stations enclosures shall be in a stainless steel 304 NEMA 4X box.

B. Stations shall be designed per contract documents with terminals blocks, control relays, silence/acknowledge pushbutton, horn, and lamps.

C. Lamps shall be LED, UL listed, and IP65 rated.

D. Operating voltage 24VDC.

E. Beacon and Multi-Status LED shall be Edwards 108 series, RAG lens option

2.10 LOCAL CONTROL STATIONS

A. Local Control Stations enclosures shall be in a stainless steel 304 NEMA 4X box.

B. Stations shall be designed per contract documents with terminals blocks, control relays, silence/acknowledge pushbutton, horn, and lamps.

C. Lamps shall be LED, UL listed, and IP65 rated.

D. Operating voltage 24VDC.

2.11 DOOR SWITCH

A. Door intrusion switch shall have a wide gap magnetic sensor with S.P.D.T. contacts mounted in a rugged steel housing with integral 3 FT stainless steel armored cable for wiring to a junction box.

B. Intrusion door switches shall be GE Sentrol 2507-A or equal.

2.12 PAINTING

A. Factory paint all instruments and equipment except where installed in pipelines. Where instrument panels are installed adjacent to electrical control panels provided under Division 16, provide instrument panels of identical color to that of electrical control panels. Paint as required in Division 9 for structural supports, brackets, etc. Repair damaged factory paint to satisfaction of the Engineer. Feathering, priming and painting shall produce a reasonable match to the surrounding paint work.

2.13 TESTING OF CONTROL AND PLC PANELS

A. All fabricated equipment shall be tested before it leaves the factory. At the factory, verify wiring continuity and equipment operation by simulating input and output.

B. Factory testing of control panels/devices/equipment shall be accomplished. Refer to individual Specification sections for tests requiring favorable review.

C. Upon completion of factory testing, submit a report certifying the control panels/devices/equipment is operable and meet the Specifications

PART 3 - EXECUTION

3.01 INSPECTION

A. In execution of the work defined in Section 17010, the Contractor shall be responsible for the following services: Inspection of each instrument and piece of equipment for damage, defects, completeness, and correct operation before drilling. Inspection of previously installed related work and verification that it is ready for installation of instruments and equipment.

3.02 EQUIPMENT MOUNTINGS

A. Mount and install equipment as indicated on the Drawings. Where mounted in control panels, obtain brackets from manufacturers suitable for panel mounting.

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. Manufacturers of all process instrument panels and instruments shall certify that their equipment, when installed and anchored, will safely transfer seismic forces through the equipment to the anchorage without failure of equipment or components.

D. Detail drawings shall be provided showing sway bracing design and anchorage requirements for their equipment. Seismic zone requirements shall be as specified for Zone 3 in the current Uniform Building Code.

E. All devices shall be accessible to operators for servicing, operating, reading, etc. The Contractor shall provide platforms or remote meters and/or control switches to assure devices are accessible for operation.

3.03 PROCESS CONNECTIONS

A. Provide instrument impulse piping, tubing, and capillary tubing to meet the intended process service and ambient environmental condition for corrosion resistance, etc. Slope lines according to service to promote self draining or venting back to the process. Terminate connection to process lines or vessels in a service rated block valve, provided under other Divisions, that will permit closing off the impulse line or removal of the element without requiring shut down of the process. Include blow-down 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 manifolds and devices are installed as part of this Specification.

3.04 FIELD WIRING

A. Ring out signal wiring prior to termination and perform surge withstand tests. Verify wire number and terminations are satisfactory as designated on the submitted Loop and Interconnect Diagrams. Verify all terminations are tight and shields are uniformly grounded at one location.

3.05 ELECTROMAGNETIC INTERFERENCE (EMI)

A. Construction shall proceed in a manner which minimizes the introduction of noise into the I&C System.

B. Cross signal wires and wires carrying ac power or control signals at right angles.

C. Separate signal wires from wires carrying ac power or switched ac/dc control signals within control panels, terminal cabinets, telemetry equipment, multiplexer

cabinets, and data loggers as much as possible. Provide the following minimum separations within such equipment unless indicated otherwise on the Drawings:

Power Wiring Capacity	Separation (inches)
120 volts ac or 10 amps	12
240 volts ac or 50 amps	18
480 volts ac or 200 amps	24

3.06 GROUNDING

A. Proper grounding of equipment and systems in this Division is critical. The Drawings and Division 16, Section 16450, specify safety grounding for all equipment in this Division.

B. 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, signal grounds, and power supplies at an isolated signal bus within each instrument panel, rack, or enclosure. See Section 17510 for isolated bus requirements. 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. Connect each isolated signal ground bus within each panel using a stranded, insulated copper wire of size 6 AWG or larger directly to a system ground rod installed per the Drawings.

C. If more than one instrument panel or rack is installed side-by-side, locate an isolated system grounding plate in one of the panels (see Section 17010 for requirements).
   1. Connect all the isolated signal buses in such instrument panel or rack radially to the system ground plate using a stranded, insulated copper wire of size 8 AWG or larger.
   2. Do not use conduit, cable raceways or building steel to distribute the grounding connections; use dedicated wires as specified above. Install a single conduit containing a #2 AWG insulated ground wire from the insulated grounding plate directly to a system ground rod installed per the Drawings. See Division 16 for conduit requirements.

3.07 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.

B. Panels shall be protected during construction to prevent damage to front panel devices and prevent dust accumulation in the intervals. Other protective measures (lamp, strip heaters, etc.) shall be included as weather conditions dictate.

3.08 FACTORY TESTING OF CONTROL PANELS

A. Verify, at the factory, wiring continuity and equipment/device/instrument operation by simulating inputs and outputs. Factory testing of panels shall be accomplished in accordance with an approved factory test procedure. Upon completion of factory testing, submit a report certifying that the control panels are operable and meet the specifications.

3.09 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 in writing a minimum of 48 hours prior to the proposed date for commencing final operational testing and acceptance.

B. Testing and scheduling shall be coordinated with Engineer.

C. 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%, 25%, 50%, 75%, and 100% 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.

D. Final Operational Testing: Upon completion of instrument verification, test all systems under process conditions in the presence of the Engineer. System testing shall be accomplished in accordance with the approved Test Plan. The test for each portion thereof shall be witnessed, documented and signed off upon completion by the Engineer. The intent of this test is to demonstrate and certify the operational interrelationship of plant instrumentation and control systems. This testing shall include, but not be limited to:
   1. Making final adjustments to levels, alarms, etc.
   2. Checking all alarms, failure interlocks, and operational interlocks.
   3. Immediately correcting all defects and malfunctions and retesting.

4. 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

3.10 INSTRUCTION OF OWNER'S PERSONNEL

A. Provide the services of a factory trained and field experienced instrumentation engineer to conduct group training of Owner's designated personnel in the operation of each instrument system. This training shall be for the time period of 1 working day 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.

END OF SECTION

SECTION 17330

PROGRAMMABLE LOGIC CONTROLLER

PART 1 - GENERAL

1.01 SUMMARY

A. Provisions: Requirements of Division 1 and Section 17010 form a part of this Section.

B. Scope of Work
   1. Provide coordination with packaged systems for a complete operating control system.
   2. The City of Albany shall make programing changes to the existing SCADA screens, existing workstation screens, and plant PLC. Provide coordination, scheduling, and assistance to assure project meets schedule and is operational. Refer to Section 01010.
   3. Modification to existing Allen Bradley ControlLogix control panel.
   4. Modifications to existing network/communications panel.
   5. Unless otherwise specified, equipment manufacturer provided control systems shall meet the requirements of Specifications 17330 for control panels and control stations and communicate using EtherNet TCP/IP.

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, programmer, magnetic program storage device, interfacing equipment, power line voltage regulation transformer, power line surge protection device, Ethernet to fiber optic manage switches 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 layout drawing of PLC Control Panel and Remote I/O panels.
   4. Software documentation to include fully-annotated, line-by-line ladder diagram in RSLogix 5000 format.
   5. A typewritten document containing startup, operation, and maintenance procedures.
   6. The Factory and Field Witnessed Test procedure.
   7. The Factory and Field Witnessed Test results.
   8. Spare Parts Items: As specified herein.
   9. O&M Manual.
   10. Screenshots of the operator interface screens.

1.03 QUALITY ASSURANCE

A. Provide programmable logic controllers (PLCs) which comply with NEMA Standard ICS 3-304. This standard applies to the construction, programming, performance, test, installation, protection, and safety of PLCs.

1.04 UL LABEL

A. Programmable controller enclosures shall bear the UL label. See Section 17510.

1.05 APPENDICES

A. Control Strategies. These strategies will be used by the Owner's Programmer to facilitate programing of the existing plant PLC. Refer to Section 17330B.

PART 2 - PRODUCTS

2.01 PROGRAMMABLE LOGIC CONTROLLERS

A. Programmable Logic Controller: Provide each PLC with the following hardware.
   1. I/O Chassis: Provide a 13-slot universal I/O chassis to house the processor, power supply and I/O modules. The selection of size slot and number of chassis to achieve a satisfactory complement of I/O modules is the responsibility of the Contractor.
   2. Power Supply: Provide power supply module to power the processor and local I/O modules. I/O back plane loading shall not exceed 75% of power supply rating amps on any chassis.
   3. Memory Enhancement: The processor shall have 1.5 MB basic memory. Provide memory enhancement if the program exceeds 75% of capacity.
   4. Cables: Provide a full complement of cables for connecting to programming terminal and interface devices.
   5. Central Processing Unit: The Central Processing Unit (CPU) shall be powered by 24 VDC, and shall have the following:
      a. PLC "ladder logic" software with extend math functions and on line/off line programming functions.
      b. Local I/O Scanner.
      c. Floating point arithmetic.
      d. PID loop control.
      e. Battery-backed (10-year lithium) CMOS RAM.
      f. The CPU shall be CompactLogix 5370 System 1769, no equal. The CPU shall be no less than a 1769-L33ER.
   6. Power Supply: 24 Vdc, Allen Bradley 1769-PB4, no equal.
   7. Input and Output Modules:
      a. Analog inputs (AI) shall meet the following requirements:
         1) 4 to 20 mAdc inputs, 250-ohm impedance maximum, 8 single ended configuration.
         2) Accuracy of ±0.15% of span.
         3) Resolution: 16 bits
         4) Common Mode Rejection of 100 dB at 60 Hz, minimum.
         5) Normal Mode Rejection of 80 dB at 60 Hz, minimum.
         6) Isolation shall meet or exceed surge-withstand test, IEEE-472.

7) Drift shall not exceed 1.5% within a one-year period @ 25°C
8) Modules shall be Allen-Bradley 1769-IF8 for CompactLogix or 1769-IF8H when Hart is required, no equal.

b. Discrete inputs (DI) shall meet the following requirements:
1) Unpowered contact inputs or power inputs at 24 Vdc.
2) Input isolation shall meet or exceed IEEE-472. Relay isolation is unacceptable.
3) Provide filtering on a per unit point basis to provide contact bounce protection.
4) Discrete inputs shall be powered by the PLC by a 24-Vdc power supply; shall be current limited to conform to NEC Class 2 remote control and signal wiring circuits.
5) Modules with 16 inputs with common ground terminals. Voltage input modules shall have their channels fully isolated.
6) Modules shall be Allen-Bradley 1769-IQ16 for CompactLogix, no equal.

c. Analog outputs (AO) shall meet the following requirements.
1) Output: 4-20 mAdc into a 0 to 500 ohm load; six individually isolated output configurations with separate grounds.
2) Isolation: From the multiplexer ground.
3) Resolution: 13 bits.
4) Accuracy: ±0.1% of 4 to 21 mA
5) Drift: Shall not exceed 1% in a 1-year period.
6) Output short circuit protection shall be electronically limited to 21 mA or less with 24 V AC/DC maximum overvoltage protection
7) Modules shall be Allen-Bradley 1769-OF4 for CompactLogix, no equal.

d. Discrete outputs (DO) shall meet the following requirements:
1) Electrically-latched outputs shall require one program command for set and reset. Loss of power shall return the output to a preselected state. Both fail open and fail close contact states shall be provided.
2) Contact configuration shall be N.O.; triac outputs - supply with suppression circuit for inductive load.
3) Provide the following ratings: 2A steady state, 15A make at 30 Vdc inductive load for external relays.
4) Provide arc-suppression for each contact.
5) Provide 16 isolated output configuration.
6) Modules shall be Allen-Bradley 1769-OW16 for CompactLogix, no equal.

e. Provide spare inputs and outputs so that a minimum of 25% of each type is spare, functional, and installed in the mounting racks. Permanently label each input and output on each module by the tag number and description given in the Instrument Schedule.

f. Provide at least two spare slots for future modifications/additions.

g. Remote I/O Adapter: Provide a remote I/O adapter for communication between the CPU and other I/O chassis, if required.

h. Provide blank plates for all unused I/O slots.

8. Network Communications: Provide each PLC and RIO with Ethernet communications (Ethernet/IP) using TCP/IP protocol. Provide Ethernet Allen Bradley 1769-AENTR, no equal.

B. Programmable Logic Controller Enclosure:
   1. The PLC hardware shall be furnished completely assembled and wired in electronic rack enclosures (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 proper.

2.02 ETHERNET SWITCHES FOR PLC NETWORK

A. Provide Ethernet network switches in the PLC panels where shown on the Drawings. Ethernet switches shall be provided with the following features:
   1. Four 10/100 BaseT(X) auto negotiation speed RJ-45 ports (minimum), full/half duplex mode, and auto MDI/MDI-X connection.
   2. 100BaseFX ports (SC connector).
   3. EtherNet/IP industrial protocol.
   4. LEDs for link, speed, activity and duplex status.
   5. Relay output with current carrying capacity of 1 A @ 24 VDC.
   6. Full IEEE 802.3 compliance.
   7. 802.1Q VLAN, Port-Based VLAN, GVRP, IGMP v1/v2, GMRP filters.

B. Management features:
   1. SNTP.
   2. NTP Server/Client.
   3. QoS.
   4. OLE for Process Control (OPC) traffic monitoring.
   5. Output warning power failure and port break alarm.

C. Manufacturer: Strattix 5700 10 or 20, number of copper and FO ports to be determined by Vendor Package and Owners.

2.03 OPERATOR INTERFACE

A. Provide a touchscreen color operator display panel to allow local control at the PLC control panel. Panel shall consist of a display and keypad to allow for monitoring and control of process variables. Panel shall be mounted on the PLC panel door. Panel features shall be as follows:
   1. Active Matrix: 12.1” TFT color screen.
   2. 1280x800 pixel resolution.
   3. 32-bit RISC CPU, 400MHz.
   4. Built-in Ethernet port and two USB port.
   5. 24Vdc power.
   6. Rating: NEMA 4, UL listed.

B. Manufacturer: Allen Bradley PanelView plus 7 touch screen.

C. Software: FactoryTalk ME.

2.04 FIBER OPTIC PATCH PANELS:

A. Fiber optic cable termination panels (patch panels) shall provide a single location for splicing, patching and testing fiber optic cables entering control panels. Fiber optic patch panels shall have a protective housing for breakout of individual fibers and for splices. The splice area shall support fusion splices for 62.5-micron multimode optical fiber and shall provide strain relief for individual fibers. A slide-up or swing-open front door shall be provided.

B. Each fiber patch panel shall be sufficiently sized to accommodate the full number of strands in each cable to be terminated.

C. Each fiber strand in each single mode cable shall be terminated so that all strands of all cables are made available at bulkhead-mounted SC connectors that are mounted on patch panels.

D. Front and rear tilt-up lids shall provide unobstructed access to adapters and mounting plates.

E. The panels shall provide for patch cord and splice tray storage in the same unit.

F. The connector shall provide a strain relief mechanism for installation on a fiber cable that contains strength elements. The fiber within the body of the connector shall be isolated mechanically from cable tension, bending and twisting.

G. A directory shall be provided at each fiber optic patch panel logically identifying each optical fiber within.

H. Dust caps shall be furnished and installed on all unused patch panel connectors.

I. Manufacturer: Telect Inc.; ADC; Panduit, or equal.

2.05 UNINTERRUPTIBLE POWER SUPPLY (UPS):

A. Provide UPS unit rated for 200 percent of PLC load with batteries sized to provide at least 1-hour service at full load. UPS shall have an input and output power of 120 Vac and shall be mounted within the control panel. UPS shall be APC Series SMT or Series SMX with APC AP9641 network interface card.

PART 3 - EXECUTION

3.01 WITNESSED TEST

A. General: The PLC shall be tested at the factory together with the computer system and Human Machine Interface (HMI) software:
   1. Programming of the PLC and HMI shall be done by equipment vendors. The programs shall be loaded to PLC during the Witnessed Factory Test and the entire system shall be tested jointly by the Equipment Vendor and Owner.

B. Prior to shipment of the PLC to the jobsite, perform a Witnessed Test. This test shall demonstrate full compliance of the PLC with contract requirements. The test shall be witnessed by the Owner or his designated representative.

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 set at least 6 weeks following delivery of the resubmitted test procedure.

D. 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.

E. Submit the results of the test in a formal document within 2 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 field test procedure to be submitted at least 2 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 6 weeks following delivery of the resubmitted test procedure.

C. Prepare a test plan for each phase of construction. Each phase shall be tested with the Dewatering Building HMI.

D. Testing of packaged system will be performed by the corresponding vendors. Coordinate work as required. Security passwords on PLC programs shall not be utilized.

E. Perform the field test in accordance with the test procedure and per Section 01650 Start-up and Commissioning Periods. 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, and then a second test shall be performed.

F. Submit the results of the test in a formal document within 2 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 training director who shall design a detailed training plan that complements the experience and skill levels of the Owner's personnel. The training course shall be conducted at the treatment plant. The text for both training courses below shall be the O&M Manual and selected handouts.

B. PLC Operations Training: A minimum 1-day course shall be provided for up to six persons. The level of training shall be sufficient to familiarize the personnel with the operation of the PLC 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 1-day course shall be conducted for up to six persons on maintenance of modifications to the PLC. 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. If it is necessary to use special purpose test equipment which is only available from the equipment manufacturer, then such test equipment shall be provided as a part of the system and shall become the property of the Owner.

END OF SECTION

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SECTION 17330B

CONTROL STRATEGIES

The Control Strategies are numbered to match the Instrumentation drawing number which they refer to. The Control Strategies are attached in the following order:

014 – Solids Dewatering
015 – Composting System

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CONTROL STRATEGY 014

TITLE: 014 - Solids Dewatering

AREA: Biosolids Dewatering

PROCESS AND INSTRUMENTATION DIAGRAM: I-011, I-012, I-013, I-013, I-014 and I-015

RELATED EQUIPMENT:

Aerobic Digester Transfer Pump	72P2101 (Existing)
Sludge Grinder	WW1-015M1021 (Existing)
Sludge Feed Pump 1	WW1-015P1001 (Existing)
Sludge Feed Pump 1 Suction Valve	WW1-015FV6001 (Existing)
Sludge Feed Pump 1 Flow Meter	WW1-015FE3121 (Existing)
Sludge Feed Pump 1 High Pressure Switch	WW1-015PSH3041 (Existing)
Sludge Feed Pump 1 Low Pressure Switch	WW1-015PSL3041 (Existing)
Sludge Feed Pump 2	WW1-015P1002 (Existing)
Sludge Feed Pump 2 Suction Valve	WW-015FV6002 (Existing)
Sludge Feed Pump 2 Flow Meter	WW1-015FE3122 (Existing)
Sludge Feed Pump 2 High Pressure Switch	WW1-015PSH3042 (Existing)
Sludge Feed Pump 2 Low Pressure Switch	WW1-015PSL3042 (Existing)
Polymer Feed System 1	WW1-062M0011
Differential Pressure Switch Low	WW1-062PDSL0011
Flow Switch Low	WW1-062FSL0011
Polymer Feed System 2	WW1-062M0012
Differential Pressure Switch Low	WW1-062PDSL0012
Flow Switch Low	WW1-062FSL0012
Screw Press 1	WW1-015M1141
Emergency Stop	WW1-015HS1141B
Screw Press 1 Motor High Temp Switch	WW1-015TSH1141
Screw Press 1 Headbox Level Sensor	WW1-015LE3111
Screw Press 1 Wash Water Solenoid Valve A	WW1- 015FV6011A
Screw Press 1 Wash Water Solenoid Valve B	WW1- 015FV6011B
Screw Press 1 Wash Water Solenoid Valve C	WW1- 015FV6011C
Screw Press 1 Wash Water Solenoid Valve D	WW1- 015FV6011D
Screw Press 1 Wash Water Solenoid Valve E	WW1- 015FV6011E
Flocculation Tank 1 Mixer	WW1-015M1151
Emergency Stop	WW1-015HS1151B
Flocculation Tank 1 Mixer High Temp Switch	WW1-015TSH1151
Flocculation Tank 1 High Level Switch	WW1-015LSH3141
Screw Press 2	WW1-015M1142
Emergency Stop	WW1-015HS1142B
Screw Press 2 Motor High Temp Switch	WW1-015TSH1142
Screw Press 2 Headbox Level Sensor	WW1-015LE3112
Screw Press 2 Wash Water Solenoid Valve A	WW1- 015FV6012A
Screw Press 2 Wash Water Solenoid Valve B	WW1- 015FV6012B
Screw Press 2 Wash Water Solenoid Valve C	WW1- 015FV6012C
Screw Press 2 Wash Water Solenoid Valve D	WW1- 015FV6012D
Screw Press 2 Wash Water Solenoid Valve E	WW1- 015FV6012E

Flocculation Tank 2 Mixer	WW1-015M1152
Emergency Stop	WW1-015HS1152B
Flocculation Tank 2 Mixer High Temp Switch	WW1-015TSH1152
Flocculation Tank 2 High Level Switch	WW1-015LSH3142
Screw Press 1 Conveyor	WW1-015M1241
Screw Press Conveyor 1 Speed Switch	WW1-015SS1241
Emergency Stop	WW1-015HS1241
Screw Press 2 Conveyor	WW1-015M1242
Screw Press Conveyor 2 Speed Switch	WW1-015SS1242
Emergency Stop	WW1-015HS1242
Cake Conveyor 1	WW1-015M1251
Cake Conveyor 1 Speed Switch	WW1-015SS1251
Emergency Stop	WW1-015HS1251
Cake Conveyor 2	WW1-015M1252
Cake Conveyor 2 Speed Switch	WW1-015SS1252
Emergency Stop	WW1-015HS1252
Cake Conveyor 3	WW1-015M1253
Cake Conveyor 3 Speed Switch	WW1-015SS1253
Emergency Stop	WW1-015HS1253
Cake Conveyor 4	WW1-015M1254
Cake Conveyor 4 Speed Switch	WW1-015SS1254
Emergency Stop	WW1-015HS1254

Biosolids Dewatering Controls, Monitoring, and Alarms

A. General:

Waste activated sludge (WAS) is removed from the liquid stream treatment process and pumped to the aerobic digesters for temporary storage prior to dewatering. When Water Reclamation Facility (WRF) staff wish to dewater the stored WAS, it is pumped to the dewatering system by the Aerobic Digester Transfer Pump that is connected to two progressive cavity type sludge pumps (Sludge Feed Pump 1 and 2) located in the Dewatering Building.

Two dewatering trains are provided in the Dewatering Building. Each train consists of a sludge feed pump, liquid polymer feed system, flocculation tank, rotary screw press, and screw press conveyor. Polymer is injected into the sludge feed line immediately upstream of the flocculation tanks. The sludge/polymer mixture enters the flocculation tank where a variable speed mixer is used to promote flocculation prior to its flow to the screw press headbox. The conditioned sludge is conveyed through screw press and is dewatered. Dewatered cake is discharged from the screw presses into dedicated screw conveyors that convey the cake outside of the Dewatering Building. Four screw conveyors outside of the building convey the dewatered cake to the East Bay of the Cake Storage Building where it is temporarily stored. An odor control system located outside the Cake Storage Building exhausts air from the East Bay helping to minimize nuisance odors.

Prior to starting dewatering operations, WRF staff confirm there is enough polymer in the liquid polymer totes associated with the polymer blending system. Once this is confirmed, normal operation is for staff to place the screw presses in Auto and initiate the dewatering cycle. When the dewatering cycle is initiated the following sequence occurs:

1. The screw press, screw press conveyor, and cake conveyors are called to run.
2. The odor control system is called to run.
3. After an adjustable time setpoint has been reached and both conveyor motion and airflow through the odor control system are confirmed, the aerobic digester transfer pump, sludge feed pump and polymer feed system are called to run.
4. The flocculation tank mixer is called to start.
5. The dewatering system continues to run automatically until WRF staff manually stop the system at which time the dewatering system enters a shutdown sequence.

During a normal shutdown sequence, the following sequence occurs:

1. The aerobic digester transfer pump and sludge feed pump stop.
2. The polymer feed system stops.
3. The flocculation tank mixer stops.
4. The screw press and conveyors continue to run for an adjustable period of time to remove solids from the system. After the time setpoint has elapsed, the screw press and conveyors stop.
5. The odor control system continues to run until WRF staff have removed all dewatered cake from the Cake Storage Building at which time the odor control system can be stopped. The odor control must run anytime dewatered cake is present to maintain the Dewatered Cake Storage Building as an unclassified space.

The screw press has two available control modes for automatic operation: variable flow and constant flow. In variable flow control mode, the screw press runs at a constant speed and sludge feed flow rate is automatically adjusted to maintain the level setpoint in the screw press headbox. In constant flow control mode, sludge feed flow rate is set to a constant value and screw press speed automatically varies to maintain the level setpoint in the screw press headbox.

In either automatic control modes, the sludge feed pump, polymer feed system, and flocculation tank mixer stop if the level in the screw press headbox reaches the high level setpoint. The screw press and conveyors continue to run until the level in the headbox drops down to the Resume Feed Setpoint at which time the sludge feed pump, polymer feed system, and flocculation tank mixer restart.

B. Operator Controls:
   1. Screw Presses:

Location	Control Item	Type
SCADA/HMI	Screw Press	
	Hand-Off-Auto	Selector switch
	Start-Stop	Push button
	Speed Setpoint	Digital input
	Auto Mode	
	Variable Flow	Selector switch
	Constant Flow	
	Headbox Level	
	Level Setpoint	Digital input
	High Level Setpoint	Digital input
	Resume Feed Setpoint	Digital input
	Auto Startup Time Setpoint	Digital input
	Auto Startup Time Setpoint	Digital input
	Flocculation Tank Mixer	
	Hand-Off-Auto	Selector switch
	Speed Setpoint	Digital input
	Wash Water Valves	
	Auto-Open	Selector switch
	Time Off Setpoint	Digital input
	Time On Setpoint	Digital input
Local Control Panels	Screw Press	
	Hand-Off-Auto	Selector switch
	Flocculation Tank Mixer	
	Hand-Off-Auto	Selector switch

B. Operator Controls (Continued):

2. Sludge Feed Pumps:

Location	Control Item	Type
SCADA/HMI	Sludge Feed Pumps	
	Hand-Off-Auto	Selector switch
	Speed Setpoint	Selector switch
	Sludge Feed Pump Suction Valves	
	Hand-Off-Auto	Selector switch
	Open-Close	Selector switch
MCC	Sludge Feed Pumps	
	Local-Off-Remote	Selector switch
	Reset	Push button
Local Control Station	Sludge Feed Pumps	
	Start	Push button
	Lock Out Stop	Push button
	Sludge Feed Pump Suction Valves	
	Local-Off-Remote	Selector switch
	Open-Close	Selector switch

3. Polymer Feed Systems:

Location	Control Item	Type
SCADA/HMI	Polymer Feed System	
	Hand-Off-Auto	Selector switch
	Pump Speed	Digital input
	Flow Ratio Setpoint	Digital input
Local Control Panel	Polymer Feed System	
	Hand-Off-Remote	Selector switch
	Mixer Speed	Hand dial
	Pump Speed	Hand dial

B. Operator Controls (Continued):

4. Conveyors:

Location	Control Item	Type
SCADA/HMI	Conveyors Hand-Off-Auto	 Selector switch
MCC	Conveyors Reset	 Push button
Local Control Station	Conveyors Hand-Off-Auto Lockout Stop	 Selector switch Push button
Equipment	Emergency Stop	Cord pull

5. Odor Control:

Location	Control Item	Type
SCADA/HMI	Odor Control Hand-Off-Auto Stop	 Selector switch Push button
MCC	Odor Control Hand-Off-Auto	 Selector switch

C. Manual Operation:

1. Screw Press: Place the Hand-Off-Auto selector switch at the local control panel in the Hand position. The screw press runs continuously at the adjustable speed setpoint until the Hand-Off-Auto selector switch is placed is the Off position.
2. Flocculation Tank Mixer: Place the Hand-Off-Auto selector switch at the local control panel in the Hand position. The mixer runs continuously at the adjustable speed setpoint until the Hand-Off-Auto selector switch is placed in the Off position.
3. Screw Press Wash Water Valves. Place the Auto-Open selector switch in the Open position. The valves will remain open until the Auto-Open selector switch is placed in the Auto position.
4. Sludge Feed Pumps:
   a. Local: Open the Sludge Feed Pump Suction Valve by placing the Local-Off-Remote selector switch at the valve in the Local position and the Open-Close selector switch at the valve in the Open position. Place the Sludge Feed Pump's Hand-Off-Auto selector switch at the MCC in the Hand position. The sludge feed pump runs continuously at the adjustable speed setpoint until the Hand-Off-Auto selector switch is placed in the Off position.
   b. Remote: Open the Sludge Feed Pump Suction Valve by placing the Local-Off-Remote selector switch at the valve in the Remote position. Place the valve's Hand-Off-Auto selector switch at the HMI/SCADA in the Hand position and place the Open-Close selector switch in the Open position. Place the Sludge Feed Pump's Hand-Off-Auto selector switch at the MCC in the Auto position. At the HMI/SCADA place the Hand-Off-Auto switch into the Hand position. The sludge feed pump runs continuously at the

adjustable speed setpoint until the Hand-Off-Auto selector switch is place in the Off position.

5. Polymer Feed System: Place the Hand-Off-Remote selector switch in the Hand position. The polymer feed system runs continuously at the adjustable speed setpoint until the Hand-Off-Remote selector switch is placed in the Off position.
6. Conveyors:
    a. Local: Place the Hand-Off-Auto selector switch at the local control station in the Hand position. The conveyor runs until the Hand-Off-Auto selector switch is placed in the Off position.
    b. Remote: Place the Hand-Off-Auto selector switch at the local control station in the Auto position. Place the Hand-Off-Auto selector switch at the HMI/SCADA in the Hand position. The conveyor runs until the Hand-Off-Auto selector switch is placed in the Off position.
    c. Conveyors will not run in Hand if their E-Stop button/cable is activated.
7. Odor Control:
    a. Local: Place the Hand-Off-Auto selector switch at the MCC in the Hand position. The Odor Control system runs until the Hand-Off-Auto selector switch is placed in the Off position.

D. Automatic Operation:

1. Screw Press: Place the Hand-Off-Auto selector switch at the local control panel in the Auto positions. At the SCADA/HMI select the preferred Auto Mode (Variable Flow or Constant Flow). In Variable Flow Mode, the speed of the sludge feed pump varies automatically to maintain the level setpoint value in the screw press headbox. In Constant Flow Mode, the screw press speed varies automatically to maintain the level setpoint value in the screw press headbox with the sludge feed pump operating at the input Sludge Feed Pump Speed setpoint. Dewatering is started by pushing the Start-Stop pushbutton at the SCADA/HMI. This initiates a startup sequence that calls the following equipment to run: screw press conveyors, cake conveyors, sludge pumps, polymer feed systems, and flocculation tank mixers. While operating, if the headbox level reaches its High-Level Setpoint, the sludge feed pump, polymer feed system and flocculation tank mixer stop and the status of all three changes to Paused. The screw press remains running to lower the level within the headbox. When the headbox level reaches its Resume Feed Setpoint, the sludge feed pump, polymer feed system, and flocculation tank mixer turn on and resume running. The dewatering system operates until the Start-Stop pushbutton is pushed at which time the screw press enters an automatic shutdown sequence.
2. Flocculation Tank Mixer: Place the Hand-Off-Auto selector switch at the local control panel in the Auto position. The mixer starts and stops automatically based on operation of the screw press. When running, the mixer operates at the mixer Speed Setpoint.
3. Wash Water Valves. Place the Auto-Open selector switch at the local control panel in the Auto position. The valves open and close based on operation of the screw press and on the Time-Off Setpoint and the Time-On Setpoint.
4. Sludge Feed Pumps: Place the Sludge Feed Pump Suction Valve's Local-Off-Remote selector switch at the valve in the Remote position. Place the valve's Hand-Off-Auto selector switch at the HMI/SCADA in the Auto position. Place the Sludge Feed Pump's Local-Off-Remote selector switch at the MCC in the Remote position. Place the Hand-Off-Auto selector switch at the SCADA/HMI in the Auto position. The

feed pumps and suction valves start/stop and open/close automatically based on the operation of the screw press. Pump speed adjusts automatically if the screw press is in Variable Flow control mode. If the screw press is in Constant Flow control mode, the pump runs at the pump Speed Setpoint.

5. Polymer Feed System: Place the Hand-Off-Remote selector switch at the local control panel in the Remote position. Place the Hand-Off-Auto selector switch at the SCADA/HMI in the Auto position. The polymer feed system starts and stops automatically based on the operation of the screw press. Feed rate adjusts automatically to maintain the Flow Ratio Setpoint.
6. Conveyors: For each conveyor, place the Hand-Off-Auto selector switch at the local control station in the in the Auto position. Place the Hand-Off-Auto selector switch at the SCADA/HMI to the Auto position. The conveyors start and stop based on operation of the screw press. Conveyors will not run in Auto if their E-Stop button/cable is activated.
7. Odor Control: Place the Hand-Off-Auto selector switch at the MCC in the in the Auto position. Place the Hand-Off-Auto selector switch at the SCADA/HMI to the Auto position. The Odor Control System conveyors starts based on operation of the screw press. The Odor Control System will continue to run until stopped by WRF staff at the SCADA/HMI. The odor control system must run anytime dewatered cake is present in the Dewatered Cake Storage Building to maintain it as an unclassified space.
8. Power Failure. The equipment will not restart automatically after a power failure.

E. Interlocks with Other Equipment:
   1. The operation of each screw press is interlocked with its associated sludge feed pump, polymer feed system, flocculation tank mixer, screw press conveyor and all four cake conveyors. The screw press and conveyors start first and operate for a preset period followed by startup of the sludge feed pump, polymer feed system, and flocculation tank mixer. Should the conveyors fail to start or cease running, the screw press, sludge feed pump, polymer feed system, and flocculation tank mixer will all shutdown. During a normal shutdown sequence, the sludge feed pump, polymer feed system, and flocculation tank mixer shut off first. The screw press and conveyors continue to run to empty their contents and go through a cleaning cycle until the Auto Shutdown Time Setpoint is reached.
   2. Interlocks between the screw press, sludge feed pump, polymer feed system, flocculation tank mixer, and conveyors are disabled, and the equipment can run independent of screw press operation when the equipment is in Hand mode.
   3. In Auto, if any one conveyor ceases to run, all conveyors stop running.
   4. If a conveyors E-Stop button/cable is activated, conveyors will not run in either Hand or Auto.

F. Operational Status Indications:

1. Screw Presses:

Location	Status	Visual Indication
SCADA/HMI	Screw Press	
	In Auto	(TBD)
	Running	Red indicating color
	Stopped	Green indicating color
	Speed	Numeric value
	Screw Press Headbox Level	Numeric value
	Flocculation Tank Mixer	
	In Auto	(TBD)
	Running	Red indicating color
	Stopped	Green indicating color
	Paused	(TBD)
	Speed	Numeric value
	Wash Water Valves	
	In Auto	(TBD)
	Open	Red indicating color
	Closed	Green indicating color

2. Sludge Feed Pumps:

Location	Status	Visual Indication
SCADA/HMI	Sludge Pump(s)	
	In Auto	(TBD)
	Running	Red indicating color
	Stopped	Green indicating color
	Paused	(TBD)
	Speed	Numeric value
	Flow Rate	Numeric value
	Total Flow	Numeric value
	Sludge Feed Pump Suction Valves	
	In Remote	(TBD)
	Open	Red indicating color
	Close	Green indicating color
MCC	Sludge Pump(s)	
	Running	Red lamp
	Ready	Clear lamp
	Speed	Numeric value

3. Polymer Feed Systems:

Location	Status	Visual Indication
SCADA/HMI	Polymer Feed System Running Stopped Paused	 Red indicating color Green indicating color (TBD)
Local Control Panel	Polymer Feed System Running Power Pumping Rate	 Red lamp Clear lamp Numeric value

4. Conveyors:

Location	Status	Visual Indication
SCADA/HMI	Conveyors In Auto Running Stopped	 (TBD) Red indicating color Green indicating color
MCC	Conveyors Running Stopped	 Red lamp Green lamp
Local Control Station	Conveyors Running Stopped	 Red lamp Green lamp

5. Odor Control:

Location	Status	Visual Indication
SCADA/HMI	Odor Control In Auto Running Stopped	 (TBD) Red indicating color Green indicating color
MCC	Odor Control Running	 Red lamp

G. Alarm Indications:

1. Screw Presses:

Location	Status	Visual Indication
HMI/SCADA	Screw Press	
	VFD Failure	Yellow indicating color
	Motor High Temp	Yellow indicating color
	Head Box	Yellow indicating color
	High Level	Yellow indicating color
	High-High Level	
	E-Stop Button Pressed	Yellow indicating color
	Flocculation Tank	
	Mixer Motor VFD Failure	Yellow indicating color
	Mixer Motor High Temp	Yellow indicating color
	High Level	Yellow indicating color
	E-Stop Button Pressed	Yellow indicating color

2. Sludge Feed Pumps:

Location	Status	Visual Indication
SCADA/HMI	Sludge Pump(s)	
	VFD Failure	Yellow indicating color
	High Pressure	Yellow indicating color
	Low Pressure	Yellow indicating color
	Seal Water Fail	Yellow indicating color
	Sludge Feed Pump Suction Valves	
	Fail	Yellow indicating color
MCC	Sludge Pump(s)	
	VFD Failure	Yellow lamp

3. Polymer Feed Systems:

Location	Status	Visual Indication
SCADA/HMI	Polymer Feed System	
	Common Alarm	Yellow indicating color
Local Control Panel	Polymer Feed System	
	Low Differential Pressure	Yellow lamp
	Low Polymer Flow Rate	Yellow lamp

G. Alarm Indications (Continued):

4. Conveyors:

Location	Status	Visual Indication
SCADA/HMI	Conveyors Failure E- Stop Activated	 Yellow indicating color Yellow indicating color
MCC	Conveyors Failure	 Yellow lamp
Local Control Station	Conveyors Failure	 Yellow lamp

5. Odor Control:

Location	Status	Visual Indication
SCADA/HMI	Odor Control Failure Low Pressure	 Yellow indicating color Yellow indicating color
MCC	Odor Control Failure	 Yellow lamp

END OF CONTROL STRATEGY

CONTROL STRATEGY 015

TITLE: 015 - Composting System

AREA: Compost Facility

PROCESS AND INSTRUMENTATION DIAGRAM: I-015 and I-016

RELATED EQUIPMENT:

Compost Supply Fan	WW1-016B0101
Supply Fan Motor Temp Switch	WW1-016TSH3011
Supply Fan Discharge Pressure	WW1-016PIT3001
Supply Air Damper Zone 1-1	WW1-016FV6111
Supply Air Damper Zone 1-2	WW1-016FV6121
Supply Air Damper Zone 2-1	WW1-016FV6211
Supply Air Damper Zone 2-2	WW1-016FV6221
Compost Exhaust Fan	WW1-016B0201
Exhaust Fan Motor Temp Switch	WW1-016TSH3041
Exhaust Fan Suction Pressure	WW1-016PIT3021
Exhaust Fan Discharge Pressure	WW1-016PIT3031
Cooling Air Damper	WW1-016FV6001
Exhaust Air Damper Zone 1-1	WW1-016FV6112
Exhaust Air Damper Zone 1-2	WW1-016FV6122
Exhaust Air Damper Zone 2-1	WW1-016FV6212
Exhaust Air Damper Zone 2-2	WW1-016FV6222
Temperature Probe 1 Zone 1-1	WW1-016TIT3111
Temperature Probe 2 Zone 1-1	WW1-016TIT3112
Temperature Probe 3 Zone 1-1	WW1-016TIT3113
Temperature Probe 1 Zone 1-2	WW1-016TIT3121
Temperature Probe 2 Zone 1-2	WW1-016TIT3122
Temperature Probe 3 Zone 1-2	WW1-016TIT3123
Temperature Probe 1 Zone 2-1	WW1-016TIT3211
Temperature Probe 2 Zone 2-1	WW1-016TIT3212
Temperature Probe 3 Zone 2-1	WW1-016TIT3213
Temperature Probe 1 Zone 2-2	WW1-016TIT3221
Temperature Probe 2 Zone 2-2	WW1-016TIT3222
Temperature Probe 3 Zone 2-2	WW1-016TIT3223
Biofilter Temperature Probe 1	WW1-016TIT3051
Biofilter Temperature Probe 2	WW1-016TIT3052
Biofilter Irrigation Solenoid Valve	WW1-016SV6011
Irrigation Solenoid Valve 1 Zone 1-1	WW1-016SV6111
Irrigation Solenoid Valve 2 Zone 1-1	WW1-016SV6112
Irrigation Solenoid Valve 1 Zone 1-2	WW1-016SV6121
Irrigation Solenoid Valve 2 Zone 1-2	WW1-016SV6122
Irrigation Solenoid Valve 1 Zone 2-1	WW1-016SV6211
Irrigation Solenoid Valve 2 Zone 2-1	WW1-016SV6212
Irrigation Solenoid Valve 1 Zone 2-2	WW1-016SV6221
Irrigation Solenoid Valve 2 Zone 2-2	WW1-016SV6222

A. General:

The Phase 1 composting system is comprised of four composting zones served by two variable speed fans, a supply fan (WW1-016B0101) and an exhaust fan (WW1-016B0201). A future Phase 2 project will add four identical composting zones adjacent to those constructed as part of the Phase 1 project. An additional eight but separate zones will also be constructed as part of the Phase 2 project that will be served by a separate supply fan. The Phase 2 project will result in 16 composting zones total. These zones will be divided into eight Primary Composting zones and eight Secondary Composting zones. Primary and secondary composting is defined below.

The system controls airflow to individual composting zones to maintain temperatures needed to achieve regulatory requirements for Class A biosolids as prescribed in Title 40 Code of Federal Regulations (CFR) Part 503 and in Chapter 340 Division 50 of the Oregon Administrative Rules (OAR). This is done through a series of temperature sensors placed into the composting piles, electrically actuated air dampers and variable speed supply and exhaust fans.

The composting system is divided into two zones. The first zone (Primary Composting) is used to meet the regulatory requirements for a “process to further reduce pathogens” (PFRP) and for vector attraction reduction (VAR). Time and temperature requirements for PFRP and VAR are as follows:

- PFRP: Compost must be held for 3 consecutive days at 55°C or higher.
- VAR: Compost must be held for 14 days at 40ºC or higher at all times with an average temperature above 45ºC. This treatment period may start at the same time as the PRFP treatment period. However, if the PRFP requirement fails, the time needed to meet the VAR requirement must also start over.

During normal operation, compost remains in the Primary Composting zone for 22 days. When monitoring compost temperature for compliance with PFRP requirements, if the temperature drops below 55ºC as measured by any of the temperature sensors, the 3-day PFRP period starts over once all sensors are back above 55ºC.

After meeting regulatory requirements for PFRP and VAR in the Primary Composting zones, compost is moved to the Secondary Composting zones where it typically stays for an additional 22 days. During this period, the temperature of the compost is maintained at an operator-determined set point to optimize the final compost product.

The Phase 1 composting system is comprised of four zones. Each zone has in-ground aeration diffuser trenches connected to two common aeration headers, one for air supply and one for exhaust air. Each zone can operate as either a Primary Composting zone or a Secondary Composting zone. Normal operation will be for two zones to be designated as Primary Composting zones and two designated as Secondary Composting zones. PRFP and VAR requirements are completed in the Primary Composting zones with the Secondary Composting zones being used to optimize the final compost product.

As described in additional detail below, the Primary Composting zones are capable of alternating aeration which means that they can operate under either positive or negative aeration. When in Secondary Composting zones, positive aeration only is used.

During normal operation, the control system varies fan speed to maintain pressure setpoints in the air ducting system. Air flow to the composting zones is controlled automatically with air dampers to maintain temperature set points in the compost pile. Each compost pile is monitored by three temperature probes which are inserted into the compost pile. Each probe has two sensors; the first sensor is located near the top of the pile with the second sensor being placed closer to the bottom of the pile. Probes can be placed at any location along the top of the pile. Two of the three temperature probes are used for system control. The third probe is used only for monitoring.

Compost pile moisture content is maintained via the irrigation system. The frequency and duration of watering events per day is programmed into the control system.

B. Aeration Modes:

The composting zones have two aeration modes:

POS: Positive Aeration. In positive aeration mode, the supply fan draws in outside air and forces it up through the bottom of the compost pile, thus providing more cooling to the bottom of the pile than to the top.
NEG: Negative Aeration. In negative aeration mode, the exhaust fan pulls air down through the top of the pile and out through the foul air (FA) air header to the biofilter. This provides more cooling to the top of the pile than to the bottom. Negative aeration helps minimize odors by sending the exhaust air through the biofilter.

The change between modes is accomplished by opening or closing motor-actuated air dampers. Each zone is equipped with two dampers: one on the supply and one on the exhaust header. Damper pairs are interlocked, so that as one damper in a pair opens the other closes.

Because odors are more likely to occur in newly constructed compost piles, Primary Composting zones typically operate in negative aeration mode for an initial period after a pile has been constructed. Negative aeration draws air down through the pile and exhausts it through the biofilter thus helping to mitigate potential odor from the newly constructed pile. After an adjustable time setpoint, the Primary Composting zone begins to alternate between negative and positive aeration modes to help maintain uniform temperatures within the pile. Secondary Composting only operates under positive aeration.

C. Temperature Control and Fan Speed:

Air flow to each zone is controlled by opening and closing the air dampers. The air dampers operate either full open or full closed. The time in each position is automatically adjusted to maintain the temperature within the compost piles at adjustable set points. Increasing the amount of time the dampers are in their open position cools the compost while decreasing the amount of time the dampers are open causes the temperature to rise.

Opening and closing the air dampers causes the pressure within the air headers to vary. The control system responds to these changes by increasing or decreasing fan speed to maintain the air header pressure setpoints.

The following table defines the typical operating ranges for the compost process:

Compost System Control Set Points

	Temp. Range/ Inversion Temp.[a]	Duration[b]	Pressure[c]
Primary Composting	57-65°C / 2-5°C	3-5 days	TBD
	40-50°C / 5-8°C	11-18 days	TBD
Secondary Composting	Secondary Compost - Operator Preferred Set Point and Treatment Duration		TBD

Notes:

(a) Temperature Range/Inversion Temp: The inversion temperature is the difference between the average top and bottom pile temperatures. The temperature range will be entered as low and high user-defined values. Compost temperatures will be controlled between the high and low temperatures by switching between aeration modes.

(b) Duration: The minimum amount of time that the fans will follow a user-defined control mode for one regime before switching to the next.

(c) Pressure: Adjustable pressure set point used to control fan speed.

D. Operator Controls:

Location	Control Item	Type
SCADA/HMI	Control Regime	Selector switch
	Start-Stop	Push button
	Compost Supply and Exhaust Fan	
	Pressure Setpoints	Digital input
	Exhaust Air Temp Setpoint	Digital input
	Air Dampers	
	Minimum open time	Digital input
	Temperature Set Points	Digital input
	Irrigation Valves	
	Time Set Points	Digital input
MCC	Compost Supply and Exhaust Fan	
	Local-Off-Remote	Selector switch
	Reset	Push button

E. Hand Mode:

1. Fans: Place the Hand-Off-Auto selector switch at the MCC in the Hand position. The fans will run continuously until the Hand-Off-Auto selector switch is placed in the Off position. Fan speed can be manually adjusted via the VFD keypad.

F. Auto Mode:

1. Fans: Place the Hand-Off-Auto selector switch at the MCC in the Auto position. When the compost pile has been prepared and is ready to begin the composting process, select the Control Regime and depress the Start push button at the SCADA/HMI.

Damper position (open/closed) and thus air flow through the compost piles is automatically controlled to maintain temperature within the user-defined range. Fan speed is automatically controlled to maintain adjustable pressure set points in the positive and negative air headers. Irrigation solenoid valves will open/close based on adjustable time settings to maintain proper moisture within the compost piles.

During normal Primary Composting operation, aeration mode switches between NEG and POS based on the temperature differential between the top and bottom of the compost pile. When the temperature differential exceeds an adjustable set point, air damper position changes to switch aeration mode (e.g., NEG to POS or POS to NED). Secondary Composting operates in POS mode only.

G. Status Indications:

Operational status is displayed as follows:

Location	Status	Visual Indication
SCADA/HMI	Compost Temperature	Numeric value
	PFRP/VAR Progress	Numeric value
	Biofilter Temperature	Numeric value
	Compost Supply and Exhaust Fan	
	Hand-Off-Auto	Switch position
	Running	Red indicating color
	Off	Green indicating color
	Speed	Numeric value
	Pressure	Numeric value
	Exhaust Air Temperature	Numeric value
	Air Damper	
	Open	Red indicating color
	Closed	Green indicating color
MCC	Compost Supply and Exhaust Fan Running	Red lamp

H. Alarm Indications:

Alarm conditions are displayed as follows:

Location	Status	Visual Indication
SCADA/HMI	VFD Failure	Yellow indicating color
	Fan Failure	Yellow indicating color
	Air Damper Fault	Yellow indicating color
	Temperature High/Low	Yellow indicating color
	Temperature Probe Fault	Yellow indicating color
MCC	Compost Supply and Exhaust Fan Fail	Yellow lamp

END OF CONTROL STRATEGY

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SECTION 17510

CONTROL PANELS

PART 1 - GENERAL

1.01 RELATED WORK SPECIFIED ELSEWHERE

A. Section 16955: Control Devices

B. Section 17330: Programmable Logic Controller

1.02 DESCRIPTION

A. Provisions: Requirements of Division 1 and Section 17010 form a part of this Section.

B. Work Included: 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) 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. UL LLC (UL) Publication:
   1. 508 Industrial Control Equipment

1.04 SUBMITTALS

A. Shop drawings to be submitted in this Section shall be made in one package in accordance with Section 01300.

B. Shop Drawings: Submit shop drawings for all control panels, including details for the following items:
   1. Electric power wiring schematics.
   2. Electric signal wiring schematics.
   3. Elementary control diagram.
   4. Air supply piping schematics.
   5. Pneumatic signal tubing schematics.
   6. Fabrication drawings, including a dimensioned outline drawing to scale, showing space for conduits, etc.
   7. Details of seismic restraints per Section 01190.
   8. Details of all panel accessories.
   9. A detailed Bill of Materials.
   10. Panel layouts and nameplate inscriptions.
   11. Connections to external equipment.
   12. Wire marking scheme.

13. Arrange submissions in a logical manner and on the shop drawings use the device abbreviation identifications and equipment names as shown on the Drawings, in order to expedite and facilitate review by the Engineer.
14. 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. 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 control panel t shall bear the UL 508 label except as noted in the following paragraph. 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.
2. Control panel enclosures containing instruments mounted through the enclosure walls or door shall meet all requirements for UL labeling as above, but no UL label is required. This exception applies only if UL Recognized instruments for the intended purpose are not made

1.06 PRODUCT DELIVERY AND HANDLING

A. Ship assembled control panels in sections that facilitate handling and field installation.

PART 2 - PRODUCTS

2.01 CONSTRUCTION

A. General:
1. Provide panels as shown on the Drawings. Panels shall conform to the requirements of NEMA Standards ICS 1 (General Standards for Industrial Controls and Systems) and ICS 2 (Standards for Industrial Control Devices, Controllers and Assemblies). The panels shall be wall-mounted or free-standing floor mounted, as shown. Provide sufficient access to the panels.
2. The enclosures shall be code gauge steel of adequate strength, when complete, to withstand seismic forces equivalent to those specified. Enclosures shall conform to requirements of NEMA Standard ICS 6 (Enclosures for Industrial Controls and Systems).
3. The enclosures shall have vertically hinged front doors; provide hinge on side of panel which ensures compliance with the 30-inch rule in NEC paragraph 110-16(a). Free-standing 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.

4. Construction requirements on a specific type of panel are provided in subsequent paragraphs.
5. Panels covered under this specification are:
   a. The SCADA Control Panel (NEMA 12).

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. Any live parts within the control panel fed from foreign control or signal circuits shall be covered or arranged to be disconnected by one of the following methods:
   1. Enclosed relays which are automatically de-energized when the main disconnecting switch is opened.
   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. Each control panel shall be arranged so that adjustments to timing relays or replacement of fuses can be done without exposure to live parts.

C. Piping and Wiring: Factory wire and pipe 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 heatshrink numbered sleeve. Number all electrically common wires the same, and number each electrically different wire uniquely. Provide red wire color for ac wiring, with white neutral and green ground. Provide blue wiring for dc wiring. Wiring shall be 14-gauge, Type MTW or THHN, 600 volt, stranded copper wire. 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 which 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 which can be energized when the branch circuit feeding the control panel, if any, is off. Provide terminals for all external (field) connections and provide at least 25% spare terminals. Identify each terminal permanently with the same number as the wire being terminated. Terminals shall be Allen-Bradley 1492 Series, Phoenix, Entrelec, Buchanan, or equal.

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 filled and sanded. All metal 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.
   2. Provide rigid supports for all devices. Supports shall not cause warping or bowing sides or mounting plates.

H. Mounting:
   1. Attachment methods shall be detailed on panel fabrication drawing submittals. Heavy panels shall be attached by anchor bolts embedded in beams supporting the floor. See the Structural Drawings for location of beams. 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 panels requiring high 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 LED 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.

2.02 PANEL HARDWARE

A. All doors shall be set flush with three-point vault-type key-locking latches in addition to any required screw clamps. A minimum of two sets of keys supplied. Doors shall be labeled with "AUTHORIZED PERSONNEL ONLY" in 1-inch letters.

B. Hinges shall be piano type. All hardware and handles shall be stainless steel.

C. Leveling adjustments on each panel section shall be provided on free-standing panels.

D. Status lights, selector switches, and pushbuttons shall be as specified in Section 16955.

E. Provide a copy of the elementary control diagram for the control panel, enclosed in plastic and mounted inside the panel.

F. Control panels and electronic racks shall be supplied with door-operated switches (for control circuit interlocking) and accessories as required by Section 16955.

G. Where 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.

H. Floor stand kits shall not exceed 24 inches in height nor cause the panel to exceed 84 inches in overall height.

2.03 CONTROL PANEL ENCLOSURES

A. General:
   1. Control panels of steel 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 free-standing 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 metal 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.

D. Manufacturers of the control panels and terminal cabinets enclosure shall be Hoffman Engineering Company, Tesco, Circle A-W Products Company, Gibbons Metal Products, or 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, free-standing control panel. Provide a 3-1/2-inch-high I-beam kick panel for each control-room mounted, free-standing 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.

END OF SECTION

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