CITY OF SANTA CRUZ
SANTA CRUZ, CALIFORNIA

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

CLIENT PROJECT NO. CWO# 2024-005

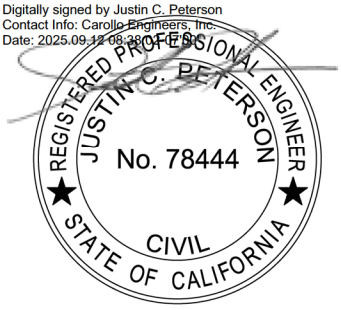
TECHNICAL SPECIFICATIONS

BID SET SUBMITTAL

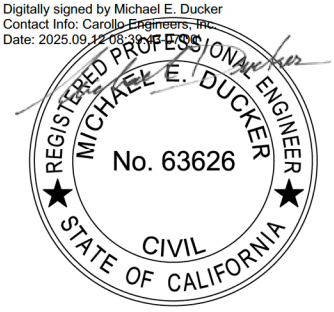
VOLUME 2 OF 3

SEPTEMBER 2025

Digitally signed by Justin C. Peterson
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 08:38:07 PDT



Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 08:39:03 PDT



2795 MITCHELL DRIVE ▪ WALNUT CREEK, CALIFORNIA 94598 ▪ P 925-932-1710

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

TABLE OF CONTENTS

VOLUME 2 OF 3

DIVISION 01 - GENERAL REQUIREMENTS

SECTION NO.	TITLE
01_35_73	DELEGATED DESIGN PROCEDURES
01_45_24	REGULATORY QUALITY ASSURANCE
01_75_19	WATER LEAKAGE TEST FOR CONCRETE STRUCTURES

DIVISION 03 - CONCRETE

SECTION NO.	TITLE
03_01_04	STRUCTURAL CONCRETE REPAIR
03_15_00	CONCRETE ACCESSORIES
03_21_17	ADHESIVE-BONDED REINFORCING BARS AND ALL THREAD RODS IN CONCRETE
03_30_01	CONCRETE WORK
03_35_29	CONCRETE FINISHES
03_48_53	PRECAST CONCRETE UTILITY STRUCTURES AND PRODUCTS
03_60_00	GROUTING
03_63_01	EPOXIES

DIVISION 05 - METALS

SECTION NO.	TITLE
05_05_24	MECHANICAL ANCHORING AND FASTENING TO CONCRETE AND MASONRY
05_50_00	METAL FABRICATIONS

DIVISION 07 - THERMAL AND MOISTURE PROTECTION

SECTION NO.	TITLE
07_11_00	DAMPPROOFING
07_92_00	JOINT SEALANTS

DIVISION 08 - OPENINGS

SECTION NO.	TITLE
08_31_14	FLOOR ACCESS DOORS (NOT USED)

DIVISION 09 - FINISHES

SECTION NO.	TITLE
09_96_01	HIGH-PERFORMANCE COATINGS

DIVISION 26 - ELECTRICAL

SECTION NO.	TITLE
26_05_00	COMMON WORK RESULTS FOR ELECTRICAL
26_05_09	LOW VOLTAGE MOTORS UP TO 500 HORSEPOWER
26_05_18	600-VOLT OR LESS WIRES AND CABLES
26_05_21	LOW VOLTAGE WIRE CONNECTIONS
26_05_26	GROUNDING AND BONDING
26_05_29	HANGERS AND SUPPORTS
26_05_33	CONDUITS
26_05_34	BOXES
26_05_44	DUCT BANKS
26_05_53	IDENTIFICATION FOR ELECTRICAL SYSTEMS
26_05_74	ELECTRICAL SYSTEM STUDIES
26_08_50	FIELD ELECTRICAL ACCEPTANCE TESTS
26_09_13	ELECTRICAL POWER MONITORING
26_22_14	DRY-TYPE TRANSFORMERS
26_24_16	PANELBOARDS
26_24_20	LOW VOLTAGE MOTOR CONTROL CENTERS
26_28_01	LOW VOLTAGE MOLDED CASE CIRCUIT BREAKERS
26_28_17	DISCONNECT SWITCHES
26_29_05	MOTOR STARTERS
26_29_24	VARIABLE FREQUENCY DRIVES 0.50 - 50 HORSEPOWER
26_43_14	SURGE PROTECTIVE DEVICES

DIVISION 31 - EARTHWORK

SECTION NO.	TITLE
31_00_00	EARTHWORK
31_05_15	SOILS AND AGGREGATES FOR EARTHWORK
31_23_22	DEWATERING
31_23_24	CONTROLLED LOW STRENGTH MATERIAL (CLSM)
31_23_35	TRENCHING
31_32_18.04	STABILIZATION FABRIC
31_50_00	EXCAVATION SUPPORT AND PROTECTION

DIVISION 32 - EXTERIOR IMPROVEMENTS

SECTION NO.	TITLE
32_01_15	PAVEMENT RESTORATION AND REHABILITATION

DIVISION 33 - UTILITIES

SECTION NO.	TITLE
33_05_01	SUBSURFACE UTILITY ENGINEERING
33_05_61.01	CONCRETE MANHOLES
33_71_21	PRECAST ELECTRICAL HANDHOLES AND ELECTRICAL MANHOLES

DIVISION 40 - PROCESS INTEGRATION

SECTION NO.	TITLE
40_05_00.01	COMMON WORK RESULTS FOR GENERAL PIPING
40_05_00.03	PIPE IDENTIFICATION
40_05_00.09	PIPING SYSTEMS TESTING
40_05_06.01	PIPING SPECIALTIES
40_05_06.03	PIPE COUPLINGS
40_05_06.10	STRAINERS
40_05_06.55	PIPING INSULATION
40_05_07.01	PIPE SUPPORTS
40_05_07.03	PREFORMED CHANNEL PIPE SUPPORT SYSTEM
40_05_17.05	COPPER WATER TUBE: SEAMLESS, ASTM B88
40_05_19.01	DUCTILE IRON PIPE: AWWA C151
40_05_23.01	STAINLESS STEEL PIPE AND TUBING
40_05_24.01	STEEL PIPE: EXPOSED
40_05_31.01	PLASTIC PIPING AND TUBING
40_05_31.14	POLYVINYL CHLORIDE (PVC) PIPE: PRESSURE
40_05_51.01	COMMON WORK RESULTS FOR VALVES
40_05_52	SPECIALTY VALVES
40_05_57.24	ELECTRIC ACTUATORS
40_05_63	BALL VALVES
40_05_64	BUTTERFLY VALVES
40_05_65.01	GATE, GLOBE, AND ANGLE VALVES
40_05_65.24	CHECK VALVES
40_05_65.26	RUBBER “DUCK BILL” CHECK VALVE
40_05_67.37	PRESSURE CONTROL VALVES
40_05_67.40	AIR AND VACUUM RELIEF VALVES
40_61_00	COMMON WORK RESULTS FOR PROCESS CONTROL AND INSTRUMENTATION SYSTEMS
40_61_15	CONTROL STRATEGIES
40_61_16.08	SPECIFIC CONTROL STRATEGIES – BELTZ 8
40_64_01	CONTROL SYSTEMS: PROGRAMMABLE LOGIC CONTROLLERS
40_64_21	CONTROL SYSTEMS: LOCAL OPERATOR INTERFACE (LOI)
40_66_01	CONTROL SYSTEMS: NETWORK MATERIALS AND EQUIPMENT
40_66_70	CONTROL SYSTEMS: WIRELESS COMMUNICATIONS - RADIO
40_67_01	CONTROL SYSTEMS: PANELS, ENCLOSURES, AND PANEL COMPONENTS
40_67_26	CONTROL SYSTEMS: UNINTERRUPTIBLE POWER SUPPLIES 10 KVA AND BELOW
40_71_15	FLOW MEASUREMENT: MAGNETIC FLOWMETERS
40_71_43	FLOW MEASUREMENT: ROTAMETERS (VARIABLE AREA FLOWMETERS)
40_72_76	LEVEL MEASUREMENT: SWITCHES (NOT USED)
40_73_13	PRESSURE/VACUUM MEASUREMENT: GAUGES

40_73_23	PRESSURE/VACUUM MEASUREMENT: DIRECT
40_73_29	PRESSURE/VACUUM MEASUREMENT: DIFFERENTIAL
40_73_36	PRESSURE/VACUUM MEASUREMENT: SWITCHES
40_73_46	WEIGHT MEASUREMENT: PLATFORM SCALE AND LOAD CELLS (NOT USED)
40_73_63	PRESSURE/VACUUM MEASUREMENT: DIAPHRAGM SEALS
40_73_64	PRESSURE/VACUUM MEASUREMENT: INSTRUMENT VALVES
40_73_65	PRESSURE MEASUREMENT: SUBMERSIBLE
40_80_01	COMMISSIONING FOR INSTRUMENTATION AND CONTROLS

DIVISION 43 - PROCESS GAS AND LIQUID HANDLING, PURIFICATION, AND STORAGE EQUIPMENT

SECTION NO.	TITLE
43_25_13.31	SUBMERSIBLE CENTRIFUGAL PUMPS FOR WASTE DRAIN PUMP STATION (NOT USED)
43_25_20.02	SUBMERSIBLE WELL PUMPS
43_33_20.01	LIQUID CHEMICAL DIAPHRAGM-TYPE METERING PUMPS (NOT USED)

DIVISION 46 - WATER AND WASTEWATER EQUIPMENT

SECTION NO.	TITLE
46_05_10	COMMON WORK RESULTS FOR MECHANICAL EQUIPMENT
46_05_94	MECHANICAL EQUIPMENT TESTING

PLEASE NOTE: Gray highlighted sections marked (NOT USED) are not included in the project.

SECTION 01_35_73

DELEGATED DESIGN PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Delegated Design procedures.

1.02 GENERAL

A. Delegated Design - Professional design services assigned to the Contractor by express delegation in the Contract Documents. Work is “Delegated Design” where the technical sections require the Contractor to provide professional design services and to submit signed and sealed documents from a registered Professional Engineer.

B. Contractor’s Professional Engineer - The design professional retained by the Contractor to perform Delegated Design.

C. Owner may require Contractor to provide professional design services for a portion of the Work by express delegation in the Contract Documents.
   1. Requirements of Delegated Design component as specified in the Technical Section and as indicated on the Drawings.
   2. Such delegation will specify the performance and design criteria that such services must satisfy, and the Submittals that the Contractor must furnish to the Engineer with respect to the Delegated Design.

D. Contractor shall cause such Delegated Design services to be provided pursuant to the professional standard of care by a properly licensed design professional, whose signature and seal shall appear on Drawings, calculations, Specifications, certifications, and Submittals prepared by such design professional.
   1. Contractor shall not be responsible for the adequacy of performance or design criteria specified by the Owner or Engineer.
   2. Contractor is not required to provide professional services in violation of applicable Laws and Regulations.
   3. Such design professional shall issue certifications of design required by Laws and Regulations.
   4. If a Shop Drawing or other Submittal related to the Owner-delegated design is prepared by the Contractor, a Subcontractor, or others for submittal to the Engineer, then such Shop Drawing or other Submittal shall bear the written approval of Contractor’s design professional when submitted by the Contractor to the Engineer.

E. Owner and Engineer shall be entitled to rely upon the adequacy, accuracy, and completeness of the services, certifications, and approvals performed or provided by the design professionals retained or employed by Contractor under Delegated

Design, subject to the professional standard of care and the performance and design criteria stated in the Contract Documents.

F. Engineer's review, approval, and other determinations regarding design drawings, calculations, Specifications, certifications, and other Submittals furnished by Contractor pursuant to a Delegated Design will be only for the following limited purposes:
   1. Confirming that Submittal is in conformance with the performance and design criteria specified in the Contract Documents.

1.03 CONTRACTOR'S PROFESSIONAL ENGINEER

A. Contractor or Subcontractor shall retain a licensed Professional Engineer to perform Delegated Design.

B. Qualifications:
   1. Holding a current license to perform the specified design in the same jurisdiction as the Project Site.
   2. Experienced in designing similar systems of similar complexity.

C. Insurance:
   1. Provide Contractor's Professional Engineer's Professional Liability Insurance as specified in Section 00 73 01 - Supplementary Conditions.

D. Responsibilities:
   1. Review and design in accordance with system performance and design criteria stated in the Contract Documents.
      a. Prepare written requests for clarifications or interpretations of performance or design criteria for submittal to the Engineer by the Contractor.
   2. Sign and seal design reports, calculations, design drawings and specifications, and other design Submittals for the Delegated Design Work.
   3. Review and submit written approval of Submittals related to the Delegated Design Work.
   4. Design modifications to the Delegated Design Work as required.
   5. Visit the Site, as required, to verify that installation of the Delegated Design Work is in conformance with the Delegated Design Drawings and Specifications.
   6. Submit through Contractor to Engineer written, signed, and sealed certification that the installed Delegated Design Work complies with Contractor's Professional Engineer's design.

1.04 SUBMITTALS

A. Prior to the start of Delegated Design:
   1. Contractor's Professional Engineer's qualifications:
      a. Experience for the Delegated Design.
      b. Evidence of Professional Engineering license.
   2. Contractor's Professional Engineer Professional Liability Insurance certificate.

B. Delegated Design:
    1. Product data:
        a. Details related to the Delegated Design as specified in technical sections to completely describe the system.
    2. Design documents with signature and seal from the Contractor's Professional Engineer:
        a. Design documents include, but are not limited to, Drawings, calculations, Specifications, inspection reports, and certifications.
    3. Lists and schedules:
        a. Prepare and submit lists or schedules of items where Delegated Design is required by the Contract Documents.
        b. Group items by location in the Work:
            1) When "Area Numbers" are indicated on the Contract Drawings, group lists in accordance with those "areas."
            2) For work without area numbers, group using logical divisions acceptable to the Engineer.
            3) Group items within each "area" as follows:
                a) Systems.
                b) Components.
                c) Supports.
                d) Anchorage.
                e) Bracing.

C. Construction services:
    1. Contractor's Professional Engineer's comments on Submittals.
    2. Other construction documents, as required.

1.05 ENGINEER RESPONSE TO DELEGATED DESIGN SUBMITTALS

A. Engineer response will be either of the following:
    1. Approved. Make Corrections Noted - See Comments:
        a. Contractor may proceed with the Work; however, all notations and comments must be incorporated into the final product.
        b. Review was for the limited purpose of determining that the document was stamped by a Professional Engineer and that such design is generally consistent with and will not negatively affect the design concept presented in the Contract Documents.
    2. Rejected - See Remarks:
        a. Contractor may not proceed with the Work described in the Submittal.
        b. Submittal does not meet the intent of the Contract Documents.
        c. Resubmittal of complete Submittal package is required with materials, equipment, methods, etc., that meet the requirements of the Contract Documents.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01_45_24

REGULATORY QUALITY ASSURANCE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Project regulatory requirements for quality assurance that includes Special Inspections, Special Certification, and Structural Observation.

B. Special Certification and Special Inspections in this Section are in addition to the requirements specified in Section 01 43 05 - Quality Assurance and Quality Control Requirements, and in the individual Sections.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 318 - Building Code Requirements for Structural Concrete.
   2. 530 - Building Code Requirements for Masonry Structures.
   3. 530.1 - Specification for Masonry Structures.

B. American Institute of Steel Construction (AISC):
   1. 360 - Specification for Structural Steel Buildings.

C. American Society of Civil Engineers (ASCE):
   1. 7 - Minimum Design Loads for Buildings and Other Structures.

D. American Welding Society (AWS):
   1. D1.3 - Structural Welding Code - Sheet Steel.
   2. D1.4 - Structural Welding Code - Reinforcing Steel.

E. ASTM International (ASTM):
   1. A706 - Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement.
   2. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   3. C172 - Standard Practice for Sampling Freshly Mixed Concrete.
   4. C1611 - Standard Test Method for Slump Flow of Self-Consolidating Concrete.

F. Building Code:
   1. As specified in Section 01 42 00 - References.

G. The Masonry Society (TMS):
   1. 402 - Building Code for Masonry Structures.
   2. 602 - Specifications for Masonry Structures.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning:
   1. Special Certification: Certification for designated seismic systems that demonstrates compliance with performance requirements.
   2. Special Inspection: Inspection of the materials, installation, fabrication, erection, or placement of components and connections requiring special expertise to ensure compliance with approved construction documents and referenced standards.
   3. Special Inspection, Continuous: The full-time observation of work requiring Special Inspection by an approved special inspector who is present in the area where the work is being performed.
   4. Special Inspection, Periodic: The part-time, or intermittent observation of work requiring Special Inspection by an approved special inspector who is present in the area where the work is being performed and at the completion of the work.
   5. Structural Observation: The visual observation of the structural system by a registered design professional for general conformance to the approved construction documents at significant construction stages and at completion of the structural system.

1.04 SUBMITTALS

A. Submit Special Certifications for designated seismic systems.

B. Schedule and coordinate the submittal of Special Inspection reports and test results prepared by others.

1.05 SPECIAL INSPECTION

A. Owner will employ one or more special inspectors who will provide Special Inspections during construction.

B. Special inspector(s) shall be qualified for inspection of the particular type of materials or operations requiring Special Inspection.

C. Testing laboratory: Testing that is required to satisfy the requirements of Special Inspection will be performed by the Owner's testing laboratory as specified in Section 01 43 05 - Quality Assurance and Quality Control Requirements.

D. Duties of special inspector:
   1. General: Required duties of the special inspector(s) shall be as described in the Building Code.
   2. Reporting: Special inspector(s) shall provide reports of each inspection to the Owner and shall distribute copies of inspection reports to the Engineer and Contractor as required:
      a. Reports shall, at a minimum, include the following items:
         1) Date and time of inspection, and name(s) of individual(s) performing the inspection.
         2) Structures and areas of the structure where work or testing was observed.

3) Discrepancies between the requirements of the Contract Documents and the work or testing observed.
4) Other areas of deficiency in the Work.

E. Special Inspections shall not be construed as fulfilling the requirements for Structural Observation (Structural Observation to be performed by Engineer).

F. Owner or special inspector are responsible to select materials for Special Inspection.
1. Contractor shall not select materials for Special Inspection.

1.06 SPECIAL CERTIFICATION

A. Provide equipment that meets the special certification requirements of the Building Code.

B. Designated seismic systems shall be subject to the testing and qualification requirements of the regulatory Building Code, and shall require Special Certification as set forth in ASCE 7:
1. Mechanical equipment that is assigned an importance factor of 1.50 as specified and as indicated on the Drawings.
2. All electrical equipment.

C. Special certification requirements for designated seismic systems:
1. Submittals shall include certification that the equipment is seismically qualified. Certifications are subject to review and acceptance by Owner.
2. Certifications may be at least one of the following in accordance with ASCE 7:
a. Analysis.
b. Testing.
c. Experience data.

1.07 STRUCTURAL OBSERVATION

A. Engineer will provide Structural Observation during construction:
1. Registered design professional will be a civil or structural engineer currently licensed as such in the state where the project is located and regularly engaged in structural design equivalent to or similar to that indicated on the Drawings.

B. Structural Observations shall not be construed as fulfilling the requirements for Special Inspections.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 SPECIAL INSPECTIONS

A. Construction Manager will provide Special Inspection of the following types of work as described in the Building Code wherever such work occurs, unless otherwise specified:
   1. Attachment A - Concrete - Special Inspection Schedule.
   2. Attachment B - Architectural, Mechanical, and Electrical Components - Special Inspection Schedule.

3.02 SPECIAL CERTIFICATION

A. Special inspector shall examine the designated seismic system(s) and determine whether the designated system components, including anchorage, are consistent with the evidence of compliance submitted for Special Certification.

3.03 STRUCTURAL OBSERVATION

A. The following work requires Structural Observation in accordance with the Building Code:
   1. All structures in all areas:
      a. Foundations.

3.04 SCHEDULE

A. Allow time necessary for Special Inspections and Structural Observation specified in this Section.

B. Minimum 10 working days' notice shall be given so that the Special Inspections and Structural Observations can be performed. Allow time for individuals performing to travel to the site.

3.05 PROCEDURE

A. Special inspector will immediately notify the Engineer of any corrections required and follow notification with appropriate documentation.

B. Contractor shall not proceed until the work is satisfactory to the Engineer.

END OF SECTION

ATTACHMENT A - CONCRETE - SPECIAL INSPECTION SCHEDULE

CONCRETE - SPECIAL INSPECTION SCHEDULE
(Includes: Cast-in-place, precast, prestressed, precast-prestressed, and shotcrete.)

Verification and Inspection	Reference Standard	Frequency of Inspection(1) (During Task Listed)	
		Continuous	Periodic
1. Reinforcing bar welding:			
a. Verify weldability of reinforcing bars other than ASTM A706;	AWS D1.4 ACI 318		●
b. Inspect single-pass fillet welds, maximum 5/16 inch; and	AWS D1.4 ACI 318		●
c. Inspect all other welds.	AWS D1.4 ACI 318	●	
2. Inspect anchors cast in concrete.	ACI 318		●
3. Inspect anchors post-installed in hardened concrete members:			
a. Adhesive anchors installed in horizontally or upwardly inclined orientations to resist sustained tension loads.	ACI 318	●	
b. Mechanical anchors and adhesive anchors not defined in 4.a.	ACI 318		●
4. Verify use of required design mix.	ACI 318 Building Code		●
5. Prior to concrete placement, fabricate specimens for strength tests, perform slump and air content tests, and determine the temperature of the concrete.	ASTM C172 ASTM C31 ACI 318 Building Code	●	
6. Inspect concrete and shotcrete placement for proper application techniques.	ACI 318 Building Code	●	
7. Verify maintenance of specified curing temperature and techniques.	ACI 318 Building Code		●
8. Inspect formwork for shape, location and dimensions of the concrete member being formed.	ACI 318		●

Notes:

(1) "●" represents a required inspection activity for the project where it occurs.

ATTACHMENT B - ARCHITECTURAL, MECHANICAL, AND ELECTRICAL COMPONENTS - SPECIAL INSPECTION SCHEDULE

ARCHITECTURAL, MECHANICAL, AND ELECTRICAL COMPONENTS - SPECIAL INSPECTION SCHEDULE

Verification and Inspection	Reference Standard	Frequency of Inspection(1) (During Task Listed)	
		Continuous	Periodic
1. Plumbing, mechanical, and electrical components:			
a. Anchorage of electrical equipment for emergency and standby power systems.	Building Code		●
b. Anchorage of other electrical and mechanical equipment over 400 lb. on floors or roofs.	Building Code		●
c. Installation and anchorage of pipelines carrying hazardous chemicals and their associated mechanical units.	Building Code		●
d. Installation and anchorage of pipelines greater than 6 inches in diameter.			●
e. Installation and anchorage of ductwork designed to carry hazardous materials.	Building Code		●
f. Installation and anchorage of ductwork greater than 6 sf in cross section.			●
g. Installation and anchorage of vibration isolation systems where Contract Documents require nominal clearance of 1/4 inch or less between the equipment support frame and its support/restraint.	Building Code		●
h. Installation of mechanical and electrical equipment, including duct work, piping systems and their structural supports, where automatic fire sprinkler systems are installed.	Building Code		●

Notes:

(1) "●" represents a required inspection activity for the project where it occurs.

SECTION 01_75_19

WATER LEAKAGE TEST FOR CONCRETE STRUCTURES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Hydrostatic leakage test for concrete water-holding structures.

1.02 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning:
   1. Containment structure lined: Liquid-containing structure with barrier coating or membrane applied to the inside surfaces to prevent leaking of contents to the outside.
   2. Containment structure, unlined: Liquid containing structure where only the concrete structure itself is used to prevent leaking of contents to the outside.
   3. Damp spots: Surfaces where visible moisture can be picked up by a dry hand.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination.

B. Pre-installation meetings.

C. Sequencing.

D. Scheduling.

1.04 SUBMITTALS

A. Product data.

B. Shop Drawings:
   1. Description and details of each evaporation/precipitation-measuring device anticipated for use during the test.

C. Samples.

D. Certificates.

E. Delegated Design Submittals.

F. Tests and evaluation reports:
   1. Results of water leakage test for each structure and for each portion of a structure designated for testing.

G. Manufacturer instructions.

H. Source quality control Submittals.

I. Field/site quality control Submittals.

J. Manufacturer reports.

K. Sustainable design Submittals.

L. Special procedure Submittals:
   1. Testing plan for each structure, or portion thereof, required to be tested.
      a. Describe methods of obtaining water for testing and of releasing water for disposal, including provisions for dechlorination if required.
      b. Include plans showing locations where measurements will be made and locations of evaporation/precipitation-measuring device.
      c. Indicate plans for filling and draining structure(s).
      d. Include schedule showing duration of test for each structure or cell to be tested, date and time for start of each test, dates and times of observations and measurements during the test, dates and times for closeout of testing procedures, and date for submittal of final results.
   2. Proposed procedures and products for repair of leaks.

M. Qualifications statements.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Test structures and portions of structures listed in the following paragraphs for water leakage.
   1. Unless otherwise specified:
      a. Obtain required permits for discharging testing water.
      b. Provide dechlorination of such water if required by the permits.
      c. Prepare and fill the structures.
      d. Provide access and equipment required for testing and for recording test results.
      e. Take measurements and make observations required for testing.
   2. At all times during testing, the Engineer shall have access to observe measurements by others or to make independent measurements.

B. Test the following concrete structures for water leakage:
   1. Storm Drain Air Gap Structure.

C. Required preparation for testing is designated in this Section. Waiver of, or failure to complete preparations shall not change the testing criteria or approval criteria for the areas tested.

D. Retest structures and portions of structures until the evaluation criteria are satisfied.

3.02 TEST WATER SOURCE AND DISPOSAL

A. Water used for the first filling of the structures(s) will be furnished by the Owner.
   1. Obtain water for leakage testing from fire hydrant near the intersection of Roland Drive and 38th Avenue, as shown on Drawing 08C02.
   2. Contractor prepare and submit the City of Santa Cruz Water Department Hydrant Meter Checkout/Permit application and comply with all requirements of the permit.

B. In the event that retesting is required, Contractor shall bear the cost of refilling the structure for subsequent tests.

C. After leakage testing is complete, Contractor shall dispose of water by discharge to storm drain. If Contractor intends to dispose of testing water to the sanitary sewer, Contractor shall obtain a disposal permit with Santa Cruz County and coordination with City staff to determine any additional discharge restrictions to avoid interference with Beltz 8 site operations.

3.03 PREPARATION

A. For each structure to be tested, prepare and submit a plan showing schedule and sequence of activities, method of filling, and methods of disposing of test water.

B. Sequencing requirements:
   1. Complete construction of concrete structure and cure concrete to obtain minimum specified 28-day compressive strength as specified in Section 03_30_01 - Concrete Work:
      a. Do not begin tests until all portions of structure are complete and have reached their minimum specified 28-day compressive strength.
      b. Do not begin tests until at least 14 days have passed since completion of the last concrete placement.
   2. Complete tests before:
      a. Covering any surface of the structure with materials that might mask the location of leaks or obscure damp concrete surfaces. Such coverings include, but are not limited to, basin bottom grout, masonry veneer, stucco, plaster, and other coatings.
      b. Installation of equipment, unless otherwise approved by the Engineer.
      c. Backfilling structures to elevations above the limits indicated in the following paragraphs.
   3. Liners and coatings:
      a. Install liners that are mechanically locked to the concrete surface during placement of plastic concrete and before leakage testing:
         1) Examine liners for pinholes, tears, and partially fused splices, complete required liner integrity testing, and make required repairs before commencing leakage testing.
      b. Unless otherwise specified, do not install surface-applied protective or decorative coatings and linings until leakage tests have been completed.

C. Weather requirements:
   1. Tests on structures with tops open to the atmosphere shall not be scheduled for periods when the 10-day weather forecast indicates a substantial change in weather patterns.
   2. Measurements of water surface levels in the structure shall not be scheduled for periods when the weather forecast indicates a difference of more than 35 degrees Fahrenheit between the ambient temperature readings at the times of initial and final measurements.
   3. Tests shall not be scheduled for periods when the 10-day weather forecast indicates that the water surface may freeze before the test is complete.

D. Groundwater requirements:
   1. Bring groundwater to a level not higher than 3 feet below the bottom of the structure and maintain at that level for the duration of the test.

E. Clean interior of structure:
   1. Remove dirt, contaminants, and construction debris.
   2. Flush floors and sumps to provide clean surfaces.
   3. Remove standing water that would interfere with examination of surfaces, cracks, or joints.

F. Observe the structure, or portions of the structure being tested, for potential leak locations:
   1. Give particular attention to cracks, open joints, voids, and honeycombed and repaired surfaces.
   2. Visually observe openings, fitting, and pipe penetrations in the structure at both faces, if possible.
   3. Repair potential leak locations in accordance with these Specifications and as approved by the Engineer.
   4. Backfill excavations to the top of the structure foundation. Do not place backfill against water-bearing walls or over footings unless approved in advance by the Engineer.
      a. If requesting backfilling of walls before testing, include a description of methods that will be used to detect leakage in the backfilled areas.
      b. Engineer’s approval of backfilling before testing shall not relieve the Contractor of the responsibility to conduct leakage tests, to satisfy the leakage acceptance criteria for the structure, or to repair leaking portions of the structure, including those portions below or behind the backfill.
   5. See Drawings and Section 31_00_00 - Earthwork for requirements to provide wall stability before backfilling.

G. Inlets to/outlets from the structure:
   1. Make inlets to and outlets from the structure watertight.
      a. Include valves; stop, sluice, and slide gates; and temporary bulkheads as required.
      b. Inlets and outlets not required to be operable may be temporarily sealed before testing of the compartments to which they open.
      c. Secure inlets used to fill the structure for testing to ensure that no water is entering or leaving the structure once it has been filled to the test level.

2. Adjustments to measured leakage at inlets and outlets based on the manufacturer's or Contractor's estimates will not be allowed.
    a. May be permitted by the Engineer, and, at his/her discretion, only when the Contractor makes specific measurements of leakage at each individual inlet and outlet using methods approved by the Engineer.

3.04 HYDROSTATIC LEAKAGE TEST FOR OPEN OR COVERED CONTAINMENT STRUCTURES ("HST-100")

A. Isolate sections of water-holding structures that can be isolated in actual operation. Fill and test sections for leakage separately.
    1. Fill structures and sections of structures scheduled for testing to 24 inches below the structure rim elevation as indicated on the Drawings.

B. Initial rate for filling of structures shall not exceed 4 feet per hour.

C. HST-100 testing includes 2 parts, "Qualitative Testing," and "Quantitative Testing," as described in the following paragraphs:
    1. HST-100, Part 1 - Qualitative Testing:
        a. During the first 24 hours after structures are filled, examine exposed concrete surfaces for damp spots or flowing water:
            1) Make observations in early morning, at midday, and in late afternoon.
            2) Continue observations through the duration of the Quantitative Testing period.
            3) Pay particular attention to conditions at joints, honeycombed areas, cracks, and repaired portions of the structure.
        b. Evaluation criteria:
            1) Structure shall be considered to have failed these Qualitative Testing requirements if any of the following conditions are observed.
                a) Water droplets or moist areas on an outside surface that could only have originated inside the structure.
                b) Water is flowing or seeping from joints, cracks, or surfaces.
                    (1) Exception: Dampness or wetness on top of a footing, in the absence of flowing water, shall not be considered as failure to meet this criterion.
                c) Moisture can be transferred to a dry hand from the outside surfaces of the filled area.
        c. Repairs and retesting:
            1) Where damp spots or flowing water as described in the preceding paragraphs are observed, mark locations, provide repairs, and retest the structure as specified in subsequent paragraphs.
    2. HST-100 - Part 2: Quantitative Testing:
        a. If approved by the Engineer, Quantitative Testing may begin before repairs are made to areas failing Part 1 of this test; however:
            1) Adjustments to volume loss calculations of Quantitative Testing based on observed leakage will not be permitted.
            2) Defects identified for repair during Qualitative Testing shall be repaired to the satisfaction of the Engineer before approval of the structure.

b. Report the results of quantitative testing:
   1) Submit completed Attachment A - Leakage Test Report or at a minimum, include the information specified in Attachment A - Leakage Test Report.
c. Unlined concrete structures:
   1) Fill to the designated water surface elevation. Maintain that level for at least 72 hours before recording initial water levels for leakage test.
   2) Duration of test:
      a) Theoretical time required to lower the water surface in the structure by 3/8 inch when leakage is occurring at the maximum allowable rate specified in subsequent paragraphs of this Section.
      b) Duration ("D") of the test in days is determined by the following equation:

$$D = \frac{0.375 \text{ inches}}{(0.0005 \text{ in/in/day} \times H \text{ ft} \times 12 \text{ in/ft})}$$

Where: H = maximum liquid depth

      (1) Round results upward to the next full 24-hour period (day).
      (2) Minimum duration of test: 24 hours (1 day).
      (3) Maximum duration of test: 120 hours (5 days).
d. Lined concrete structures and secondary containment areas:
   1) Fill to the designated water surface elevation. Recording of water levels for leakage tests may begin as soon as the designated water surface level is reached, and the water surface is calm.
   2) Duration of test: 72 hours (3 days).
e. Measurements: Water level:
   1) Record water levels at 24-hour intervals for the full duration of the test period.
   2) Measure water levels at not less than 2 locations on opposite ends of the structure and preferably at 4 locations spaced equally around the structure. Mark locations on the structure and take measurements at the same locations throughout the duration of the test.
   3) Measure, to an accuracy of 1/16 inch, the vertical distance to the water surface from a fixed point on the structure above.
f. Measurements: Temperatures:
   1) As part of the first and last sets of level measurements, record water temperature at a depth of 18 inches below the water surface. Measure temperature at the same locations where level measurements are taken.
   2) Record ambient temperature at the time of each water level measurement.
g. Measurements: Evaporation and precipitation:
   1) Measure evaporation and precipitation by floating pans inside the structures during testing.
      a) For uncovered structures, measure both evaporation and precipitation.
      b) For covered structures that are well ventilated, measure evaporation.

2) Measure using specially constructed clear containers:
   a) Provide clear plastic, calibrated, open-top containers not less than 18 inches in diameter and 18-inches deep.
   b) Partially fill containers with water and float inside the structure. Make provisions to hold containers in place at each measurement location, but away from structure walls and items passing overhead, such as beams or pipes.
   c) Measure initial depth of water in each device. Measure changes in water level in each device at the same time measurements of the water level inside the structure are taken.

h. Restart of test:
   1) Engineer may order a restart of the test when, in the Engineer's opinion, measurements have become unreliable due to unusual precipitation or other factors.
   2) If measurements or observed leakage during the testing period indicate that the allowable leakage requirements will be exceeded, the test may be terminated before completion of the full test period. Take appropriate actions to correct problems before restarting the test.

i. Calculations of leakage test results:
   1) For each section of the structure tested, use water surface level records to calculate average loss of volume per 24-hour interval.
      a) For each 24-hour interval during the test, calculate the average of all measured drops in water level around the structure.
      b) Use the average drop thus determined to calculate an average loss of volume for each 24-hour interval.
   2) Adjustments to leakage calculations:
      a) For uncovered basins, calculations shall be corrected for precipitation added to the structure.
      b) Calculations may be corrected for evaporation and water temperature.

j. Evaluation criteria:
   1) Unless otherwise specified, the average loss of volume during any 24-hour interval shall not exceed the limits shown in Table A.

Table A - Loss of Volume Criteria for Leakage Tests

Structure Type	Maximum Loss of Water Volume
Structure fully lined prior to leakage test.	No measurable loss over 72-hour test period.
Secondary containment areas.	
Structure with monolithically placed membrane floor slab.	0.0125 percent of volume per 24-hour period.
Concrete paved canals, drying beds, lagoons, and similar structures.	0.100 percent of volume per 24-hour period.
Other containment structures.	0.050 percent of volume per 24-hour period.

k. Repairs and retesting:
    1) Structures and portions of structures that have satisfied the qualitative requirements of HST-100 but have failed to satisfy the quantitative requirements of HST-100 may be immediately retested for volume loss.
        a) If the structure fails the second test for volume loss, the structure shall be drained, and the Contractor shall observe the interior for probable areas of leakage.
        b) Structure shall not be retested until repairs to the probable areas of leakage are complete.

3.05 REPAIRS FOR RETESTING

A. Locations showing damp spots or flowing water:
    1. Mark locations of visible leaks and damp spots.
    2. Drain structures for repair.
    3. Repair defects causing damp spots and flowing water using methods specified in Section 03_30_01 - Concrete Work and approved by the Engineer.
        a. Repair both interior and exterior surfaces and make structures watertight.
        b. Submit proposed repair products and procedures for Engineer's review.
        c. Refill structures for retesting.
    4. Repeat filling, observations, and repairs until no leaks or damp spots appear.

B. Structures for which water volume loss exceeds the limits specified after adjustments for evaporation, and precipitation:
    1. Determine cause of volume loss.
    2. Drain structures of water.
    3. Repair defects causing loss of water volume using methods specified in Section 03_30_01 - Concrete Work and approved by the Engineer.
        a. Submit proposed repair products and procedures for Engineer's review.
    4. Refill water-holding structures.
    5. Repeat testing and repairs until volume loss does not exceed specified limits.

END OF SECTION

ATTACHMENT A - LEAKAGE TEST REPORT

LEAKAGE TEST REPORT

PROJECT:		SUBMITTED BY:	
STRUCTURE:		WITNESSED BY:	
AREA:		TEST DATES:	
TEST DURATION:		TEST DURATION:	

Surface area of structure tested:		(square feet)
Volume of structure tested:		(cubic feet)
Volume of structure tested:		(gallons)
Measured loss through gates, etc.:		(gallons / day)
Allowable loss of water volume:		(per day)
Allowable loss of water volume:		(% in 24 hours)
Allowable measured loss over test duration (inches):		
Measured loss of water:		(gallons / day - From E below)
Measured loss of water volume (%):		(in 24 hours - From E below)

Water Temperature: Start of test: °F End of test: °F

			Water Surface Elevation (top of structure to top of water)				
			Location #1	Location #2	Location #3	Location #4	Initials**
Day	Date	Time	(inches)	(inches)	(inches)	(inches)	
1							
2							
3							
4							
5							
Changes in Level:							

A. Average change in level (feet): (Average of total charges for all locations)

B. Correction for precipitation: (Measured from pan)

C. Correction for evaporation: (Measured from pan)

D. Corrected change in level (CL):

E. Total days tested:

F. Average measured % water loss in 24 hours: = $\frac{\text{(CL) x (surface area) x 100}}{\text{(initial water volume) x (number of test days)}}$

Notes and field observations**

**Place date and initials at the beginning of each entry.

SECTION 03_01_04

STRUCTURAL CONCRETE REPAIRGENERAL

1.01 SUMMARY

A. Section includes:
   1. Repairing damaged structural concrete.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-inch or Cube Specimens).
   2. C293 - Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading).
   3. C348 - Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars).
   4. C666 - Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.
   5. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear.

1.03 SUBMITTALS

A. Product data: Submit manufacturer's data completely describing structural repair concrete materials.

B. Certificates of Compliance.

C. Manufacturer's instructions.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: The manufacturer of the specified product shall have been in existence for a minimum of 10 years.

B. Allowable tolerances: Deviation from plumb or level shall not exceed 1/8 inch within 10 feet in any direction, as determined with a 10-foot straight edge.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver the specified product in original, unopened containers with the manufacturer's name, labels, product identification, and batch numbers.

B. Store and condition the specified product as recommended by the manufacturer.

C. Deliver, store, and handle packaged materials in the manufacturer's original, sealed containers, each clearly identified with the manufacturer's name, and name and type of product.

D. Store materials subject to damage by dirt and moisture in a clean, dry location, off the ground, and suitably protected.

1.06 PROJECT CONDITIONS

A. Existing conditions:
   1. Hot weather: ACI 305.
   2. Cold weather: ACI 306.
   3. Do not place concrete repair mortar during precipitation, unless adequate protection is provided.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. General: Structural repair concrete composed of cementitious material capable of being placed in formed vertical and overhead applications, and on horizontal surfaces.

B. Design requirements:
   1. Provide material suitable for performing in environments subject to corrosive attack by chlorides and sulfates, freeze/thaw cycles, low permeability, and abrasion resistant.
   2. Provide concrete repair mortar cement that is placeable from 1 inch in depth and extendable in greater depths.
   3. Concrete repair mortar shall be capable of being poured in place or troweled in place to suit the conditions encountered.

2.02 MATERIALS

A. Structural repair concrete:
   1. Manufacturers: One of the following or equal:
      a. Master Builder Solutions/Sika, MasterEmaco S 466CI.
      b. Sika Corp., SikaTop 123 Plus.
   2. Compressive strength: As follows in accordance with ASTM C109:
      a. 1 day: 2,500 pounds per square inch, minimum.
      b. 7 day: 6,000 pounds per square inch, minimum.
      c. 28 day: 7,000 pounds per square inch, minimum.
   3. Bond strength by slant shear: 2,200 pounds per square inch minimum at 28 days, in accordance with ASTM C882 modified.
   4. Flexural strength: 2,000 pounds per square inch minimum at 28 days, when tested in accordance with ASTM C293, or 770 pounds per square inch minimum at 28 days when tested in accordance with ASTM C348.
   5. Rapid freeze/thaw durability: In accordance with ASTM C666; Procedure A.
      a. Relative durability factor at 300 cycles: 95 percent minimum.

6. Working time: 30 to 40 minutes.
7. Color: Concrete gray.

B. Water: Potable, clean, not detrimental to concrete.

C. Form materials:
   1. Smooth finish.
   2. Brace as required to maintain tolerances.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that concrete surfaces and exposed reinforcing are clean and free of contaminants.

3.02 PREPARATION

A. Prepare existing concrete by cleaning with steel brush and applying bonding agent in accordance with manufacturer's instructions.

B. Thoroughly clean reinforcement and other embedded items to remove loose rust and other objectionable matter.

C. Thoroughly wet wood forms, except coated plywood, and adjacent concrete at least 1 hour in advance of placing concrete; securely close cleanout end inspection ports; repeat wetting as necessary to keep forms damp.

D. Damaged concrete:
   1. Areas to be repaired shall be clean, sound, and free of contaminants.
      a. Remove loose and deteriorated concrete by mechanical means acceptable to the Engineer.
      b. Saw cut perimeter 1/2-inch maximum.
   2. Chip concrete substrate to obtain a surface profile of 1/16 inch to 1/8 inch in depth with a new fractured aggregate surface.
      a. Area to be repaired shall be not less than 1 inch in depth.
   3. Concrete removal shall extend along the reinforcing steel to locations along the bar free of bond inhibiting corrosion, and where the bar is well bonded to surrounding concrete.

E. Use the following procedures where reinforcing steel with active corrosion is encountered:
   1. Sandblast reinforcing steel to remove contaminants and rust.
   2. Determine section loss, splice new reinforcing steel where there is more than 15 percent loss as directed by the Engineer.
      a. If more than half the diameter of the reinforcing steel is exposed, chip out behind the reinforcing steel a minimum of 1/2 inch. Distance chipped behind the reinforcing steel must also equal or exceed the minimum placement depth of the accepted material.

F. Treat cracks in the substrate at the area of patching or overlay work as directed by the Engineer.

G. Extend existing control and expansion joints through any concrete repair.

H. Apply an epoxy-bonding agent to area to be repaired, as specified in Section 03_63_01 - Epoxies, prior to patching concrete with polymer-modified Portland cement mortar.

3.03 MIXING

A. Mix in accordance with manufacturer's mixing instructions.

3.04 INSTALLATION

A. Formed surface finishes:
   1. Smooth finish:
      a. Obtain by the use of plywood, sheet metal, or lined wood forms; no fins, pockmarks, or other irregularities shall be present in the exposed surfaces of concrete.
      b. Place no structural repair concrete without prior authorization of the Engineer.

B. Verify that form materials are in place and ready to receive installation of concrete repair material.

C. Install in accordance with manufacturer's installation instructions.

D. In accordance with ACI recommendations, apply concrete repair material only when ambient conditions of moisture, temperature, humidity, and wind are favorable for curing.

E. Scrub mortar into substrate, filling cracks, voids, and pores.

F. For new construction, finish of repaired area shall match required finish for concrete being repaired.

G. For existing concrete, finish of repair area shall match finish of concrete being repaired.

H. During the curing process, protect concrete repair from rain, wind, or freezing as required:
   1. Keep sufficient covering on hand at all times for protection of repair concrete.

3.05 CLEANING

A. Remove debris and excess material. Leave work site in a neat, clean condition.

END OF SECTION

SECTION 03_15_00

CONCRETE ACCESSORIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Joint fillers.
   2. Waterstops.
   3. Joint dowels.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D570 - Standard Test Method for Water Absorption of Plastics.
   2. D624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers.
   3. D638 - Standard Test Method for Tensile Properties of Plastics.
   4. D746 - Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
   5. D747 - Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam.
   6. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
   7. D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
   8. D1752 - Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.
   9. D2240 - Standard Test Method for Rubber Property - Durometer Hardness.

B. American National Standards Institute (ANSI):
   1. A135.4 - Basic Hardboard.

C. U.S. Army Corps of Engineers (USACE):
   1. CRD-C-572, Specification for Polyvinyl Chloride Waterstop.

1.03 SUBMITTALS

A. Product data:
   1. Polyvinyl chloride waterstops: Complete physical characteristics.
   2. Preformed expansion joint material: Sufficient information on each type of material for review to determine conformance of material to requirements specified.

B. Samples:
   1. Polyvinyl chloride waterstop.

C. Laboratory test reports: Indicating that average properties of polyvinyl chloride waterstops material and finish conform to requirements specified in this Section.

D. Quality control submittals:
   1. Certificates of Compliance:
      a. Written certificates that polyvinyl chloride waterstops supplied on this Project meet or exceed physical property in accordance with USACE CRD-C-572 and the requirements of this Section.
   2. Manufacturer's instructions: For materials specified in this Section that are specified to be installed with such instructions.

1.04 QUALITY ASSURANCE

A. Mock-ups:
   1. Welding demonstration:
      a. Demonstrate ability to weld acceptable joints in polyvinyl chloride waterstops before installing waterstop in forms.

B. Field joints:
   1. Polyvinyl chloride waterstops field joints: Free of misalignment, bubbles, inadequate bond, porosity, cracks, offsets, and other defects which would reduce the potential resistance of material to water pressure at any point. Replace defective joints. Remove faulty material from site and disposed of by Contractor at its own expense.

C. Inspections:
   1. Quality of welded joints will be subject to acceptance of Engineer.
   2. Polyvinyl chloride waterstop: Following defects represent partial list that will be grounds for rejection:
      a. Offsets at joints greater than 1/16 inch or 15 percent of the material thickness, at any point, whichever is less.
      b. Exterior crack at joint due to incomplete bond, which is deeper than 1/16 inch or 15 percent of material thickness, at any point, whichever is less.
      c. Any combination of offset or crack that will result in net reduction in cross section of waterstop in excess of 1/16 inch or 15 percent of material thickness, at any point, whichever is less.
      d. Misalignment of joint that will result in misalignment of waterstop in excess of 1/2 inch in 10 feet.
      e. Porosity in welded joint as evidenced by visual inspection.

f. Bubbles or inadequate bonding.

PART 2 PRODUCTS

2.01 JOINT FILLERS

A. General:
1. Use specific type in applications as indicated on the Drawings.
2. Do not use scrap or recycled materials to manufacture joint fillers.

B. Preformed expansion joint materials:
1. Bituminous fiber expansion joint material:
a. Properties:
1) Thickness: To match joint width indicated on the Drawings.
2) Asphalt-impregnated fiber in accordance with ASTM D1751.
b. Manufacturers: One of the following or equal:
1) Durajoint.
2) W.R. Meadows, SealTight Fibre Expansion Joint.
2. Synthetic sponge rubber expansion joint material:
a. Properties:
1) Thickness: As recommended for width indicated on the Drawings.
2) Material in accordance with ASTM D1752, Type I.
b. Manufacturers: One of the following or equal:
1) Williams Products Inc., Everlastic 1300.
2) W.R. Meadows, SealTight Sponge Rubber.

2.02 WATERSTOPS

A. Waterstops - polyvinyl chloride (PVC):
1. Manufactured from prime virgin polyvinyl chloride plastic compound containing the plasticizers, resins, stabilizers, and other materials necessary to meet the requirements as specified in this Section.
2. Manufacturers: One of the following or equal:
a. Vinylex Corp.
b. Sika Corp., Greenstreak PVC Waterstop.
3. Type: Ribbed waterstop:
a. Construction joints: 6-inch-wide ribbed type.
b. Expansion joint for wall penetrations for concrete encased electrical duct banks: 6-inch ribbed type with hollow center bulb.
c. Expansion joints: 9-inch wide ribbed type with hollow center bulb.
d. Dumbbell-type waterstop will not be allowed unless otherwise specified or indicated on the Drawings.
e. No scrap or reclaimed material shall be used.

4. Properties as indicated in the following table:

Physical Characteristics	Test Method	Required Results
Specific Gravity	ASTM D792	Not less than 1.3.
Hardness	ASTM D2240	70 to 90 Type A15 Shore durometer.
Tensile Strength	ASTM D638	Not less than 2,000 pounds per square inch.
Ultimate Elongation	ASTM D638	Not less than 300 percent.
Alkali Extraction	CRD-C-572	Change in weight after 7 days: Between minus 0.1 percent and plus 0.25 percent. Change in hardness after 7 days: Not more than plus 5 points.
Low Temperature Brittle Point	ASTM D746	No sign of cracking or chipping at -35 degrees Fahrenheit.
Water Absorption	ASTM D570	Not more than 0.15 percent after 24 hours.
Accelerated Extraction Test	CRD-C-572	Tensile strength: Not less than 1,600 pounds per square inch. Elongation: Not less than 280 percent.
Stiffness in Flexure	ASTM D747	Not less than 600 pounds per square inch.
Tear Resistance	ASTM D624	Not less than 225 pounds per inch.
Thickness	-	3/8 inch.
Center Bulb		
6-inch Waterstops	-	7/8 inch or 1-inch nominal outside diameter.
9-inch Waterstops	-	For expansion joints 1 inch and narrower: 1-inch nominal outside diameter. For expansion joints wider than 1 inch: 2-inch nominal outside diameter.
Allowable Tolerances		
Width	-	Plus or minus 3/16 inch.
Thickness	-	Plus or minus 1/32 inch.

2.03 JOINT DOWELS

A. Expansion joint dowels:
   1. Smooth, un-deformed steel bars conforming to ASTM A615, Grade 60.
   2. Provide dowels straight and clean, free of loose flaky rust and loose scale.
   3. Dowels may be sheared to length provided deformation from true shape caused by shearing does not exceed 0.04 inches on the diameter of the dowel and extends no more than 0.04 from the end.
   4. Expansion end of the dowel:
      a. Coat bars with a bond breaker.
      b. Provide expansion dowel caps.

B. Slip dowel plastic sleeves: Manufactured using polypropylene:
   1. Manufacturers: The following or equal:
      a. Sika Corp., speed dowel.

C. Slip dowel end caps:
   1. Manufacturers: One of the following or equal:
      a. Heckmann Building Products, Inc., No. 87 Dowel Caps.
      b. Dayton Superior Corp., Style K-11 Dowel Caps.

PART 3 EXECUTION

3.01 INSTALLATION

A. Waterstops:
   1. General:
      a. Store waterstops so as to permit free circulation of air around waterstop material and prevent direct exposure to sunlight.
      b. Install waterstops in concrete joints where indicated on the Drawings.
      c. Carry waterstops in walls into lower slabs and join to waterstops in slabs with appropriate types of fittings.
      d. In water bearing structures: Provide all joints with waterstops, whether indicated on the Drawings or not.
      e. Provide waterstops that are continuous.
      f. Set waterstops accurately to position and line as indicated on the Drawings.
      g. Hold and securely fix edges in position at intervals of not more than 24 inches so that they do not move during placing of concrete.
      h. Position the waterstop so that symmetrical halves of waterstop are equally divided between concrete pours. Center axis of waterstop shall be coincident with centerline of the joint.
      i. Do not drive nails, screws, or other fasteners through waterstops in vicinity of construction joints.
      j. Use wires at not more than 24 inches on centers near outer edge of waterstop to tie waterstops into position.
      k. Special clips may be used in lieu of wires, at Contractor's option.
      l. Terminate waterstops 3 inches from top of finish surfaces of walls and slabs unless otherwise specified or indicated on the Drawings.
      m. When any waterstop is installed in concrete on one side of joint, while the other half or portion of the waterstop remains exposed to the atmosphere for more than 2 days, take suitable precautions to shade and protect exposed waterstop from direct rays of sunlight during entire exposure and until exposed portion is embedded in concrete.
      n. When placing concrete at waterstops in slabs, lift edge of waterstop while placing concrete below the waterstop. Manually force waterstop against and into concrete, and then cover waterstop with fresh concrete.
   2. Polyvinyl chloride waterstop:
      a. Install waterstops so that joints are watertight.
      b. Weld joints such as unions, crosses, ells, and tees, with thermostatically controlled equipment recommended by waterstop manufacturer:
         1) Do not damage material by heat sealing.

2) Make joints by overlapping, then simultaneously cut ends of sections to be spliced so they will form smooth even joint. Heat cut ends with splicing tool until the plastic melts. Press 2 ends together until plastic cools.
3) Maintain continuity of waterstop ribs and tubular center axis.
4) The splices shall have tensile strength of not less than 60 percent of unspliced materials tensile strength.

c. Butt joints of ends of 2 identical waterstop sections may be made while material is in forms.
d. Manufacturer shall factory prefabricate joints for crosses and tees.
e. Split-type waterstops will not be permitted except where specifically indicated on the Drawings.

B. Joints:
1. Construct construction and expansion joints as indicated on the Drawings.
2. Preformed expansion joint material: Fasten expansion joint strips to concrete, masonry, or forms with adhesive. No nailing will be permitted, nor shall expansion joint strips be placed without fastening.

C. Slip dowels at expansion joints:
1. Where indicated on the Drawings, install smooth dowels at right angles to expansion joints.
a. Align dowels with finished surface.
b. Rigidly hold in place and support during concrete placement.
2. Slip dowel sleeves:
a. Locate slip dowel sleeves on expansion joints as indicated on the Drawings.
3. Slip dowel end caps:
a. Unless otherwise indicated on the Drawings, apply a bond breaker at one end of dowels through expansion joints.
b. Provide slip dowel end caps on the lubricated end of expansion dowels.

END OF SECTION

SECTION 03_21_17

ADHESIVE-BONDED REINFORCING BARS AND ALL THREAD RODS IN CONCRETE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Bonding reinforcing bars and all thread rods in concrete using adhesives.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Concrete Institute (ACI).
   1. 355.4 - Qualification of Post-Installed Adhesive Anchors in Concrete and Commentary.

B. American National Standards Institute (ANSI):
   1. Standard B212.15 - Carbide Tipped Masonry Drills and Blanks for Carbide Tipped Masonry Drills.

C. ASTM international (ASTM):
   1. C881 - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.

D. Concrete Reinforcing Steel Institute (CRSI).

E. ICC Evaluation Service, Inc. (ICC-ES):
   1. AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements.

F. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

G. Society for Protective Coatings (SSPC):
   1. SP-1 - Solvent Cleaning.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Evaluation Service Report (ESR): Report prepared by ICC-ES, or other testing agency acceptable to Engineer and to the Construction Manager, that

documents testing and review of a product to confirm that it complies with the requirements of designated ICC-ES Acceptance Criteria, and to document its acceptance for use under the California Building Code specified in Division 01.

1.04 SUBMITTALS

A. Product data: Technical data for adhesives, including:
   1. Manufacturer's printed installation instructions (MPII).
   2. Independent laboratory test results indicating allowable loads in tension and shear for concrete of the types included in this Work, with load modification factors for temperature, spacing, edge distance, and other installation variables.
   3. Handling and storage instructions.
   4. Evidence of current listing under NSF-61 for use in contact with potable water.

B. Quality control Submittals:
   1. Special inspection: Detailed step-by-step instructions for the special inspection procedures required by the California Building Code specified in Division 01.
   2. For each adhesive to be used, Evaluation Report confirming that the product complies with the requirements of AC308 for both un-cracked and cracked concrete and for use in Seismic Design Categories A through F.
   3. Installer qualifications:
      a. Submit evidence of successful completion of adhesive manufacturer's installation training program.
      b. Submit evidence of current certification for installation of inclined and overhead anchors under sustained tension loading.

C. Inspection and testing reports:
   1. Inspections: Field quality control: Reports of inspections and tests.
   2. Inspections: Field quality assurance: Reports of special inspections and tests.

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Installation requirements:
      a. Have available at the site, and install anchors in accordance with the adhesive manufacturer's printed installation instructions.
   2. Installer qualifications:
      a. Demonstrating successful completion of adhesive manufacturer's on-site training program for installation of adhesive-bonded anchors.
      b. Holding current certification for installation of adhesive-bonded anchors by a qualified organization acceptable to the Engineer and to the Construction Manager:
         1) Organizations/certification programs deemed to be qualified are:
            a) ACI-CRSI Adhesive Anchor Installer Certification Program.
            b) Adhesive anchor manufacturer's certification program, subject to acceptance by the Engineer and Construction Manager.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store and protect products as follows, unless more restrictive requirements are recommended by the manufacturer:
   1. Store adhesives and adhesive components on pallets or shelving in a covered storage area protected from weather.
   2. Control temperature to maintain storage within manufacturer's recommended temperature range:
      a. If products have been stored at temperatures outside manufacturer's recommended range, test by methods acceptable to the Engineer to confirm acceptability before installing in the Work.
   3. Dispose of products that have passed their expiration date.

1.07 PROJECT CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

B. Seismic Design Category (SDC) for structures: SDC = D.

PART 2 PRODUCTS

2.01 GENERAL

A. Like items of materials: Use end products of one manufacturer in order to achieve structural compatibility and singular responsibility.

B. Adhesives shall have a current Evaluation Report documenting testing and compliance with the requirements of ACI 355.4 and ICC-ES AC308 for use with uncracked concrete and with cracked concrete in the Seismic Design Category specified.

C. Bond reinforcing bars and all thread rods in concrete using epoxy adhesive unless other adhesives specified are specifically indicated on the Drawings or approved in writing by the Engineer.

D. For locations where adhesive will be in direct contact with potable water in the finished work, provide documentation of testing and listing under NSF-61. Testing shall be by a nationally recognized agency acceptable to the Engineer.

2.02 EPOXY ADHESIVE

A. Materials:
   1. Meeting the physical requirements of ASTM C881, Type IV, Grade 3, Class B or C depending on site conditions.
   2. 2-component, 100 percent solids, insensitive to moisture.
   3. Cure temperature, pot life, and workability: Compatible with intended use and environmental conditions.

B. Packaging:
   1. Disposable, self-contained cartridge system furnished in side-by-side cartridges designed to fit into a manually or pneumatically operated caulking gun, and with resin and hardener components isolated until mixing through manufacturer's static mixing nozzle:
      a. Nozzle designed to dispense components in the proper ratio and to thoroughly blend the components for injection from the nozzle directly into prepared hole.
      b. Provide nozzle extensions as required to allow full-depth insertion and filing from the bottom of the hole.
   2. Container markings: Include manufacturer's name, product name, batch number, mix ratio by volume, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.

C. Manufacturers: One of the following or equal:
   1. Hilti, Inc., HIT-RE 500-V3.
   2. Simpson Strong-Tie Co., Inc., SET-XP.

2.03 ALL THREAD RODS

A. Carbon steel:
   1. In accordance with ASTM A36 unless otherwise indicated on the Drawings.
   2. High strength all thread rods: In accordance with ASTM F1554, Grade 55.
   3. Nuts: ASTM A194.
   4. Washers: ASTM F436.

B. Galvanized carbon steel:
   1. In accordance with ASTM A36 unless otherwise indicated on the Drawings, and hot dip galvanized in accordance with ASTM A153.
   2. High strength galvanized all thread rods: In accordance with ASTM F1554, Grade 55, and galvanized in accordance with ASTM F2329.
   3. Nuts: ASTM A194, hot-dip galvanized in accordance with ASTM A153.
   4. Washers: ASTM F436, hot-dip galvanized in accordance with ASTM A153.

C. Stainless steel:
   1. Units descaled, pickled, and passivated.
   2. Threaded rods and nuts to be the products of a single manufacturer/fabricator to ensure proper fit without galling. Ship all thread rods with properly fitting nuts attached.
   3. Alloy Type 304 or Type 316 as indicated on the Drawings.
   4. Type 304:
      a. Rod: ASTM F593, Group 1, Condition CW, coarse threads.
      b. Nuts: ASTM F594. Match alloy of rod (group and UNS designation).
      c. Washers: Type 304 stainless steel.
   5. Type 316:
      a. Rod: ASTM F593, Group 2, Condition CW, coarse threads.
      b. Nuts: ASTM F594. Match alloy of rod (group and UNS designation).
      c. Washers: Type 316 stainless steel.

2.04 REINFORCING BARS

A. As specified in Section 03_30_01 - Concrete Work.

PART 3 EXECUTION

3.01 GENERAL

A. Execution of this work is restricted to installers who have personally completed the adhesive manufacturer's on-site training for the products to be installed, and who are personally certified through a qualified certification program described under Quality Assurance and accepted by the Engineer and the Construction Manager:
   1. Do not install holes or adhesive until training is complete.

B. Perform work in strict compliance with the accepted MPII and the following instructions. Where the accepted MPII and the instructions conflict, the MPII shall prevail.

C. Install reinforcing bars and all thread rods to embedment depth, and at spacing and locations indicated on the Drawings:
   1. If embedment depth is not indicated, contact the Engineer for requirements.
   2. Do not install adhesive-bonded all thread rods or reinforcing bars in upwardly inclined or overhead applications unless accepted in advance by the Engineer.

3.02 PREPARATION

A. Do not begin installation of adhesive bonded anchors until:
   1. Concrete has achieved an age of at least 21 days after placement.
   2. On-site training in installation of adhesive bonded anchors by manufacturer's technical representative is complete. Do not drill holes in concrete or install adhesive and embeds in holes.

B. Review manufacturer's printed installation instructions (MPII) and "Conditions of Use" stipulated in the Evaluation Report before beginning work:
   1. Bring to the attention of the adhesive manufacturer's technical representative any discrepancies between these documents and resolve before proceeding with installation.

C. Install adhesive bonded anchors in full compliance with manufacturer's printed installation instructions using personnel who have successfully completed manufacturer's on-site training for products to be used and who hold certifications specified in this Section.

D. Confirm that adhesive and substrate receiving adhesive are within manufacturer's recommended range for temperature and moisture conditions and will remain so during the curing time for the product.

3.03 HOLE SIZING AND INSTALLATION

A. Drilling holes:
   1. Determine location of reinforcing bars or other obstructions with a nondestructive indicator device, and mark locations with construction crayon on the surface of the concrete.
   2. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without prior acceptance by the Engineer.

B. Hole drilling equipment:
   1. Electric or pneumatic rotary impact type with medium or light impact:
      a. Installation of anchors in cored holes is not permitted.
      b. Set drill to “rotation only” mode, or to “rotation plus hammer” mode in accordance with the manufacturer’s installation instructions and the requirements of the Evaluation Report.
      c. Where edge distances are less than 2 inches and “rotation plus hammer” mode is permitted, use lighter impact equipment to prevent micro-cracking and concrete spalling during the drilling process.
   2. Drill bits: Carbide-tipped in accordance with ANSI B212-15 unless otherwise recommended by the manufacturer or required as a “condition of use” in the Evaluation Report:
      a. Hollow drill bits with flushing air systems are preferred. Air supplied to hollow drill bits shall be free of oil, water, or other contaminants that will reduce bond.

C. Hole diameter: As recommended in the manufacturer’s installation instructions and the Evaluation Report.

D. Hole depth: As recommended in the manufacturer’s installation instructions to provide minimum effective embedment indicated on the Drawings.

E. Obstructions in drill path:
   1. If an existing reinforcing bar or other obstruction is hit while drilling a hole, unless otherwise accepted by the Engineer, stop drilling. Prepare and fill the hole with dry-pack mortar. Relocate the hole to miss the obstruction and drill another hole to the required depth:
      a. Obtain Engineer’s acceptance of distance between abandoned and relocated holes before proceeding with the relocation.
      b. Allow dry-pack mortar to cure to a strength equal to that of the surrounding concrete before resuming drilling in the area.
      c. Epoxy grout may be substituted for dry-pack mortar when accepted by the Engineer.
   2. Avoid drilling an excessive number of holes in an area of a structural member, which would excessively weaken the member and endanger the stability of the structure.
   3. When existing reinforcing steel is encountered during drilling and when specifically accepted by the Engineer, enlarge the hole by 1/8-inch, core

through the existing reinforcing steel at the larger diameter, and resume drilling at original hole diameter using pneumatic rotary impact drill.

4. Bent bar reinforcing bars: Where edge distances are critical and interference with existing reinforcing steel is likely, if acceptable to the Engineer, drill hole at 10-degree (or less) angle from axis of reinforcing bar or all thread rod being installed.

F. Cleaning holes:
   1. Insert air nozzle to bottom of hole and blow out loose dust:
      a. Use compressed air that is free of oil, water, or other contaminants that will reduce bond.
      b. Provide minimum air pressure of 90 pounds per square inch for not less than four seconds.
   2. Using a stiff bristle brush with diameter that provides contact around the full perimeter of the hole, vigorously brush hole to dislodge compacted drilling dust:
      a. Insert brush to the bottom of the hole and withdraw using a simultaneous twisting motion.
      b. Repeat at least 4 times.
   3. Repeat the preceding steps as required to remove drilling dust or other material that will reduce bond, and in the number of cycles required by the MPII and the Evaluation Report.
   4. Leave prepared holes clean and dry.
   5. Protect prepared and cleaned holes from contamination and moisture until adhesive is installed.
   6. Re-clean and dry previously prepared holes if, in the opinion of the Engineer, the hole has become contaminated after initial cleaning.

3.04 INSTALLATION OF ADHESIVE AND INSERTS

A. Clean and prepare inserts reinforcing bars and all thread rods:
   1. Prepare embedded length of reinforcing bars and all thread rods by cleaning to bare metal. Inserts shall be free of oil, grease, paint, dirt, mill scale, rust, or other coatings that will reduce bond.
   2. Solvent clean prepared reinforcing bars and all thread rods over the embedment length in accordance with SSPC SP-1. Provide an oil and grease free surface for bonding of adhesive to steel.

B. Fill holes with adhesive:
   1. Starting at the bottom of the hole, fill hole with adhesive inserting the reinforcing bar or all thread rod.
   2. Fill hole as nozzle is withdrawn without creating air voids.
   3. Unless otherwise indicated on the Drawings, fill hole with sufficient adhesive so that excess adhesive is extruded out of the hole when the reinforcing bar or all thread rod is inserted.
   4. Where necessary, seal hole at surface of concrete to prevent loss of adhesive during curing.

C. Installing reinforcing bars and all thread rods:
   1. Unless otherwise indicated on the Drawings, install bars and rods perpendicular to the concrete surface.

2. Insert reinforcing bars and all thread rods into adhesive in accordance with manufacturer's recommended procedures.
3. Confirm that insert has reached the designated embedment in the concrete, and that adhesive completely surrounds the embedded portion.
4. Securely brace bars and all thread rods in place to prevent displacement while the adhesive cures. Bars and rods displaced during curing will be considered damaged and replacement will be required.
5. Clean excess adhesive from the mouth of the hole.

D. Curing and loading:
1. Provide and maintain curing conditions recommended by the adhesive manufacturer for the period required to fully cure the adhesive at the temperature of the concrete.
2. Do not disturb or load bonded embeds until manufacturer's recommended cure time, based on temperature of the concrete, has elapsed.

3.05 POST-INSTALLATION ACTIVITIES

A. Do not bend bars or all thread rods after bonding to the concrete, unless accepted in advance by the Engineer.

B. Attachments to all thread rods:
1. After assemblies to be connected are placed, install nuts and washers for threaded rods as indicated on the Drawings.
2. Draw nuts down tight, using practices specified for "snug tight" installation of bolts in steel-to-steel connections.

3.06 FIELD QUALITY CONTROL

A. Provide field quality control over the Work of this Section as specified in Section 01 43 05 - Quality Assurance and Quality Control Requirements.

B. Do not allow work described in this Section to be performed by individuals who do not hold the specified certifications and who have not completed the specified job site training.

C. Manufacturer's services:
1. Before beginning installation, furnish adhesive manufacturer's technical representative to conduct on-site training in proper storage and handling of adhesive, drilling and cleaning of holes, and preparation and installation of reinforcing bars and all thread rods:
a. Provide notice of scheduled training to the Engineer and to special inspector(s) not less than 10 working days before training occurs. Engineer and special inspector may attend training sessions.
2. Submit record, signed by the manufacturer's technical representative, listing Contractor's personnel who completed the training. Only qualified personnel who have completed manufacturer's on-site training shall perform installations.

D. Field inspections and testing:
   1. Hole drilling and preparation.
   2. Results: Submit records of inspections and testing to the Engineer by electronic copies within 24 hours after completion.

3.07 FIELD QUALITY ASSURANCE

A. Provide field quality assurance over the Work of this Section as specified in Section 01 43 05 - Quality Assurance and Quality Control Requirements.

B. Special inspections, special tests, and structural observation:
   1. Provide as specified in Section 01_45_24 - Regulatory Quality Assurance.
   2. Frequency of inspections:
      a. Unless otherwise indicated on the Drawings or in this Section, provide periodic special inspection as required by the Evaluation Report for the product installed.
      b. Provide continuous inspection for the initial installation of each type and size of adhesive bonded reinforcing bar and all thread rod. Subsequent installations of the same anchor may be installed with periodic inspection as defined in subsequent paragraphs.
      c. Provide continuous inspection of drilling, cleaning and bonding activities for bars and rods installed in horizontal and upwardly inclined positions.
   3. Preparation:
      a. Review Drawings and Specifications for the Work to be observed.
      b. Review adhesive manufacturer's MPII and recommended installation procedures.
      c. Review Evaluation Report "Conditions of Use" and "Special Inspection" requirements.
   4. Inspection: Periodic:
      a. Initial inspection. Provide an initial inspection for each combination of concrete and reinforcing bar strength or concrete strength and all thread rod material being installed. During initial inspection, observe the following for compliance with the installation requirements:
         1) Concrete: Class (minimum specified compressive strength) and thickness.
         2) Environment: Temperature conditions at work area, and moisture conditions of concrete and drilled hole.
         3) Holes: Locations, spacing, and edge distances; verification of drill bit compliance with requirements; cleaning equipment and procedures; cleanliness of hole. Before adhesive is placed, confirm that depth and preparation of holes conforms to the requirements of the Contract Documents, the MPII, and the "Conditions of Use" listed in the Evaluation Report.
         4) Adhesive: Product manufacturer and name; lot number and expiration date; temperature of product at installation; installation procedure. Note initial set times observed during installation.
         5) Reinforcing bars and all thread rods: Material diameter and length; steel grade and/or strength; cleaning and preparation; cleanliness at insertion; minimum effective embedment provided.

b. Subsequent inspections: Subsequent installations of the same reinforcing bars or all thread rods may be performed without the presence of the special inspector, provided that:
    1) There is no change in personnel performing the installation, the general strength and characteristics of the concrete receiving the inserts, or the reinforcing bars and all thread rods being used.
    2) For ongoing installations, the special inspector visits the site at least once per day during each day of installation to observe the work for compliance with material requirements and installation procedures.

5. Inspection: Continuous:
    a. Make observations as described under “Inspection - Periodic, Initial Inspection” during drilling, cleaning, and bonding activities for all bars and rods installed.
6. Records of inspections:
    a. Provide a written record of each inspection using forms acceptable to the Engineer and to the Construction Manager.
    b. Submit electronic copies of inspection reports to the Engineer within 24 hours after completion of inspection.

END OF SECTION

SECTION 03_30_01

CONCRETE WORK

TABLE OF CONTENTS

PART 1 GENERAL 2

1.01 SUMMARY 2
1.02 REFERENCES 2
1.03 TERMINOLOGY 3
1.04 SUBMITTALS 4
1.05 QUALITY ASSURANCE 6
1.06 DELIVERY, STORAGE, AND HANDLING 7
1.07 PROJECT CONDITIONS 7
1.08 SEQUENCING AND SCHEDULING 7

PART 2 PRODUCTS 7

2.01 FORMWORK 7
2.02 JOINT MATERIALS 9
2.03 REINFORCEMENT 9
2.04 SOURCE QUALITY CONTROL 10
2.05 CONCRETE MIXES 10
2.06 CONCRETE BATCHING AND MIXING EQUIPMENT 14
2.07 CONCRETE FINISHING AND CURING MATERIALS 15

PART 3 EXECUTION 15

3.01 GENERAL 15
3.02 FORMING 16
3.03 PLACING CONCRETE REINFORCEMENT, EMBEDS, AND ACCESSORIES 18
3.04 BATCHING, MIXING, TRANSPORTING, AND DELIVERING CONCRETE 19
3.05 CONVEYING, DEPOSITING, AND CONSOLIDATING CONCRETE 21
3.06 FINISHING CONCRETE 23
3.07 CURING AND PROTECTING CONCRETE 23
3.08 JOINTS AND JOINT PREPARATION 25
3.09 TOLERANCES 26
3.10 FIELD QUALITY CONTROL BY CONTRACTOR 27
3.11 FIELD QUALITY CONTROL BY OWNER 28
3.12 NON-CONFORMING WORK 28

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Concrete formwork, concrete accessories, concrete reinforcement, batching and mixing of concrete to be cast-in-place, concrete placement and curing, and tooled concrete finishes.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00_45_46.4 and Section 00_73_74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. CODE-318 - Building Code Requirements for Structural Concrete and Commentary.
   2. MNL-66 - ACI Detailing Manual.
   3. PRC-305 - Specification for Hot Weather Concreting.
   4. PRC-306 - Standard Specification for Cold Weather Concreting.
   5. SPEC-117 - Standard Specifications for Tolerances for Concrete Construction and Materials.
   6. SPEC-301 - Specifications for Concrete Construction.

B. ASTM International (ASTM):
   1. A615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   2. A1064 - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
   3. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   4. C33 - Standard Specification for Concrete Aggregates.
   5. C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   6. C94 - Standard Specification for Ready-Mixed Concrete.
   7. C138 - Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.
   8. C143 - Standard Test Method for Slump of Hydraulic-Cement Concrete.
   9. C150 - Standard Specification for Portland Cement.
   10. C156 - Standard Test Method for Water Loss from a Mortar Specimen Through Liquid Membrane-Forming Curing Compounds for Concrete.
   11. C171 - Standard Specification for Sheet Materials for Curing Concrete.
   12. C172 - Standard Practice for Sampling Freshly Mixed Concrete.
   13. C173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
   14. C260 - Standard Specification for Air-Entraining Admixtures for Concrete.

15. C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
16. C311 - Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete.
17. C494 - Standard Specification for Chemical Admixtures for Concrete.
18. C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
19. C989 - Standard Specification for Slag Cement for Use in Concrete and Mortars.
20. C1064 - Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.
21. C1218 - Standard Test Method for Water-Soluble Chloride in Mortar and Concrete.
22. C1260 - Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).
23. C1293 - Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction.
24. C1602 - Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete.
25. C1778 - Standard Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete.
26. D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
27. D1752 - Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.
28. D2103 - Standard Specification for Polyethylene Film and Sheeting.

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

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section have the indicated meaning:
   1. Alkali load: Amount of alkalies contributed by the cement in a concrete mixture, expressed in lb/yd^3, and calculated by multiplying the cement content of the concrete in lb/yd^3 by the alkali content of the Portland cement; or the Portland cement portion of a blended cement, divided by 100.
   2. Cementitious materials: Portland cement and supplementary cementitious materials.
   3. Green concrete: Concrete whose current compressive strength is less than 100 percent of the minimum specified compressive strength, f'c.
   4. Hand mixed concrete: Concrete mixed at or near the point of placement using shovels, hoes, or other similar manually operated tools.
   5. Hot weather: A period when project conditions such as low humidity, high temperature, solar radiation, and high winds promote rapid drying of freshly placed concrete.
   6. Neat cement grout: Grout made from a mixture of Portland cement and water.

7. Supplementary cementitious material: Inorganic material such as fly ash, natural pozzolans, silica fume, or slag cement that reacts pozzolanically or hydraulically.

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Product data:
   1. Formwork:
      a. Formwork facing materials. Data on facing materials for concrete exposed to view in the finished work, if different from that specified in this Section.
      b. Form release agent. Manufacturer's name and catalog data, including materials safety datasheet and documentation of suitability for use in contact with potable water.
   2. Joint materials:
      a. Preformed expansion joint material: Manufacturer's name and catalog data with documentation of conformance to materials standards specified for each type and thickness of material.
   3. Reinforcement:
      a. Mill certificates for each heat of steel provided.
      b. Reinforcement placement drawings:
         1) Show anchor bolt locations based on anchor bolt templates for approved equipment.
      c. Concrete bar supports:
         1) Precast concrete bar supports (dobies): Manufacturer's product data indicating compression strength of concrete supports and material used for tie wires.
         2) Wire chairs and slab bolsters: Manufacturer's product data.
   4. Concrete materials:
      a. Cement:
         1) Mill certificate in accordance with ASTM C150. Include type and results of testing for alkali content measured as equivalent alkalies.
      b. Supplementary cementitious materials:
         1) Fly ash: Identify source and provide testing results documenting compliance with ASTM C618 and any additional requirements of this Section.
         2) Slag cement: Identify source and provide testing results documenting compliance with ASTM C989 and any additional requirements of this Section.
      c. Aggregates:
         1) Type, pit or quarry location, and producer's name.
         2) Commercial laboratory test reports for samples of each aggregate proposed for use. Tests shall have been made not more than 24 months prior to the date of the Submittal.
            a) Fine aggregate: Gradation analysis, specific gravity, reactivity, and reports of deleterious materials to document compliance with ASTM C33.
            b) Coarse aggregate: Gradation analysis, specific gravity, soundness, reactivity, and reports of deleterious materials to document compliance with ASTM C33 for each size used.

d. Admixtures:
    1) Manufacturer's catalog cuts and product data indicating compliance with the standards specified.

5. Concrete mixes: Submit full details, including:
    a. Mix proportions measured by both weight and volume and concrete properties for each class of concrete proposed for use.
        1) Information on correction of batching for varying moisture contents of fine aggregate.
    b. Data to establish the average compressive strength:
        1) If established by field test records, submit:
            a) Product and test data for the materials used in the mix.
            b) Actual mix proportions used in the mix producing the record.
            c) Field test data for slump, air content, and 28-day compressive strength. Include not less than 15 tests in accordance with ACI SPEC-301.
        2) If established by testing of trial batches, submit:
            a) Confirmation that the materials and proportions used in the trial batches are those that will be provided for the mix.
            b) Mix test data for slump, air content, and 28-day compressive strength.
        3) For either method, include calculations for:
            a) Standard deviation: Calculated in accordance with ACI SPEC-301 requirements.
            b) Required average compression strength (f'cr) using the standard deviation calculated in accordance with ACI SPEC-301 requirements.
            c) Statement demonstrating that the average compression strength from field test records or from trial batch testing for each mix ($f'c_{avg}$) exceeds the required average compressive strength (f'cr) for that mix.
    c. Data to establish alkali load:
        1) Determine and include the alkali load of the proposed mix.
    d. Data to establish chloride content:
        1) Submit test results showing that the concrete mix contains water-soluble chloride ion content contributed from the constituents, including water, aggregates, cementitious materials, and admixtures is less than the limit specified in Table B of this Section. Test shall be performed in accordance with ASTM C1218 at age between 28 and 42 days after mixing.
6. Concrete finishing and curing materials:
    a. Manufacturer's name and product datasheets.

C. Shop Drawings:
    1. Reinforcement:
        a. Submit Drawings showing bending and placement of reinforcement:
            1) Drawings shall be in accordance with ACI MNL-66.
            2) Clearly show placement, shapes, and dimensions of each bar listed in the bill of materials, including additional reinforcement at corners and openings required by details in the Contract Documents.
            3) Show splice locations and bar lengths reflecting the Contractor's intended placement sequence.

D. Samples:
   1. Form ties: If requested by the Construction Manager or Engineer.
   2. Concrete bar supports: If requested by the Construction Manager or Engineer, provide samples of:
      a. Precast concrete bar supports (dobies).
      b. Wire chairs and slab bolsters.

E. Procedures:
   1. Contractor's plans for production, placement, finishing, curing, protection, and temperature monitoring of concrete during the following environmental conditions:
      a. Hot weather.

F. Project record documents:
   1. For the following items, note location of concrete in the structure, and include tag numbers of associated cylinders for compression strength tests.
   2. Concrete delivery tickets. Submit copies of concrete delivery tickets within 24 hours after delivery.
   3. Field test reports: Results of field-testing for slump, temperature, unit weight, and air entrainment.
   4. Testing laboratory reports for compression strength.

G. Notifications:
   1. Modifications to concrete mixes:
      a. Submit notification of any adjustments to mixture proportions and any changes in materials made during the course of the Work for the Engineer's review.
      b. Include details of the changes and supporting documentation.
   2. Joint locations:
      a. Where joint locations other than those indicated on the Drawings are requested, submit proposed locations for the Engineer's review.
      b. Provide Drawings showing proposed joint locations with joint types labeled and joint details referenced.
   3. Reinforcement placement: Where necessary to move reinforcement beyond the specified placing tolerances to avoid interference, submit the proposed arrangement for the Engineer's review.
   4. Concrete placements: Submit notification of readiness for each concrete placement at least 24 hours in advance.
   5. Concrete repairs:
      a. Where concrete surfaces or sections exhibit defects after removal of forms, submit description of existing conditions and of proposed repair procedures and materials.
      b. Include photos of existing conditions with Submittal.

1.05 QUALITY ASSURANCE

A. Tolerances on concrete construction: In accordance with ACI SPEC-117 unless more stringent requirements are specified in the Contract Documents.

B. Concrete mixtures:
   1. Ensure that concrete produced has the specified characteristics in the freshly mixed state, and that those are maintained during transport and delivery and to the point of final placement.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle concrete materials to prevent damage and inclusion of foreign substances.

B. Deliver reinforcing steel bundled and tagged with identifying tags marked in a legible manner with waterproof markings showing the same designations as indicated on the submitted Shop Drawings:
   1. Store off the ground and protect from moisture, dirt, oil, and other injurious contaminants.

C. Protect concrete accessories from weather and direct exposure to sunlight before installation.

1.07 PROJECT CONDITIONS

A. Environmental requirements:
   1. Hot weather concreting: Construct in accordance with ACI PRC-305 during conditions when the ambient air temperature is above 90 degrees Fahrenheit.
   2. Conditions that promote rapid drying of freshly placed concrete, such as low humidity, high temperature, and wind: Take corrective action to minimize loss of water from the concrete.

1.08 SEQUENCING AND SCHEDULING

A. Schedule placing of concrete in such a manner that completes any single placing operation to a construction, or expansion joint as indicated on the Drawings or accepted by the Engineer in advance of the placement.

PART 2 PRODUCTS

2.01 FORMWORK

A. Forms:
   1. Design and performance requirements:
      a. Design and performance of formwork shall be the responsibility of the Contractor, subject to the requirements of the Contract Documents.
      b. Design, construct, and brace formwork to:
         1) Carry all loads applied or transmitted, including the pressure resulting from placement and vibration of plastic concrete.
         2) Remain tight to prevent loss of mortar.
         3) Maintain specified tolerances and provide finished surfaces as specified.

c. Maximum deflection of facing materials and supporting members on surfaces exposed to view in the finished work: 0.0042 times the clear span (span/240).
d. Maximum deviation from alignment (horizontal or vertical): In accordance with ACI SPEC-117.

2. Form facing materials:
   a. Surfaces exposed to view in the finished work:
      1) Facing materials shall produce a smooth, uniform texture on the concrete.
      2) Do not use materials with raised grain, tears, worn edges, patches, dents, or other similar defects.
      3) Acceptable materials: Plywood with “C” or better face, plastic-faced plywood, tempered concrete form grade hardboard, or steel.
   b. Surfaces not exposed to view in the finished work:
      1) Special form facing material not required.
3. Forms for chamfers and keyways:
   a. Uniform steel, plastic, or lumber section of dimensions shown or specified.
   b. Provide adequate stiffness and support to maintain a true line at the concrete surface.
   c. Treated to eliminate bond with the concrete if required to produce a smooth, uniform, and undamaged finish upon removal.

B. Form ties:
1. General:
   a. Provide form ties fabricated by recognized manufacturer of concrete forming equipment and suitable for use with the forming system selected.
   b. Provide ties that accurately tie, lock, and spread forms:
      1) Do not use wire ties or wood spreaders.
   c. Provide form ties manufactured such that, when forms are removed, the tie leaves no metal or other material within 1-1/2 inches of the surface of the concrete.
   d. Do not allow tie holes through forms for ties to leak during concrete placement.
2. Cone snap ties: Tie with removable plastic cone leaving a tapered depression having a minimum diameter of 1 inch at the surface of the concrete and a depth of 1-1/2 inches below the surface.

C. Dry-pack mortar for filling cone snap tie holes:
1. Proportioned mix of 1 part of Portland cement to 1 part plaster sand with potable water added to provide a stiff consistency that can be driven into holes and properly compacted.
2. For repairs in concrete exposed to view in the finished work, mix repair mortar using the same cement and sand as that used for the concrete being patched:
   a. Mix a trial batch and confirm color compatibility with the surrounding material.
   b. Adjust color to match that of the surrounding concrete by adding white Portland cement if necessary.
3. Admixtures or additives to mortar are not permitted.

D. Form release agent: Commercially manufactured, non-staining formwork release agent that will prevent absorption of water by the formwork and will prevent bond between the formwork and the concrete.
    1. Form release agent shall comply with local air quality management regulations.

2.02 JOINT MATERIALS

A. Synthetic sponge rubber expansion joint material:
    1. Elastic sponge rubber compound in accordance with ASTM D1752, Type I.
    2. Concrete-gray color unless otherwise noted.
    3. Thickness: As indicated on the Drawings.
    4. Manufacturers: One of the following or equal:
        a. Williams Products Inc., Everlastic 1300.
        b. W.R. Meadows, SealTight Sponge Rubber Expansion Joint.

B. Bituminous fiber expansion joint material:
    1. Thickness: To match joint width indicated on the Drawings.
    2. Asphalt-impregnated fiberboard in accordance with ASTM D1751.
        a. Manufacturers: One of the following or equal:
            1) Durajoint.
            2) W.R. Meadows, SealTight Fibre Expansion Joint.

C. Sealants and caulking: As specified in Section 07_92_00 - Joint Sealants.

2.03 REINFORCEMENT

A. Materials:
    1. Deformed bars: In accordance with ASTM A615 Grade 60.
    2. Welded wire fabric: Sheets of plain wire in accordance with ASTM A1064.
    3. Bar supports:
        a. Over ground or mud mat:
            1) Precast concrete blocks with cast-in annealed steel tie wires, 16 gauge or heavier:
                a) Compressive strength of blocks equal to or exceeding the compressive strength of the surrounding concrete.
            2) Height as required for a minimum 3 inches of clear concrete cover below reinforcement.
            3) Minimum block footprint of 4 square inches, or as required to supporting load from reinforcement while maintaining the required concrete cover.
        b. Wire supports: Class 2, Type B stainless steel protected wire in accordance with CRSI Manual of Standard Practice.
    4. Tie wire: Annealed steel.

B. Fabrication:
    1. Cut and cold-bend bars in accordance with provisions of ACI MNL-66 and ACI CODE-318.
    2. Fabricate reinforcement to the tolerances in accordance with ACI SPEC-117.
    3. Provide bars free from defects and kinks and from bends not indicated on the Drawings.

2.04 SOURCE QUALITY CONTROL

A. Submit documentation that the proposed concrete mixes will conform to the requirements of this Section and will produce concrete having the required proportions and properties specified:
   1. Do not place concrete until the design for that mix and the results of any trial batch testing have been accepted by the Engineer.
   2. If the Engineer requires changes to the mix design, modify mixes within limits set forth in this Section and submit new mix design for the Engineer's review.

B. After acceptance, do not change mixes or mix proportions without prior acceptance by the Engineer:
   1. Exception: At all times, adjust batching of water to compensate for free moisture content of aggregates. Total water content in the mix shall not exceed that specified.

C. If there is change in source of cement or aggregate, or if there is a significant change in the characteristics or quality of any constituent material received from a source accepted to supply materials, submit new design mixes for each class of concrete affected.

D. Testing of materials and mixes before placement to demonstrate that they comply with the requirements of this Section shall be at the Contractor's expense.

2.05 CONCRETE MIXES

A. Constituent materials:
   1. Cement:
      a. Portland cement: In accordance with ASTM C150, Type I or II:
         1) Cement for finishes or repairs: Provide cement from same source and of same type as concrete to be finished.
   2. Supplementary cementitious materials (SCM):
      a. Fly ash:
         1) In accordance with ASTM C618, Class F.
         2) Sampling and testing: In accordance with ASTM C311.
         3) Loss on ignition: Not to exceed 4 percent.
      b. Slag cement:
         1) Grade 80, 100, or 120, in accordance with ASTM C989, except as modified below:
            a) Fineness: Amount retained on a No. 325 sieve: 20 percent maximum.
            b) Total alkalies $Na_2O + 0.658\ K_2O$:
               (1) Minimum: 0.60 percent.
               (2) Maximum: 0.90 percent.
   3. Aggregates:
      a. General:
         1) Provide normal weight concrete aggregates that are sound, uniformly graded, and free of deleterious material in excess of the amounts specified.

2) Do not use aggregate made from recycled materials such as crushed and screened hydraulic-cement concrete, brick, or other construction waste.
3) Obtain aggregate from source that is capable of providing uniform quality, moisture content, and grading during any single day's operations.
4) Alkali-silica reactivity:
a) Provide fine and coarse aggregate classified as aggregate-reactivity class of R0 in accordance with ASTM C1778 and with expansion not greater than 0.10 percent at 14 days when tested in accordance with ASTM C1260 and not greater than 0.04 percent at 1 year when tested in accordance with ASTM C1293.

b. Fine aggregate:
1) Provide fine aggregate consisting of clean, natural sand or of sand prepared from crushed stone or crushed gravel.
2) In accordance with ASTM C33.

c. Coarse aggregate:
1) Provide coarse aggregate consisting of gravel or crushed stone made up of clean, hard, durable particles free from calcareous coatings, organic matter, or other foreign substances; and in accordance with ASTM C33, Class 4S.
2) Grading: Unless otherwise specified or accepted in writing by the Engineer, provide the following:
a) Aggregate for Class A, and C, and PM Concrete: ASTM C33, Size No. 57.
b) Aggregate for Class CE Concrete: ASTM C33, Size No. 8.
c) Where a combination of 2 or more sizes of coarse aggregate are used, the gradation of the blend shall conform to the grading requirements in accordance with ASTM C33 for the size number specified.

4. Water:
a. Water for concrete mixes, for washing aggregate, and for curing concrete: Potable water, clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances.
b. Do not exceed the optional chemical limits of ASTM C1602.

5. Admixtures:
a. General:
1) Do not use admixtures, except those specified, unless written authorization has been obtained from the Engineer.
2) Admixtures shall be compatible with concrete and other admixtures. Admixtures (other than fly ash) shall be the products of a single manufacturer to ensure compatibility.
3) Do not use admixtures containing chlorides in excess of 0.5 percent by weight of cement when calculated as chloride ion.
b. Air entraining admixture: In accordance with ASTM C260.
c. Water reducing admixture:
1) In accordance with ASTM C494, Type A or Type D.
2) Not containing air-entraining agents.

d. Coloring admixture:
    1) To produce red-colored concrete for encasement of electrical ducts, conduits, and similar items:
        a) Mix 10 pounds of coloring agent into each cubic yard of concrete, unless otherwise recommended by the manufacturer and accepted by the Construction Manager.
    2) Manufacturers: One of the following or equal:
        a) Davis Colors, #100 Utility Red.
        b) I. Reiss Co., Inc., equivalent product.
        c) Euclid Chemical Co., Increte Division, Colorcrete Brick Red.

B. Mix design and proportioning:
    1. Proportion mixes to provide compression strength, workability, and durability as specified in this Section.
    2. Submit documentation that the proposed mixes will conform to the requirements of this Section and will produce concrete having the required properties.
    3. Compression strength:
        a. Proportion each concrete mix to provide the required average compressive strength (f'cr) determined in accordance with the provisions of ACI SPEC-301.
        b. Determine required average compressive strength (f'cr) for each class of concrete using the specified compressive strength of the mix, f'c, and the standard deviation determined in accordance with ACI SPEC-301.
            1) Establish the standard deviation in accordance with ACI SPEC-301 and based on either field test records or based on trial batches.
            2) Documentation of standard deviation based on field test records:
                a) Calculate standard deviation in accordance with ACI SPEC-301 procedures using test records that:
                    (1) Represent materials, quality control procedures, and conditions similar to those expected for this Work.
                    (2) Do not include provisions for materials and proportions that are more restrictive than the materials proposed for use in this Work.
                    (3) Represent a mix proportioned to provide a specified compressive strength (f'c) within 1,000 pounds per square inch of that specified for the corresponding mix in this Section.
            3) Documentation of standard deviation based on trial batches plus empirical code requirements:
                a) When records including at least 15 consecutive tests that span a period of at least 45 calendar days are not available, determine required average compressive strength (f'cr) from Table A:

Table A: Required Average Compressive Strength

Specified Compressive Strength f'c (pounds per square inch)	Required Average Compressive Strength f'cr (pounds per square inch)
Less than 3,000	f'c + 1,000
3,000 to 5,000	f'c + 1,200

4. Workability:
    a. Provide concrete with workability and consistency that can be readily worked into corners and angles of forms and around reinforcement without excessive vibration and without permitting materials to segregate or free water to collect on the surface.
5. Cement content:
    a. Cementitious materials content: Conform to values specified in Table B of this Section.
    b. Ratio of water to cementitious materials:
        1) Conform to values specified in Table B of this Section.
        2) Total water, including that from moisture content of aggregates and admixtures, shall not exceed that specified in Table B of this Section.
6. Supplementary cementitious materials:
    a. Fly ash:
        1) Maximum of 15 percent by weight of total weight of cementitious materials (cement plus fly ash).Other supplemental cementitious materials shall not be used without prior acceptance by the Engineer.
    a. Slag cement:
        1) Minimum content: 20 percent of the total weight of cementitious materials.
        2) Maximum content: 30 percent of the total weight of cementitious materials.
7. Aggregates:
    a. Ratio of coarse aggregate to fine aggregate: Not less than 1.0 or more than 2.0 for all concrete classes, with exception of Class CE.
8. Admixtures:
    a. Use in accordance with manufacturer’s instructions.
    b. Air entraining admixture:
        1) Provide concrete with entrained air content indicated in Table B of this Section and consisting of evenly dispersed air bubbles. Water reducing admixture:
        2) No decrease in cementitious materials content is permitted as a result of use of water-reducing admixture.
    c. High range water reducing admixture/plasticizing admixture:
        1) Not permitted.
    d. Coloring admixture:
        1) Unless otherwise recommended by the manufacturer, mix into each cubic yard of concrete 10 pounds of coloring agent.
9. Concrete mix design requirements by class:
    a. Provide concrete mixes for each class specified in this Section and indicated in Table B of this Section.
    b. Use each class at the locations specified in the following paragraphs or indicated on the Drawings.
        1) Class A concrete: General use. Use at all locations unless otherwise indicated on the Drawings or listed in the following paragraphs.
        2) Class C concrete: May be used as fill for unauthorized excavation, for thrust blocks and ground anchors for piping, for bedding of pipe, and elsewhere as indicated on the Drawings.
        3) Class CE concrete: Use for electrical conduit and duct bank encasements.

4) Class PM concrete: Use for concrete pavement, cart paths, curbs, gutters, and sidewalks.

c. Pumped concrete: Provide a separate mix design and substantiation testing for each class to be placed by pumping.

Table B: Concrete Classes

Concrete Class	Minimum Specified Compressive Strength at 28 days, f'c[1] (pounds per square inch)	Ratio of water to cementitious materials[2,3] (minimum - maximum)	Cementitious Materials Content[3] (pounds per cubic yard of concrete by weight)	Cement Type	Maximum Chloride Content (percent by weight of cement)	Maximum Coarse Aggregate Size[4]	Air Entrainment (percent) (N/R: not required)	Admixtures required[5]	Slump Range (inches)
A	4,500	0.40 to 0.45	535 to 575	ASTM C150, Type II(MH)	0.15	57	6±1.5	AEA WRA	2 to 4
C	2,500	0.62 max.	423 min.	ASTM C150, Type II(MH)	No limit	57	6±1.5	AEA WRA	3 to 6
CE	2,500	0.62 max.	423 min.	ASTM C150, Type II(MH)	No limit	8	5±1.5	AEA WRA CA	3 to 6
PM	5,000	0.40	535 to 575	ASTM C150, Type II(MH)	0.15	57	5+1.5	AEA WRA	3 to 6

Notes:

(1) At locations where concrete will not be subjected to load from other elements of the structure or from the Contractor's placing operations, maximum time period for achievement of specified compressive strength may be extended to 56 days when accepted by the Contractor's Engineer.

(2) W/C Ratio = Ratio of water to cementitious materials (Portland cement plus supplemental cementitious material) by weight Include weight of admixtures in the water content of the mix when the quantity of the admixtures exceeds 10 ounces per 100 pounds of cement.

(3) Provide mix within the range of W/C ratio and cementitious materials content indicated.

(4) Size number in ASTM C33, Table 2.

(5) Admixtures are designated as follows:

AEA - Air entraining admixture.

CA - Coloring admixture.

WRA - Water reducing admixture.

2.06 CONCRETE BATCHING AND MIXING EQUIPMENT

A. Provide equipment and facilities for accurate measurement and control of materials.
   1. At all times, maintain proportions of concrete mix within specified limits.
   2. Control and adjust batch weights to secure maximum yield.

B. Measuring or weighing equipment:
   1. Furnish apparatus for weighing aggregates and cementitious materials that is suitably designed and constructed for this purpose.
   2. Devices shall bear the current and valid seal of the Sealer of Weights and Measures in the Authority having jurisdiction.
   3. Furnish devices capable of providing successive quantities of individual materials measured to within 2 percent of desired amount of that material.

C. Mixing equipment:
   1. Mixes shall be ready-mix or transit-mixed concrete in accordance with ASTM C94.
   2. Provide equipment capable of combining aggregates, cementitious materials, water, and admixtures into a thoroughly mixed and uniform mass during the time periods specified, and capable of discharging the resulting mixture without segregation.
   3. Maintain mixing equipment in good working order. Operate at loads and speeds, and for periods of time recommended by the manufacturer or specified in this Section.

2.07 CONCRETE FINISHING AND CURING MATERIALS

A. Evaporation retardant:
   1. Manufacturers: One of the following or equal:
      a. Euclid Chemical Co., Eucobar.
      b. Master Builders Solutions/Sika, MasterKure ER 50.

B. Plastic membrane for curing:
   1. White polyethylene film in accordance with ASTM C171:
      a. Nominal thickness not less than 0.0040 inches when measured in accordance with ASTM D2103, and thickness at any point not less than 0.0030 inches.
      b. Loss of moisture: Not to exceed 0.055 grams per square centimeter of surface when tested in accordance with ASTM C156.

C. Sprayed membrane curing compound:
   1. In accordance with ASTM C309, Type 1D. Clear with fugitive dye.

PART 3 EXECUTION

3.01 GENERAL

A. Preparation:
   1. Use construction methods and sequences that allow time for concrete to reach adequate strength to prevent damage to or overstress of the concrete structure or its elements during construction.
   2. Locations of construction and expansion joints are indicated on the Drawings:
      a. Make no other joints, except as accepted in advance by the Engineer.

b. Schedule placing of concrete to complete any single placing operation between designated joints.
c. Schedule and sequence placements to allow adequate time for concrete to achieve adequate strength before subsequent placements and loads are applied to the structure.

B. Verification of conditions:
1. Do not place concrete until:
a. Forms have been thoroughly cleaned of dirt and debris, and form release agents have been applied.
b. Forms have been thoroughly checked for alignment, level, strength, and accurate location of reinforcement, joint accessories, and mechanical and electrical inserts or other embedded items.
c. Reinforcement is secure and properly fastened in its correct position.
d. Dowels, bucks, sleeves, hangers, pipes, conduits, anchor bolts, and any other fixtures required to be embedded in concrete have been placed and adequately anchored to maintain a minimum 1 1/2-inch clearance between the item and any concrete reinforcement. Secure embedded items in position by wiring or welding to the reinforcement is not permitted.
e. Forms are aligned and secured, and loose form ties at construction joints have been retightened.
2. Notify the Engineer in writing of readiness, not just intention, to place concrete in any portion of the Work:
a. Provide this notification in advance of operations, allowing such time as the Engineer deems necessary to make final observation of preparations at location of the concrete placement.
b. Have forms, reinforcement, screeds, anchors, ties, embeds, and inserts in place before notifying the Engineer of readiness for final observations.
3. Do not place concrete until the Engineer has completed final observations of conditions at the placement and has given acceptance to proceed.

3.02 FORMING

A. General:
1. Do not use earth cuts as forms for vertical or sloped surfaces unless specifically required by or indicated on the Contract Documents.
2. Joints: Locate joints as indicated on the Drawings:
a. Submit joint locations other than or differing from those indicated on the Drawings for the Engineer’s review before construction.
3. Chamfers:
a. Permanently exposed outside corners: Provide 3/4-inch chamfer.
b. Re-entrant corners:
1) Chamfer not required.
2) Corner may be left square.
c. Edges of formed joints: Chamfer not required, except where indicated on the Drawings.
4. Level strips: Install level strips at top of wall concrete placements to maintain true line at horizontal construction joints.

B. Constructing and erecting formwork:
   1. Brace and anchor formwork to ensure vertical and lateral stability and to maintain finish tolerances when subjected to uplift pressures and lateral pressures from plastic concrete:
      a. Ensure that formwork is positioned, braced, and firmly held against previously placed concrete to maintain flush surfaces and to prevent loss or leaking of mortar at construction joints:
         1) At joints with flush surfaces exposed to view, lap contact surface of form a maximum of 1 inch over the previously placed concrete.
      b. Design and construct forms with sufficient strength and stiffness that deflections resulting from loading by plastic concrete will not exceed the surface tolerance limits specified.
      c. Set forming materials in an orderly and symmetrical arrangement, keeping the number of seams to a practical minimum.
      d. Form ties: Tie forms together using cone snap ties placed at not more than 2-foot centers vertically and horizontally.
      e. Construct formwork to permit easy removal without damage to formed surfaces.
      f. Provide temporary openings at the base of column and wall formwork to allow cleaning and inspection immediately before concrete placement.
      g. Cracks, openings, or offsets at joints in formwork: Close those that are 1/16-inch or larger by tightening forms or by filling with acceptable crack filler.
   2. Where forms are reused, clean surfaces of mortar, grout, and foreign materials before coating with form release agent and setting.
   3. Cover formwork surfaces with form release agent to prevent bond with the concrete:
      a. Do not allow form release agent to puddle in the forms.
      b. Do not allow form release agent to contact reinforcement, embeds, or previously placed concrete.
   4. Provide runways supported directly on the formwork for moving equipment and supplies during preparations for concreting:
      a. Do not rest such runways on reinforcement.

C. Embeds, joints, and accessories:
   1. Position pipes, sleeves, conduits, inserts, anchors, castings, and other embedded items in the forms, and anchor to formwork to prevent displacement.
   2. Fill voids in sleeves, pipes, inserts and anchor slots with readily removable material, and seal if required to prevent entry of mortar.
   3. For pipe or conduit runs, position embeds to allow at least 3 inches of clear concrete separation between parallel runs of pipes, conduits or any combination of these items with each other or with reinforcement.

D. Removing formwork:
   1. Remove forms after the specified time for curing and protection has been provided and when operations will not damage concrete.

2. Immediately after forms are removed, carefully examine concrete surfaces:
    a. Report any irregularities in surfaces and finishes to the Engineer.
    b. Where surface repairs are needed, contact the Engineer with description of conditions and description of repair procedures before proceeding with the work.
3. Immediately follow form removal with installation of specified curing materials and procedures.
4. After forms are removed from wall and curing is complete, fill tie holes as follows:
    a. Remove form ties and cones from surfaces.
    b. Roughen cone-shaped tie holes by heavy sandblasting before repair.
    c. Clean and dampen tie holes, maintaining a saturated surface for at least two hours before applying dry-pack mortar.
    d. Dry pack cone-shaped tie holes with dry-pack mortar as specified in this Section.

3.03 PLACING CONCRETE REINFORCEMENT, EMBEDS, AND ACCESSORIES

A. Preparation:
1. Cut and bend deformed steel reinforcement in the shop and deliver completed bars to the Site for installation:
    a. Do not field-bend deformed reinforcement.
2. Surface preparation:
    a. Thoroughly clean reinforcing bars from rust scale, loose mill scale, rust coat, dirt, oil, and other coatings that adversely affect bonding capacity when placed in the Work:
        1) Thin coating of red rust resulting from short exposures will not be considered objectionable.
    b. Remove concrete or other deleterious coatings on dowels and other reinforcement projecting from previous placements by wire brushing or sandblasting before the reinforcement is embedded in the subsequent placement.

B. Support of reinforcement and accessories:
1. Provide supports for deformed bars and wire fabric to maintain reinforcement position indicated on the Drawings and to provide specified minimum clear concrete cover around the reinforcement.
2. Use number of supports required to prevent reinforcement from sagging and to support loads during construction, but in no fewer quantities and locations than recommended by ACI MNL-66 and CRSI Manual of Standard Practice.
3. Support wire fabric from reinforcing supports:
    a. Do not place wire fabric on grade or forms for subsequent lifting into plastic concrete during the concrete placement.
    b. Take care to maintain specified position of wire fabric in the concrete section and to prevent bending, draping, or kinking of the wires.
4. Do not:
    a. Use brick, broken concrete masonry units, concrete spalls, rocks, or other such material for supporting reinforcement.

b. Support reinforcement on additional reinforcing bars installed with less cover than that required by the Contract Documents (give away bars).
c. Adjust location of reinforcement indicated on the Drawings to increase cover over support bars.

5. Furnish and use templates for placing column dowels.

C. Placing reinforcement:
1. Locate reinforcement to provide minimum clear concrete cover specified:
a. Where cover is not specified, provide cover in accordance with ACI CODE-318.
2. Accurately place reinforcement in accordance with the tolerances of ACI SPEC-117:
a. Where reinforcement must be moved beyond the specified placing tolerances to avoid interference with other reinforcement, conduits, or embeds, submit the proposed arrangement for the Engineer's review.
3. Fasten reinforcement securely in place with wire ties:
a. After tying, bend ends of wire ties inward towards the center of the concrete to match clear concrete cover provided for reinforcement.
4. Do not weld reinforcing bars or wires.
5. Deformed reinforcing bars:
a. Tie slab bars at every intersection around the perimeter of slabs.
b. Tie wall bar and slab bar intersections, other than those around the perimeter, at every fourth intersection, but not more than 48 inches on center each way.
c. Lap splices:
1) Lap reinforcement at splices as indicated on the Drawings or specified.
2) Unless indicated on the Drawings, install lap splices with bars in contact and fastened together with tie wire.
3) If lap splice length is not indicated on the Drawings, provide lap splice equal to 40 times reinforcing bar diameter.
6. Welded wire fabric reinforcement:
a. Bend fabric as indicated on the Drawings or required to fit Work.
b. Straighten fabric to make reinforcement in each face a flat, planar surface before placing in the Work.
c. Extend welded wire fabric across concrete section to provide fabric to within 2 inches of vertical concrete edges.
d. Lap splice welded wire fabric as indicated on the Drawings:
1) If no splice details are indicated, lap fabric at least 12 inches, fasten with wire ties spaced not more than 24 inches on center, and lace lap with wire of the same diameter of the fabric.

3.04 BATCHING, MIXING, TRANSPORTING, AND DELIVERING CONCRETE

A. General:
1. Measure, batch, mix, transport, and deliver ready-mixed concrete in accordance with ASTM C94.

B. Measuring and batching:
   1. Measure materials by weighing, except as otherwise specified or where other methods are specifically authorized in writing by the Engineer:
      a. Weigh cementitious materials separately.
   2. Furnish satisfactory means for checking moisture content of aggregates before batching:
      a. Adjust mix water to compensate for free moisture content of aggregate.
   3. Mixing water:
      a. Measure by volume or by weight.
      b. Maximum water-to-cementitious materials ratio for each concrete class shall not exceed that specified in Table B of this Section.
   4. Admixtures:
      a. Provide admixtures as specified.
      b. Batch products by means of mechanical batcher capable of accurate measurement, and in accordance with the admixture manufacturer's instructions.

C. Mixing and transporting:
   1. Mixing:
      a. Equip each truck mixer with device capable of counting number of drum revolutions and interlocked to prevent discharge of concrete from drum before required number of revolutions is complete.
      b. Once drum revolutions commence, continuously revolve drum until it has completely discharged its batch.
      c. Do not add water until drum commences revolutions.
      d. Engineer may require an increase in the designated minimum number of revolutions, or a decrease in the designated maximum number of revolutions if necessary to obtain satisfactory mixing:
         1) Incorporate such changes without additional costs to the Owner.
   2. Do not exceed the following time period for mixing and delivery:
      a. Total elapsed time from addition of water at batch plant through discharging of mix: Not to exceed the lesser of 90 minutes or 300 revolutions of the mixer drum.
      b. Total elapsed time for from arrival at the Project Site to completing discharge of mix: Not to exceed 30 minutes.
      c. Under conditions contributing to quick setting, the Engineer may reduce total elapsed time permitted.

D. On-site acceptance of concrete mixes:
   1. Concrete shall possess the properties specified in this Section at the point of placement.
   2. Do not place concrete:
      a. Having slump outside the limits indicated in Table B of this Section.
      b. That does not conform to specifications for entrained air content.
      c. For which the total elapsed time of mixing or elapsed time at the Site exceeds the specified maximums.

3.05 CONVEYING, DEPOSITING, AND CONSOLIDATING CONCRETE

A. Preparation:
   1. General:
      a. Clean construction joints and forming surfaces of dirt, sawdust, chips, and other debris after forms are built and immediately before concrete or grout placement:
         1) Use vacuum cleaner if required to provide clean surfaces.
      b. Remove snow, ice, frost, and standing water from surfaces of formwork, reinforcement, and embeds in contact with concrete.
      c. Secure reinforcement, joint materials, anchors, embeds, and other items in place.
      d. During conveying, placement, consolidation, and finishing of concrete, protect surrounding construction, including concrete walls and slab surfaces, from concrete splatter.
      e. Thoroughly clean surrounding construction at the completion of each placement and before splatter sets up.
   2. Concrete construction on grade:
      a. Provide subgrade preparation, base materials, and compaction as required by the Contract Documents.
      b. Remove loose soils, debris, standing water, snow, or ice from subgrade.
      c. Provide moist subgrade with no standing or free water and no muddy or soft spots:
         1) When subgrade is not moist, sprinkle with water not less than 2 or more than 6 hours in advance of placing concrete.
         2) If subgrade becomes dry prior to actual placing of concrete, sprinkle again, without forming pools of water.
   3. Weather conditions:
      a. Hot weather: In hot weather conditions, make provisions in advance of placement for windbreaks, shading, fogging, sprinkling, ponding, or wet covering.
      b. Cold weather: In cold weather conditions, make provisions to maintain the required concrete temperatures without overheating or drying, and without exposing concrete to carbon dioxide from heater exhaust.
      c. Precipitation:
         1) Do not begin placements while rain, sleet, or snow is falling or anticipated, or unless adequate protection is provided.
         2) Do not allow precipitation to increase concrete water content or to damage the surface of the concrete.
      d. Wind:
         1) Do not begin placements during wind events that will blow dust or debris into the plastic concrete.
         2) Do not allow wind-blown debris to become embedded in or to damage the surface of the concrete.
         3) At all times, have sufficient coverings on hand to protect new concrete from excessive drying or blowing debris.

B. Conveying concrete:
   1. Convey from mixer to place of final deposit by methods that prevent segregation or loss of materials.

2. Use chutes, pumps, and conveyors of size and design that will ensure continuous flow of concrete at point of delivery without cold joints.
3. Design and use chutes and devices for conveying and depositing concrete that direct concrete vertically downward when discharged from the chute or conveying device.
4. Keep conveying equipment clean by thoroughly washing and scraping upon completion of any placement.

C. Depositing concrete:
   1. Do not place concrete under the following conditions:
      a. After initial set has occurred.
      b. When re-tempering has occurred.
   2. Deposit concrete at or near its final position to avoid segregation caused by rehandling or flowing:
      a. Do not use vibrators to move concrete from its point of deposit.
      b. Use tremies for placing concrete where drop is over 5 feet.
   3. Place concrete continuously in approximately horizontal layers not exceeding 24 inches in depth. Bring level up evenly in all parts of forms:
      a. After placement begins, continue without significant interruption and as a continuous operation until the end of that placement is reached.
      b. Do not allow “cold joints” to form between adjacent layers or areas of the placement, or initial set to form on “wet edge” of placements.
      c. Take precautions to prevent delays between placement of adjacent layers or areas from exceeding 20 minutes:
         1) If more than 20 minutes elapse after the initial surface was placed, spread a layer of neat cement grout, as specified for construction joints before depositing additional concrete.
   4. Placing concrete on slopes: Commence placement at bottom of slope and work upward.
   5. Placing horizontal concrete monolithically with structures below:
      a. If concrete for slabs, beams, or walkways is to be cast monolithically with walls or columns below, do not place the horizontal concrete elements until the concrete in walls or columns below has been placed, consolidated, and allowed to achieve initial set.
      b. Allow set time of not less than 1 hour.
      c. Maintain a moist surface at the top of the walls or columns during the setting period.
   6. Placing a second concrete lift over hardened concrete below:
      a. Take special precautions in formwork at top of old lift and bottom of new lift to prevent:
         1) Spreading and vertical or horizontal displacement of forms.
         2) Grout “bleeding” onto finished concrete surfaces.

D. Consolidating concrete:
   1. Thoroughly consolidate concrete into forms and around reinforcement, pipes, and other embeds using mechanical vibrators:
      a. Take special care to place concrete solidly against forms, leaving no voids.
      b. Make concrete solid, dense, compact, and smooth.
   2. Provide vibration energy sufficient to cause concrete to flow and readily settle into place, leaving no voids. Vibration should visibly affect concrete over a radius of at least 18 inches without segregation.

3. Vibrators:
    a. At all times, have sufficient vibrators on hand to consolidate concrete as it is placed.
    b. In addition to vibrators in use while concrete is being placed, have on hand at least 1 spare vibrator in serviceable condition.
    c. Place no concrete until it has been ascertained that vibrating equipment, including spares, is in serviceable condition.

3.06 FINISHING CONCRETE

A. Provide concrete finishes as indicated on the Drawings.

B. Liquid evaporation retardant:
1. Apply evaporation retardant when environmental conditions will result in rapid evaporation of moisture from the surface of the fresh concrete during finishing operations. Such conditions include low humidity, high heat, and wind occurring alone or in combination.
2. Immediately after the concrete is screeded, coat the surface of the concrete with a liquid evaporation retardant.
3. Apply the evaporation retardant again after each work operation as necessary to prevent drying shrinkage cracks and crazing at the surface.

3.07 CURING AND PROTECTING CONCRETE

A. Curing concrete:
1. Cure concrete by methods specified in this Section.
2. Keep concrete continuously moist and at a temperature of at least 50 degrees Fahrenheit for at least 7 days (cure period) after placement unless the details of a particular method specify a longer period.
3. Make provisions to maintain moisture or curing membrane integrity at edges of slabs, tops of walls, and joint surfaces, and to prevent loss of protection.
4. Schedule of curing methods:
    a. Concrete surfaces that will receive additional materials that require bond to the initial placement (including concrete; concrete repairs, coatings, paints, sealers; grout; and other materials):
        1) Water curing or plastic membrane curing.
    b. Formed surfaces:
        1) If non-absorbent forms are left in place for the duration of the cure period after placement: No additional requirements.
        2) For absorbent forms or when forms are removed before the completion of the cure period: Cure by water curing, plastic membrane curing, or sprayed membrane curing.
    c. Unformed concrete surfaces:
        1) Water curing, plastic membrane curing, or sprayed membrane curing.
5. Water curing:
    a. Keep surfaces of concrete constantly and visibly saturated by ponding, continuous fogging, or continuous sprinkling at all times during curing period:
        1) Cover surfaces if required to maintain saturated conditions.

2) For horizontal surfaces, pond the surface with at least 2 inches of water or cover with saturated mats or fabric kept continuously wet.

b. Formed surfaces:
   1) Each day forms remain in place may be counted as 1 day of water curing.
   2) Do not loosen form ties while concrete is being cured by forms left in place.
   3) No further credit for curing time will be allowed after contact between the concrete surface and the forms have been broken.

6. Plastic membrane curing:
   a. Cover concrete with plastic membrane, sealing joints and edges against displacement by wind or Site operations and to prevent loss of moisture.
   b. Install plastic membrane as soon as concrete is finished and can be walked on without damage.
   c. Keep surfaces of concrete under plastic membrane moist at all times during the curing period.
7. Sprayed membrane curing:
   a. Application of curing compound:
      1) Apply curing compound to concrete surface after repairing and patching, and within 1 hour after forms are removed:
         a) If more than 1-hour elapses between removal of forms and application of curing compound, provide water curing of affected surfaces for the full curing period.
      2) Contractor is cautioned that the method of applying curing compound specified in this Section may require more compound than normally suggested by manufacturer of compound, and also more than is customary in the trade.
      3) Apply curing compound by mechanical, power-operated sprayer with mechanical agitator that will uniformly mix all pigment and compound.
      4) Apply compound in at least 2 coats, with each subsequent coat in a direction turned 90 degrees from the preceding coat.
      5) Apply curing compound in sufficient quantity that concrete has uniform appearance and that the natural color of the concrete is effectively and completely concealed immediately after spraying.
      6) Continue to coat and recoat surfaces until specified coverage is achieved and until coating film remains on concrete surfaces.
      7) Apply compound to a film thickness that can be scraped from surfaces at any and all points after drying for at least 24 hours.
      8) Take care to apply curing compound to edges of placements and over full surface profile of construction joints.
   b. Removal of curing compound:
      1) Do not remove curing compound from concrete before the completion of the cure period.
      2) Before placing fresh concrete against a surface previously coated with curing compound, remove the curing compound by heavy sandblasting, or alternate method acceptable to the Engineer.
      3) Prior to final acceptance of the Work, remove any curing compound on surfaces exposed to view by sandblasting or other acceptable method. After removal, only the natural color of finished concrete shall remain visible, and such color shall be uniform over the entire surface.

B. Protecting concrete:
   1. Immediately after placement, protect concrete from hot or cold weather, and mechanical damage.
   2. Temperature:
      a. Cold weather: Protect concrete during the curing period so that the concrete temperature is maintained within the following requirements:
         1) Sections less than 12 inches thick: Minimum 55 degrees Fahrenheit.
         2) Sections 12 to 36 inches thick: Minimum 50 degrees Fahrenheit.
      b. Hot weather: Protect concrete during the curing period so that the concrete temperature does not exceed 90 degrees Fahrenheit.
      c. Remove protection against temperature gradually so that concrete surface temperature does not drop or rise by more than 40 degrees Fahrenheit during any 24-hour period.
   3. Maintain forms, shoring, and bracing in place after concrete placement for a period after concrete placement as indicated in the following paragraphs. Forms may be removed after these periods if the concrete has developed sufficient strength and hardness to resist surface or other damage:
      a. Vertical forms:
         1) General: Minimum 24 hours after concrete placement.
         2) Sides of footings: Minimum 24 hours after concrete placement.
         3) Sides of beams, girders, and similar members: Minimum 48 hours after concrete placement.
      b. Horizontal forms:
         1) Slabs, beams, and girders: Until concrete reaches specified compressive strength, f'c, or until shoring is installed.
      c. Shoring for slabs, beams, and girders:
         1) Shore until concrete strength reaches specified compressive strength, f'c:
            a) Temporary shoring may be required after the specified compressive strength is reached if construction loads will exceed the designated live load capacity of the structure.
      d. Wall bracing:
         1) Brace until strength of concrete beams and slabs laterally supporting the wall reaches specified compressive strength, f'c.

C. Loads against or on the concrete:
   1. Loading of green concrete, by backfilling or by placing personnel and equipment on the surface, is not permitted.
   2. Backfilling: Do not place backfill against concrete walls until the wall and all elements attached to it, including connecting slabs or beams, are fully braced by the structure, and have achieved their minimum specified compressive strength, f'c.

3.08 JOINTS AND JOINT PREPARATION

A. Joint locations and details:
   1. Construct concrete work as monolith to the extent practical.

2. Construct joints as indicated on the Drawings and as specified.
3. Locations of construction, expansion, and other joints are indicated on the Drawings or specified in this Section:
    a. Do not relocate, add, or delete joints without prior approval from the Engineer.

B. Construction joints:
1. Where spacing is not indicated on the Drawings, provide construction joints in slabs and walls at intervals not greater than 35 feet.
2. Construct as indicated on the Drawings.
3. Before placing fresh concrete against the joint: Use heavy sandblast to thoroughly clean joint surfaces and reinforcement crossing the joint of laitance, grease, oil, mud, dirt, curing compounds, mortar droppings, or other objectionable matter.
4. Just before placing concrete against the joint, wash surface with water to saturate joint surface and concrete surfaces within 12 inches of the joint.
5. Horizontal joints:
    a. Immediately before placing concrete, thoroughly spread bed of neat cement grout over the joint surface. Grout shall be as follows:
        1) Use same sand-to-cementitious materials ratio that is used for concrete mix.
        2) Use same materials that are used for concrete.
        3) Use water-to-cementitious materials ratio that is no more than that specified for concrete.
    b. Grout thickness: Not less than 1/2 inch, or more than 1 inch.

C. Expansion joints:
1. Where width is not indicated on the Drawings, provide 3/4-inch wide joint.
2. Construct as indicated on the Drawings.
3. Do not extend reinforcement, conduits, or other items through expansion joints unless details for such crossings are indicated on the Drawings.
4. Preformed expansion joint material:
    a. Accurately position joint filler in the joint:
        1) Fasten to concrete or forms with adhesive.
        2) Fastening joint filler using nails, bolts, screws, or similar items is not permitted.
    b. Tape splices in joint filler to prevent intrusion of mortar.

3.09 TOLERANCES

A. Concrete:
1. Finished concrete: Conform to shapes, lines, grades, and dimensions indicated on the Drawings.
2. In accordance with ACI SPEC-117, except as modified in the following paragraphs:
    a. Where more restrictive tolerances to accommodate equipment are indicated on the Drawings.
    b. Slabs where slope is indicated:
        1) Uniformly slope to drain.
        2) Without depressions that puddle water.

c. Slabs indicated to be level:
    1) Maximum deviation of 1/8 inches in 10 feet without any apparent changes in grade.
    2) Without depressions that puddle water.

B. Embeds:
1. General:
    a. Sleeves and inserts: Plus or minus 1/8 inch.
    b. Projected ends of anchor bolts: Plus 1/4 inch; minus 0 inches.
    c. Anchor bolt position: Plus or minus 1/16 inch.
2. Equipment: Set inserts to tolerances required for proper installation and operation of equipment or systems to which insert pertains.

3.10 FIELD QUALITY CONTROL BY CONTRACTOR

A. Provide quality control over the Work of this Section as specified in Section 01 43 05 - Quality Assurance and Quality Control Requirements.

B. Field tests:
1. During progress of construction, provide testing to determine whether the concrete, as being produced, complies with requirements specified.
2. Sampling and testing shall be performed by the Contractor's testing laboratory. Requirements as specified in Section 01 43 05 - Quality Assurance and Quality Control Requirements:
    a. Cooperate in testing by allowing free access to the Work for testing laboratory to sample and test materials.
    b. Provide full access for the Engineer to observe concrete sampling and testing at any time.
    c. Contractor is responsible for providing care of and curing conditions for test specimens in accordance with ASTM C31 until specimens are collected by testing laboratory.
    d. Provide firmly braced, insulated, heated, closed wooden curing boxes. Include cold weather temperature and hot weather temperature control thermostat for initial curing and storage from time of fabrication through receipt at the Contractor's testing laboratory.
3. Testing shall include:
    a. Sampling of concrete in accordance with ASTM C172.
    b. Temperature of concrete at delivery in accordance with the requirements of ASTM C1064 and as specified in this Section.
    c. Slump of concrete using slump cone in accordance with the requirements of ASTM C143. Test slump at the following intervals:
        1) Test slump at the beginning of each placement.
        2) As often as necessary to keep slump within the specified range, but not less than every 6th truck.
        3) When requested to do so by the Engineer.
        4) Observe concrete during slump test for signs of segregation:
            a) Observe concrete for mortar or moisture flow from slumped concrete.
            b) Reject concrete if mortar or moisture flows out of the mix.
    d. Unit weight of concrete in accordance with ASTM C138.

e. Air entrainment in accordance with ASTM C173. Test air content at the following intervals:
    1) At the beginning of each placement.
    2) As often as necessary to keep entrained air within the specified range, but not less than every 6th truck.
    3) When requested to do so by the Engineer.
f. Compressive strength, f'c, in accordance with ASTM C39. Required number of cylinders:
    1) Not less than 4-cylinder specimens, 4-inch diameter by 8-inches long, will be tested for each 150 cubic yards of each class of concrete; not less than 4 specimens for each half day of placement.
    2) One cylinder will be broken at 7 days and 3 cylinders will be broken at 28 days.

4. Furnish concrete for test specimens and provide manual assistance to testing lab in preparing said specimens.
5. Assume responsibility for providing care and on-site curing and protection for test specimens in accordance with ASTM C31.

3.11 FIELD QUALITY CONTROL BY OWNER

A. As specified in Section 01 43 05 - Quality Assurance and Quality Control Requirements.

B. Special tests and inspections: As specified in Section 01_45_24 - Regulatory Quality Assurance.

C. Field inspections:
1. Observe construction for conformance to the Contract Documents and the accepted Submittals.
2. Records of inspections:
    a. Provide a record of each inspection.
    b. Submit copies to the Contractor upon request.

D. Field tests:
1. Engineer may request, at any time, additional testing to confirm materials being delivered and placed conform to the requirements of the Specifications:
    a. If such additional testing shows that the materials do not conform to the specified requirements, the Contractor shall pay the cost of these tests.
    b. If such additional testing shows that the materials do conform to the specified requirements, the Engineer shall pay the cost of these tests.

3.12 NON-CONFORMING WORK

A. Do not place concrete that does not conform to the requirements of these Specifications. Remove non-conforming materials from the Site.

B. Strength requirements:
1. Concrete is expected to reach higher compressive strength than the minimum specified compressive strength f'c as indicated in Table B of this Section.

2. Concrete strength will be considered acceptable if following conditions are satisfied:
    a. Averages of all sets of 3 consecutive strength test results are greater than or equal to specified compressive strength f'c.
    b. No individual strength test (average of 2 cylinders tested at 28 days) falls below specified compressive strength f'c by more than 500 pounds per square inch.
3. Whenever one or both of the conditions stated above is not satisfied, provide additional curing or testing of the affected portion as directed by the Engineer:
    a. Costs of such curing or testing shall be at the Contractor's expense.

C. Remove and replace or repair defective Work as directed by the Engineer:
1. Do not patch, repair, or cover defective Work before observation by the Engineer.
2. Make no repairs until the Engineer has accepted proposed methods for preparation and repair.

END OF SECTION

SECTION 03_35_29

CONCRETE FINISHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Concrete finishes.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 117-10 - Specification for Tolerances for Concrete Construction and Materials and Commentary.

B. International Concrete Repair institute (ICRI):
   1. Guideline No. 301.2: Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning:
   1. Architectural concrete:
      a. Concrete surfaces that will be exposed to view in the finished work:
         1) For purposes of this Section, includes exposed concrete surfaces that are designated to receive paint or coatings.
         2) Exposed concrete in open basins, channels, and similar liquid-containing structures: Surfaces will be considered exposed to view if located above the water line as defined in this Section.
   2. Grade line: A reference line that separates surfaces considered to be above grade from those considered to be below grade. Located 12 inches below finished grades at the perimeter of the structure.
   3. Water line: A reference line that separates surfaces considered to be above the water level (and visible in the finished work) from those considered to be below the water level (and not visible in the finished work). For each water-bearing cell of a structure, defined as a line located 2 feet below the normal operating water level in that cell.

1.04 QUALITY ASSURANCE

A. Qualifications:
   1. Finishing personnel:
      a. Use qualified flatwork finishers.
      b. Finishing supervisor must have at least 5 years of experience finishing concrete.

B. Mockups:
    1. Construct mockup panels showing finishing of formed surfaces for review by the Engineer:
        a. Construct mockup panels demonstrating concrete finishes for vertical surfaces:
            1) Construct mockup panels for F4 and F5 finishes and tie-hole repairs for review by the Engineer.
    2. Construct mockup slabs showing finishing of unformed surfaces for review by the Engineer:
        a. Construct mockup slabs demonstrating concrete finishes for horizontal surfaces:
            1) Construct mockup slabs for S1, S2, S4, and S5 finishes.
    3. Include the following elements in mockup panels and slabs:
        a. Concrete joints:
            1) Horizontal and vertical joints of the types included in the Work.
        b. Concrete repairs:
            1) Repairs using materials and procedures proposed for the Work.
    4. Construct mockup panels and slabs at beginning of project for review by the Engineer.
    5. Panels and portions thereof accepted by the Engineer will serve as the standard of quality and workmanship for the Work.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
    1. Deliver and store packaged materials in original containers until ready for use.

PART 2 PRODUCTS

2.01 MATERIALS

A. Materials for mortar:
    1. As specified in Section 03_30_01 - Concrete Work, unless otherwise noted.
    2. Where finished surfaces will be visible in the finished work, use same cement used for concrete batches in that area. Add white cement if required to obtain color match between base concrete and finishing mortars.

2.02 MIXES

A. Cement mortar:
    1. As specified in Section 03_60_00 - Grouting.

B. Dry-pack mortar:
    1. As specified in Section 03_60_00 - Grouting.

PART 3 EXECUTION

3.01 CONCRETE FINISHING - FORMED SURFACES

A. Scope:
   1. Finish formed surfaces with one of the finishes specified in the following paragraphs and as indicated in the Schedule of Concrete Finishes in this Section.
   2. Formed surfaces are those surfaces that the plastic concrete is placed against a temporary containment surface that will be removed after the concrete sets and takes its final form.

B. General:
   1. Provide setting and curing time from casting of concrete to removal of forms as specified in Section 03_30_01 - Concrete Work.
   2. Provide curing after removal of forms as specified in Section 03_30_01 - Concrete Work.
   3. Materials and mixes for finishes:
      a. Cement: Add white cement to mortars and grouts used for finishing if required to match color of repairs to surrounding surfaces.
   4. Grinding:
      a. Where grinding of concrete surfaces is permitted:
         1) Perform grinding using an iron-free wheel, such as an aluminum oxide wheel, to avoid entrapment of particles that produce rust stains.
         2) At locations where plastic-protected reinforcing bar supports are used, limit grinding to a maximum depth of 1/16 inch.

C. F3 finish: “Smooth Form Finish”:
   1. Repair defective work.
   2. Repair rough or irregular surface finishes resulting from failure of form release agent or other form conditions and provide a smooth, uniform surface appearance.
   3. Remove fins: Grind offsets, projections, and rough spots smooth.
   4. Fill tie holes using dry pack mortar.
   5. Fill depressions:
      a. Fill after removal of any curing compounds.
      b. Fill depressions 1/4 inch and larger in depth or width using cement mortar.
      c. For larger depressions, fill using dry pack mortar.
   6. Top coat tie holes and filled depressions with cement mortar to provide uniform appearance.
   7. Leave surfaces with texture that is generally smooth and uniform in appearance.
   8. Surface irregularity: Not exceeding a 1/8-inch gap when measured over the length of a 5-foot straightedge.

3.02 CONCRETE FINISHING - UNFORMED SURFACES

A. Scope:
   1. Finish unformed surfaces with one of the finishes specified in the following paragraphs and as indicated in the Schedule of Concrete Finishes in this Section.
   2. Unformed surfaces are those surfaces that are not cast against a temporary containment and the specified finish is achieved by tooling.

B. General:
   1. Concrete placement:
      a. Place concrete at a rate that allows spreading, straight-edging, and initial floating before bleed water appears:
         1) Consider characteristics of concrete mixes used, including potential for accelerating or retarding effects of admixtures, fly ash, and temperatures, on plans for and scheduling of placement and finishing.
      b. Place, consolidate, strike-off, and screed concrete level to bring surfaces to required planes and lines. Eliminate high and low spots.
      c. Strike tops of walls and similar surfaces smooth and finish as specified to a texture consistent with that of adjacent formed surfaces.
      d. After screeding, apply evaporation retardant to concrete surface if weather conditions will result in rapid evaporation of moisture from the surface of the concrete. Do not work evaporation retardant into the surface of the concrete.
   2. Floating and re-straightening:
      a. Float concrete to compact and consolidate the surface.
      b. Initial floating:
         1) Provide initial floating immediately after screeding.
         2) Perform by hand using a wide bull float, darby, or highway straightedge.
         3) Complete before excess moisture or bleed water is present on the surface.
      c. Wait for concrete to stiffen and for the bleed water to stop rising and dissipate before proceeding with edging, hand-tooled jointing, and second floating.
      d. After initial floating, apply evaporation retardant to concrete surface if weather conditions will result in rapid evaporation of moisture from the surface of the concrete. Do not work evaporation retardant into the surface of the concrete.
      e. Second floating:
         1) Do not commence until bleed water has dissipated and concrete has stiffened enough to support weight of finishers and finishing equipment.
         2) May be by hand, or, if accepted by the Engineer, may be done using a bladed power float equipped with float shoes, or a power disk float.
         3) Float surfaces to a true, even plane, with no coarse aggregate visible.
         4) Evaporation retardant may not be applied after second floating.

f. Flatness:
    1) Specified tolerances for flatness may require re-straightening of the surface between first and second floating operations and before steel troweling. Re-straighten concrete as required.
    2) Modify power equipment with alternate float shoes or other equipment if required to achieve specified flatness.

3. Troweling: Where finishes require troweling, conform to the following requirements:
    a. After surface moisture from floating has disappeared, steel trowel to a smooth, hard, dense concrete surface.
    b. Provide at least 2 trowelings:
        1) Avoid excessive troweling.
        2) Use smaller trowels for successive troweling.
        3) Make each successive troweling perpendicular to the previous pass.
    c. Do not add dry cement or additional water to the surface during troweling.
    d. In lieu of hand steel troweling, a power machine for finishing concrete may be used if accepted by the Engineer:
        1) Do not use power machine if concrete has not attained the set necessary to permit finishing without introduction of high and low spots into the concrete surface.
        2) Use equipment in full compliance with the manufacturer's recommendations.
        3) Use smaller blades or higher pressure for each successive troweling.
        4) Hand trowel areas of the concrete not accessible to power equipment.
        5) Tolerances for flatness specified may require re-straightening of the surface during finishing. Modify power equipment with alternate shoes or other equipment if required to achieve these requirements.
    e. Finishing with a fresno trowel or finishing to a "fresno finish" is not allowed.
4. Finishing tolerances:
    a. Slabs sloped to drain: Finish surfaces to adequately drain toward designated points or lines, regardless of tolerances specified.

C. S2 finish: "Floated Finish":
1. Place, consolidate, and screed concrete to required elevations and slopes.
2. Provide initial and second floatings of concrete. Float to a uniform texture.
3. Provide surface conforming to the "Flat" floor flatness tolerance requirements of ACI 117 using the manual straightedge method (maximum 1/4-inch gap in 10 feet at 90 percent of locations; maximum 3/8-inch gap at any location), unless otherwise indicated.
4. Remove laitance and leave surface clean.

3.03 FIELD QUALITY CONTROL

A. Provide field quality control for the Work of this Section as specified in Section 01 43 05 - Quality Assurance and Quality Control Requirements.

3.04 NON-CONFORMING WORK

A. Unsatisfactory finishes that have hardened will require removal, grinding, topping, or other correction acceptable to the Engineer.

B. Re-work or refinish unsatisfactory finishes at no additional cost to the Owner.

C. See Section 03_30_01 - Concrete Work for requirements.

3.05 SCHEDULE OF CONCRETE FINISHES

A. Formed surfaces:
   1. Vertical surfaces of cast in place equipment pads, containment basins, and pipe support footings:
      a. F3 finish.

B. Unformed surfaces:
   1. Horizontal surfaces of cast in place equipment pads, containment basins, and pipe support footings:
      a. S2 finish.

END OF SECTION

SECTION 03_48_53

PRECAST CONCRETE UTILITY STRUCTURES AND PRODUCTSGENERAL

1.01 SUMMARY

A. Section includes:
   1. Precast concrete products manufactured to ASTM industry standards.

B. Alternates:
   1. Contractor may propose to construct cast-in-place structures in lieu of the precast structures specified.
      a. Obtain the Engineer's acceptance of this alternative before submitting, providing, or installing.
      b. Submit full information on design and detailing of proposed alternatives, including design details and drawings of the same types required by this Section for precast structures.

C. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes "American Iron and Steel (AIS)" requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Association of State Highway Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

B. American Concrete Institute (ACI):
   1. 318 - Building Code Requirements for Structural Concrete and Commentary.

C. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. C94 - Standard Specification for Ready-Mixed Concrete.
   3. C443 - Standard Specification for Joints for Concrete Pipe and Manholes Using Rubber Gaskets.
   4. C478 - Standard Specification for Circular Precast Reinforced Concrete Manhole Sections.
   5. C857 - Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
   6. C858 - Standard Specification for Underground Precast Concrete Utility Structures.
   7. C890 - Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures.
   8. C891 - Standard Practice for Installation of Underground Precast Concrete Utility Structures.
   9. C913 - Standard Specification for Precast Concrete Water and Wastewater Structures.

10. C990 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint.
11. C1037 - Standard Practice for Inspection of Underground Precast Concrete Utility Structures.
12. C1244 - Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill.
13. C1260 - Standard Test Method for Potential Alkali Reactivity of Aggregates.
14. C1293 - Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction.
15. C1567 - Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method).
16. C1778 - Standard Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete.

D. Code of Federal Regulations (CFR):
   1. Title 29, Chapter XVII, Part 1910 - Occupational Safety and Health Standards (OSHA).

E. National Precast Concrete Association (NPCA).

F. City of Santa Cruz Standard Specifications.

G. City of Capitola Public Improvement Design Standards.

H. County of Santa Cruz Standards of Construction.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Culvert: A single cell precast box element open on opposing faces intended to be used to form a linear structure to convey stormwater or sewage.
   2. Drainage inlet: A drainage structure that collects and diverts stormwater into a below grade conveyance system.
   3. Handhole: An enclosure for use in underground electrical systems that has been sized and detailed to allow personnel to reach into, but not enter, the enclosure to install, operate, or maintain equipment or wiring or both.
   4. Manhole: An enclosure for use in underground systems that has been sized and detailed to allow personnel to enter the enclosure to access, install, operate, or maintain equipment, wiring, or clean or service piping. As specified in this Section, manhole may refer to a sewer manhole, stormwater manhole, or electrical manhole.
   5. Precast concrete: A concrete fabrication designed by a qualified engineer and subsequently fabricated at a qualified fabrication site, which is usually located some distance from the site where the fabrication will be installed.
   6. Vault: A below grade enclosure designed to house equipment or instrumentation.

1.04 DELEGATED DESIGN

A. As specified in Section 01_35_73 - Delegated Design Procedures.

B. Shop Drawings and calculations for precast concrete utility products.

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures and Section 01 61 00 - Common Product Requirements.

B. Product data:
   1. Manufacturer's catalog data, details, and warranties for the following items.
      a. Materials of construction.
      b. Joint details and joint-sealing materials.
      c. Data for hatches or covers and frames.
      d. Threaded lifting inserts.

C. Delegated Design Submittals:
   1. Shop Drawings:
      a. Dimensioned plans, sections, and details drawn to scale for each structure, including:
         1) Layout plan for that structure.
         2) Sizes, locations, and vertical positions of pipe penetrations, duct bank windows, and knockout panels.
         3) Locations and details for access openings and sumps.
         4) Details of structural reinforcement showing bar size and spacing; true position of reinforcement in structural members with clear concrete cover at both inside and outside faces; location, bar size, and spacing of added reinforcement around openings; and other details relevant to design and fabrication of the structure.
         5) Details of joints between adjacent precast sections, including provisions for overlap and for placement of sealants.
   2. Calculations:
      a. Submit calculations that demonstrate the adequacy of the precast to support the required loads:
         1) Temporary loads during manufacture, including casting, handling, transportation, and installation.
         2) Specified final soil, fluid, and live loads.
   3. Concrete mix design.
      a. Certification from the manufacturer's engineer that the concrete mix used for manufacture is in accordance with the specified ASTM standard, the additional durability performance requirements, and the aggregate reactivity mitigation requirements listed in this Section. Certification shall include the following aggregate reactivity data:
         1) Sources, grading, and specific gravities of aggregates.
         2) Aggregate reactivity data.
            a) ASTM C1260 and ASTM C1293 test results for:
               (1) Coarse aggregate.
               (2) Fine aggregate.

b) If reactivity test results of either coarse or fine aggregates indicates a potential for reactivity, indicate the method by which the risk reduction measures of ASTM C1778 are satisfied. See Design and Performance Criteria in this Section for durability requirements.

D. Installation instructions:
   1. Detail the complete installation of the equipment, including rigging, moving, and setting into place.
   2. Provide manufacturer's installation instructions.
   3. Instructions for operation and maintenance of hatches.

E. Quality Control Submittals:
   1. Test reports:
      a. Manufacturer's tests for compressive strength of concrete used in products, made in accordance with the specified ASTM requirements.
      b. Reinforcing steel: Mill certificates.
      c. Manufacturer's inspection reports in accordance with ASTM C1037.
   2. Certificates:
      a. Manufacturer's current plant certification under NPCA for the products to be supplied.
         1) Certification shall be current and in effect at the time products are manufactured.
      b. Manufacturer's certification that the precast products are in accordance with the requirements of the standard specified in Part 2.

F. Project record documents:
   1. Final revised plans and details of as-constructed precast concrete products if requested for record by the Engineer.

1.06 QUALITY ASSURANCE

A. Qualifications:
   1. Manufacturer:
      a. Holding current NPCA plant certification for the products produced.
      b. Demonstrating at least 5 years of experience in the design, production, and installation of products of the type required for this Work.
      c. Capable of providing structural designs in the state where the products will be installed.
      d. Providing inspection during fabrication and handling in accordance with the requirements of ASTM C1037.
      e. Provide permanent quality control department and laboratory facility capable of performing inspections and testing as specified in this Section.
   2. Installer:
      a. Capable of providing equipment of adequate capacity and mobility to handle and set units with proper bearing on the subgrade and without damage to the unit.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01 61 00 - Common Product Requirements, and the manufacturer's instructions.

B. Packing, shipping, handling, and unloading:
   1. Package and brace structures to avoid damage during shipping and handling.
   2. Furnish crane or forklift for unloading and setting of the precast concrete products. Equipment shall be rated to lift the intended load.
   3. Transport and handle precast products in accordance with the manufacturer's instructions.
      a. Where lifting devices are provided in precast sections, such lifting devices shall be used as intended.
      b. Where no lifting devices are provided, follow the manufacturer's recommendations for lifting procedures to provide proper support during lifting.
      c. Dragging or dropping of precast concrete products are not permitted.

C. Acceptance at Site:
   1. Structures delivered to the Site with cracks, damage, and damaged or missing accessories shall be removed from the Site and replaced at no additional cost to the Owner.
   2. Furnish labor necessary to assist the Engineer in inspecting manholes upon delivery.

D. Storage and protection:
   1. Store precast concrete utility structures, products, and their appurtenances in areas protected from damage due to weather and Site operations.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawing.

1.09 SEQUENCING

A. Coordinate installation of precast electrical handholes and manholes with duct banks specified in Section 26_05_44 - Duct Banks.

1.10 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

B. Provide manufacturer's standard warranty for precast products and accessories.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01 61 00 - Common Product Requirements.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Design, manufacture, and install precast concrete members as indicated on the Drawings and specified.

B. Design and detail precast concrete members and connections to withstand design loads indicated, to maintain clearances at openings; to allow for fabrication and installation tolerances.
   1. Analyze and design structures, including the effects of 2-way action ("plate action") and of load transfer around current and future openings.
   2. Where structures include panels designed for future removal ("knockout panels"), design structures for loads and stresses with any combination of any or all such panels in place or removed.
   3. Design structures in accordance with the requirements of ACI 318 or AASHTO Standard Specifications for Highway Bridges and this Section.
   4. Provide reinforcement at areas subject to tensile stress when loaded with the specified loads and combinations thereof.

C. Unless otherwise indicated on the Drawings, design precast products as follows:
   1. Use "roadway" load designation for all utility structures located in or within 15 feet of roadways.
   2. Use "sidewalk" load designation for all utility structures that do not require "roadway" designation.

D. Structural analysis, including loads on structures, and design:
   1. For structures designated to be in accordance with ASTM C857, follow the requirements of that standard, except as modified in this Section as follows:
      a. Vehicle and pedestrian loadings in the following paragraphs need not be additive, however, structures designated for "roadway" loading shall also support "sidewalk" loads.
         1) Sidewalk: Load from regular pedestrian traffic with considerations for occasional non-deliberate vehicular traffic: Designation A-0.3 in ASTM C857, Table 1 (300-psf uniform load).
         2) Roadway: Load from heavy, frequently repeated vehicle traffic: Designation A-16 in ASTM C857, Table 1 (AASHTO HS20-44).
      b. Lateral earth pressure loads: Determine in accordance with the following requirements. Include effects of groundwater and seismic accelerations on lateral earth pressures.
         1) Equivalent lateral pressure: minimum 30 pounds per square foot per foot of depth (triangular distribution).
         2) Surface surcharge load:
            a) Backfill-induced live load surcharge of 100 pounds per square foot (rectangular distribution) for 10-feet depth from finish grade.
            b) In accordance with ASTM C857 Vehicle Load Designation A-16 for Roadway, or A-0.3 for Sidewalk, where such surcharge exceeds backfill loads described in the preceding paragraph.
         3) Groundwater effects:
            a) Include effects from groundwater and soils saturated by flooding to site finished grade elevation.

b) Use equivalent lateral pressure of 63 pounds per square foot per foot of depth (triangular distribution) for soil below the design groundwater elevation.

c. Groundwater and flood loads - buoyancy effects:
   1) As specified in technical sections and as indicated on the Drawings, for design groundwater and design flood elevations.
   2) Design for site groundwater elevation taken at the level of finished grade around the structure.
   3) Buoyancy: For groundwater and flood conditions, provide factor of safety against flotation of at least 1.20.
      a) If the weight of soil overlying footing projections on the structure is considered to resist flotation, use a buoyant unit weight of soil equal to not more than 30 pounds per cubic foot.

d. Soil-bearing pressure at base:
   1) Maximum 1,000 pounds per square foot total pressure on prepared subgrade soils.

e. Lifting and handling loads:
   1) Make provision in the design for the effects of loads or stresses that may be imposed on structures during fabrication, transportation, or installation.

f. Load combinations:
   1) Design structures to sustain the specified loads individually or in combination.

2. For structures designated to be in accordance with ASTM C890, follow the specified design requirements for loads, except as modified for hydrostatic load as follows:
   a. Hydrostatic load:
      1) Design for dead, live, lateral earth pressures, seismic loads, groundwater and flood loads, soil-bearing pressure, lifting and handling loads as specified for structures to be designed for ASTM C857.
         a) Design for fluid elevation taken at the top of the structure.

E. Materials:
   1. Proportion cement, supplemental cementitious materials, aggregates, admixtures, and water in accordance with the specified ASTM standard.
   2. Aggregate reactivity.
      a. If reactivity test results of either coarse or fine aggregates indicates a potential for reactivity, the concrete mix design shall be proportioned with an appropriate supplemental cementitious material to mitigate the potential risk of aggregate silica reaction in accordance with either the performance-based approach or the prescriptive-based approach of ASTM C1778.
         1) If the performance-based approach is used, ASTM C1567 and ASTM C1293 test results must be available.
         2) If the prescriptive-based approach is used, the following parameters shall be assumed:
            a) Concrete is exposed to humid air, buried, or immersed.
            b) Structure classification based on the severity of consequences: SC3 (Precast elements in which economic costs of replacement are severe).

2.03 GENERAL

A. Identification markings: Provide identification marks on the exterior of bases, risers, grade rings, and include the following information:
   1. Date of manufacture of the item.
   2. Name or trademark of the manufacturer.
   3. Internal dimensions in inches.
   4. Number of the precast structure as indicated on the Drawings.

B. Precast products shall be solid walled construction.
   1. Where penetrations of the precast concrete walls are required for piping, conduit, or duct banks, such penetrations shall be accommodated through precast openings or core-drilled sections.
   2. Wall openings shall be smooth and free of surface irregularities and without exposed steel reinforcing.
   3. Precast need not be designed to resist thrust from piping passing through the vault unless indicated on the Drawings.
   4. Coordinate opening locations with piping or duct bank arrangement as indicated on the Drawings.

C. Joints in precast products:
   1. Construct floors as a monolith. Where sump or low-point drain is included, slope floor to that point.
   2. Where joints are designed in precast concrete products, such joints shall be interlocking to secure proper alignment between members and prevent migration of soil or water through the joint. Provide structures with non-skid, shiplap or tongue and groove joints between sections.
   3. Joints shall be sized sufficiently to reinforce the section against localized distress during transportation and handling and against excess contact bearing pressures through the joint.
   4. Seal joints watertight with precast concrete joint sealant as specified in this Section.
   5. Provide structures with watertight joints between sections and detailed to minimize water infiltration at duct bank and conduit penetrations.

2.04 PRECAST CONCRETE VAULTS

A. Includes reinforced precast concrete section comprised of one or more components that, when properly assembled in the field, forms a vault that houses piping or instrumentation.

B. Manufacturers:
   1. One of the following or equal.
      a. Jensen Precast.
      b. Oldcastle Precast.

C. Design basis:
   1. Furnish precast concrete vaults in accordance with the requirements of ASTM C858.
   2. Furnish products of nominal sizes as indicated on the Drawings.

3. Structural design in accordance with ASTM C858 and the requirements of ASTM C857, and Design and Performance Criteria in this Section.

D. Materials:
   1. Concrete in accordance with ASTM C858 and as specified in this Section.

2.05 PRECAST CONCRETE MANHOLES

A. Precast concrete manholes include grade rings, flat slab tops, conical tops, risers, and base sections.

B. Manufacturers:
   1. One of the following or equal:
      a. Jensen Precast.
      b. Oldcastle Precast.

C. Design basis:
   1. Furnish precast concrete manholes that are in accordance with the requirements of ASTM C478.
   2. Furnish products of nominal sizes as indicated on the Drawings.
   3. Structural design in accordance with the prescriptive requirements of ASTM C478 and Design and Performance Criteria in this Section.
   4. Maximum elevation from top of conical top section to final grade: 18 inches.
   5. Furnish grade rings in 1 or 2 sections.

D. Materials:
   1. Concrete in accordance with ASTM C478 and as specified in this Section.

2.06 PRECAST CONCRETE ELECTRICAL MANHOLES AND HANDHOLES

A. Precast concrete manholes and handholes include reinforced precast box sections comprised of one or more components that, when properly assembled in the field, form a vault that may be used to route electrical conduits and conductors or house electrical or instrumentation equipment.

B. Design basis:
   1. As specified in Section 26_05_00 - Common Work Results for Electrical for general requirements for electrical work.
   2. Furnish products of nominal sizes as indicated on the Drawings.
   3. Precast concrete manholes and handholes in accordance with the requirements of ASTM C858.
   4. In accordance with the requirements of the NEC.
   5. Structural design in accordance with the requirements of ASTM C857 and specified in this Section.
   6. Install embedded items with provisions for drainage to remove dripping or standing water, and to minimize corrosion.
      a. Pulling irons may not be placed on the floor or in pockets that will collect water.
      b. Detail bottom of cable rack channels to provide a downward sloping “sill” at the bottom of each vertical channel, so that the channel slot drains toward the floor.

C. Manufacturers:
   1. One of the following or equal:
      a. Jensen Precast.
      b. Oldcastle Precast.

D. Materials:
   1. Concrete in accordance with ASTM C858 and as specified in this Section.

E. Tests and inspections:
   1. In accordance with ASTM C858 and ASTM C1037.

2.07 APPURTENANCES

A. Manholes:
   1. Manholes and manhole accessories, including frame and cover, within the Beltz 8 site shall confirm to City of Santa Cruz Standard Specifications, except where indicated otherwise.
   2. Manholes and manhole accessories, including frame and cover, within the 38th Avenue right-of-way to County of Santa Cruz Standards of Construction.
   3. Manholes and manhole accessories, including frame and cover, within the Roland Drive right-of-way shall confirm to City of Capitola Public Improvement Design Standards.

2.08 OTHER MATERIALS

A. Coatings:
   1. Dampproofing: As specified in Section 07_11_00 - Dampproofing.

B. Joint sealant:
   1. Preformed, cold applied flexible joint sealant in accordance with ASTM C990 and ASTM C443.
   2. Manufacturers:
      a. One of the following or equal.
         1) Henry Corp., Ram-Nek.
         2) Kent Seal - Hamilton Kent Corp.
   3. Physical properties:
      a. Hydrocarbon content: 50 to 70 percent.
      b. Inert mineral filler: 30 to 50 percent by weight.
      c. Volatile matter: 2.0 to 3.0 percent by weight lost when heated for 5 hours at 325 degrees Fahrenheit.
      d. Specific gravity: 1.20 to 1.35 at 77 degrees Fahrenheit.
      e. Ductility: 5.0 at 77 degrees Fahrenheit.
      f. Softening point: 320 degrees Fahrenheit.
      g. Sag or flow: None.
      h. Chemical resistance: No reaction when exposed for 30 days by 5 percent sulfuric acid, potassium hydroxide, caustic potash, and hydrochloric acid; and saturated hydrogen sulfide solution.
   4. Precast concrete joint sealer primer: As recommended by the precast concrete joint sealer manufacturer.

2.09 SOURCE QUALITY CONTROL

A. Source Testing (Factory Acceptance Tests):
   1. As specified in Section 01 91 00 - Commissioning.
   2. Precast concrete manholes:
      a. Perform pre-production and post-production tests by the manufacturer.
      b. Examine each completed manhole section for dimensional requirements, strength, and workmanship.
      c. Complete required testing in accordance with ASTM C478.
   3. All tools and equipment shall have current calibrations.
   4. Furnish test reports and the Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 GENERAL

A. Furnish and install precast concrete products as indicated on the Drawings and specified.

B. Manufacturer shall make available services of representative throughout the project duration when deemed necessary by the Engineer.

3.02 PREPARATION

A. Site preparation:
   1. Excavate and prepare exposed subgrade as indicated on the Drawings and as specified.
   2. Install and compact foundation layer as indicated on the Drawings and specified.
   3. Level foundation materials so that structures will be set plumb and duct banks will be at proper grade and alignment.
      a. Install with uniform bearing on foundation materials.
      b. Wedging or blocking of base sections for leveling over the foundation materials will not be permitted.

3.03 INSTALLATION

A. General:
   1. Protect precast concrete utility structures from displacement, flooding, or flotation.
   2. Install structures in accordance with ASTM C891 and as specified in this Section.
      a. In the event of conflicts, the more restrictive provisions shall apply.
   3. Clean and prime joints between adjacent precast sections.
      a. Install joint sealant between sections in accordance with the manufacturer's instructions and provide watertight joints.
   4. Set manhole covers and floor access doors at elevations indicated on the Drawings.
      a. Lay grade rings in joint sealant with sides plumb and tops level. Securely attach frames to top of precast structures or grade rings.

5. Penetrations:
    a. Holes for duct banks, piping, and other penetrations may not be cut into precast products unless they are located at designated locations shown on the Shop Drawings or at knockout panels cast into the structure during manufacturing.
    b. Carefully remove concrete from knockout panel areas with saws.
        1) Ensure that break-back does not extend beyond the designated limits of the knockout panel.
    c. Coat any reinforcement cut or exposed during removal of knockout panel sections with minimum 2 coats of high solids epoxy as specified in Section 09_96_01 - High-Performance Coatings.
        1) Apply epoxy coating applied over and at least 1 inch past the perimeter of the reinforcement.
6. Install duct banks, conduit, and pipe penetrations in accordance with the penetration details indicated on the Drawings.
    a. Place joint fillers, caulks, and sealants before coating exterior concrete surface with bituminous dampproofing.
7. Fill blockouts that were provided for threaded lifting inserts or other temporary purposes with non-shrink cement grout using procedures as specified in Section 03_60_00 - Grouting, unless otherwise detailed by the manufacturer.
8. After structures are set and before backfilling, coat exterior below-grade surfaces (around the sidewalls, over the top slab, around any vertical risers to grade, and to face of grade rings) with 2 heavy coats of bituminous dampproofing as specified in Section 07_11_00 - Dampproofing.
    a. Mask over at least 1 inch back from joint caulks or sealants and prevent dampproofing from coming in contact with those materials.
    b. Apply dampproofing in accordance with the coating manufacturer's instructions and at a rate of 40 to 60 square feet per gallon per coat.
    c. Allow dampproofing to dry sufficiently before backfilling.
9. Backfill precast concrete products as indicated on the Drawings and as specified in Section 31_00_00 - Earthwork.

B. Site tolerances:
1. Set precast concrete products plumb and true at locations indicated on the Drawings.
2. Tolerances on placing:
    a. Horizontal location: Within 1 inch.
    b. Vertical elevation: Within 1/2 inch.
    c. Plumb: Within 1/8 inch over 10 feet.

3.04 REPAIR/RESTORATION

A. Repair cracks or blemishes in concrete as specified in Section 03_30_01 - Concrete Work.

3.05 FIELD QUALITY CONTROL BY CONTRACTOR

A. As specified in Section 01 43 05 - Quality Assurance and Quality Control Requirements.

3.06 FIELD QUALITY CONTROL BY OWNER

A. Special tests and inspections: As specified in Section 01_45_24 - Regulatory Quality Assurance.

B. Field tests:
   1. Engineer may request, at any time, additional testing to confirm materials being delivered and placed conform to the requirements of the Contract Documents.
      a. If such additional testing shows that the material do not conform to the specified requirements, the Contractor shall pay the cost of these tests.
      b. If such additional testing shows that the materials do conform to the specified requirements, the Owner will pay the cost of these tests.

3.07 ADJUSTING

A. After final grading is complete, adjust access covers to grade.

3.08 CLEANING

A. Remove concrete spoil, other construction material, forms, debris, silt, dust, and other foreign material.

B. Pressure wash interior of structures if required to provide clean interior surfaces.
   1. Block drains and provide pumps to remove washwater from structures.
   2. Do not permit washwater to drain into subgrade soils.

END OF SECTION

SECTION 03_60_00

GROUTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Cement grout.
   2. Cement mortar.
   3. Dry-pack mortar.
   4. Epoxy grout.
   5. Grout.
   6. Non-shrink epoxy grout.
   7. Non-shrink grout.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (using 2-inch cube specimens).
   2. C230 - Standard Specification for Flow Table for Use in Tests of Hydraulic Cement.
   3. C531 - Standard Test Method for Liner Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes.
   4. C579 - Standard Test Method for Compressive Strength of Chemical-Resistant Mortars, Grouts, and Monolithic Surfacings and Polymer Concretes.
   5. C939 - Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method).
   6. C942 - Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory.
   7. C1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).
   8. C1181 - Standard Test Methods for Compressive Creep of Chemical-Resistant Polymer Machinery Grouts.

B. International Concrete Repair Institute (ICRI):
   1. 310.2R - Selecting and specifying Concrete Surface Preparations for Sealers, Coatings, Polymer Overlays, and Concrete Repair.

1.03 SUBMITTALS

A. Cement grout:
   1. Mix design.
   2. Material Submittals.

B. Cement mortar:
   1. Mix design.
   2. Material Submittals.

C. Non-shrink epoxy grout:
   1. Manufacturer's literature.

D. Non-shrink grout:
   1. Manufacturer's literature.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to jobsite in their original, unopened packages or containers, clearly labeled with manufacturer's product identification and printed instructions.

B. Store materials in cool dry place and in accordance with manufacturer's recommendations.

C. Handle materials in accordance with the manufacturer's instructions.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Non-shrink epoxy grout:
   1. Manufacturers: One of the following, or equal:
      a. Five Star Products, Inc., Five Star DP Epoxy Grout.
      b. L&M Construction Chemicals, Inc., EPOGROUT.
      c. Master Builder Solutions/Sika, MasterFlow 648.
   2. Non-shrink epoxy grout shall be 100 percent solid, premeasured, prepackaged system containing 2-component thermosetting epoxy resin and inert aggregate.
   3. Maintain flowable consistency for at least 45 minutes at 70 degrees Fahrenheit.
   4. Shrinkage or expansion: Less than 0.0006 inches per inch when tested in accordance with ASTM C531.
   5. Minimum compressive strength: 10,000 pounds per square inch at 24 hours and 14,000 pounds per square inch at 7 days when tested in accordance with ASTM C579, Method B.
   6. Compressive creep: Not exceed 0.0037 inches/per inch when tested under 400 pounds per square inch constant load at 140 degrees Fahrenheit in accordance with ASTM C1181.
   7. Coefficient of thermal expansion: Not exceed 0.000018 inches per inch per degree Fahrenheit when tested in accordance with ASTM C531, Method B.

B. Non-shrink grout:
   1. Manufacturers: One of the following, or equal:
      a. Five Star Products, Inc., Five Star Grout.
      b. L&M Construction Chemicals, Inc., CRYSTEX.
      c. Master Builder Solutions/Sika, MasterFlow 928.
   2. In accordance with ASTM C1107.
   3. Preportioned and prepackaged cement-based mixture.

4. Contain no metallic particles such as aluminum powder and no metallic aggregate such as iron filings.
5. Require only addition of potable water.
6. Water for pre-soaking, mixing, and curing: Potable water.
7. Free from emergence of mixing water from within or presence of water on its surface.
8. Remain at minimum flowable consistency for at least 45 minutes after mixing at 45 degrees Fahrenheit to 90 degrees Fahrenheit when tested in accordance with ASTM C230:
    a. If at fluid consistency, verify consistency in accordance with ASTM C939.
9. Dimensional stability (height change):
    a. In accordance with ASTM C1107, volume-adjusting Grade B or C at 45 degrees Fahrenheit to 90 degrees Fahrenheit.
    b. Have 90 percent or greater bearing area under bases.
10. Have minimum compressive strengths at 45 degrees Fahrenheit to 90 degrees Fahrenheit in accordance with ASTM C1107 for various periods from time of placement, including 5,000 pounds per square inch at 28 days when tested in accordance with ASTM C109 as modified by ASTM C1107.

2.02 MIXES

A. Cement grout:
    1. Use same sand-to-cementitious materials ratio for cement grout mix that is used for concrete mix.
    2. Use same materials for cement grout that are used for concrete.
    3. Use water-to-cementitious materials ratio that is no more than that specified for concrete.
    4. For spreading over surfaces of construction or cold joints.

B. Cement mortar:
    1. Use same sand-to-cementitious materials ratio for cement mortar mix that is used for concrete mix.
    2. Use same materials for cement mortar that are used for concrete.
    3. Use water-to-cementitious materials ratio that is no more than that specified for concrete being repaired.
    4. At exposed concrete surfaces not to be painted or submerged in water: Use sufficient white cement to make color of finished patch match that of surrounding concrete.

C. Dry-pack mortar:
    1. Proportions by weight: 1 part Portland cement to 2 parts concrete sand:
        a. Portland cement: As specified in Section 03_30_01 - Concrete Work.
        b. Concrete sand: As specified in Section 03_30_01 - Concrete Work.

D. Epoxy grout:
    1. Consists of mixture of epoxy or epoxy gel and sand.
        a. Epoxy: As specified in Section 03_63_01 - Epoxies.
        b. Epoxy gel: As specified in Section 03_63_01 - Epoxies.
        c. Sand: Clean, bagged, graded, and kiln-dried silica sand.

2. Proportioning:
    a. For horizontal work: Consist of mixture of 1 part epoxy with not more than two parts sand.
    b. For vertical or overhead work: Consist of 1 part epoxy gel with not more than two parts sand.

E. Grout:
1. Mix in proportions by weight: 1 part Portland cement to 4 parts concrete sand:
    a. Portland cement: As specified in Section 03_30_01 - Concrete Work.
    b. Concrete sand: As specified in Section 03_30_01 - Concrete Work.

F. Non-shrink epoxy grout:
1. Mix in accordance with manufacturer's installation instructions.

G. Non-shrink grout:
1. Mix in accordance with manufacturer's installation instructions such that resulting mix has flowable consistency and is suitable for placing by pouring.

PART 3 EXECUTION

3.01 EXAMINATION

A. Inspect concrete surfaces to receive grout or mortar and verify that they are free of ice, frost, dirt, grease, oil, curing compounds, paints, impregnations, and loose material or foreign matter likely to reduce bond or performance of grout or mortar.

3.02 PREPARATION

A. Surface preparation for grouting other baseplates:
1. Remove grease, oil, dirt, dust, curing compounds, laitance, and other deleterious materials that may affect bond to concrete and bottoms of baseplates.
2. Roughen concrete surfaces in contact with grout to ICRI CSP-6 surface profile or rougher:
    a. Remove loose or broken concrete.
3. Metal surfaces in contact with grout: Grit blast to white metal surface.

3.03 INSTALLATION

A. Mixing:
1. Cement grout:
    a. Use mortar mixer with moving paddles.
    b. Pre-wet mixer and empty out excess water before beginning mixing.
2. Cement mortar:
    a. Use mortar mixer with moving paddles.
    b. Pre-wet mixer and empty out excess water before beginning mixing.
3. Dry-patch mortar:
    a. Use only enough water so that resulting mortar will crumble to touch after being formed into ball by hand.

4. Non-shrink epoxy grout:
    a. Keep temperature of non-shrink epoxy grout from exceeding manufacturer's recommendations.
5. Non-shrink grout:
    a. May be dry packed, flowed, or pumped into place. Do not overwork grout.
    b. Do not retemper by adding more water after grout stiffens.

B. Placement:
1. Cement grout:
    a. Exercise care in placing cement grout because it is required to furnish structural strength, impermeable water seal, or both.
    b. Do not use cement grout that has not been placed within 30 minutes after mixing.
2. Cement mortar:
    a. Use mortar mixer with moving paddles.
    b. Pre-wet mixer and empty out excess water before beginning mixing.
3. Epoxy grouts:
    a. Wet surfaces with epoxy for horizontal work or epoxy gel for vertical or overhead work prior to placing epoxy grout.
4. Non-shrink epoxy grout:
    a. Mix in complete units. Do not vary ratio of components or add solvent to change consistency of mix.
    b. Pour hardener into resin and mix for at least 1 minute and until mixture is uniform in color. Pour epoxy into mortar mixer wheelbarrow and add aggregate. Mix until aggregate is uniformly wetted. Over mixing will cause air entrapment in mix.
5. Non-shrink grout:
    a. Add non-shrink cement grout to premeasured amount of water that does not exceed the manufacturer's maximum recommended water content.
    b. Mix in accordance with manufacturer's instructions to uniform consistency.

C. Curing:
1. Cement based grouts and mortars:
    a. Keep continuously wet for minimum of 7 days. Use wet burlap, soaker hose, sun shading, ponding, and in extreme conditions, combination of methods.
    b. Maintain above 40 degrees Fahrenheit until it has attained compressive strength of 3,000 pounds per square inch, or above 70 degrees Fahrenheit for minimum of 24 hours to avoid damage from subsequent freezing.
2. Epoxy based grouts:
    a. Cure grouts in accordance with manufacturers' recommendations:
        1) Do not water cure epoxy grouts.
    b. Do not allow any surface in contact with epoxy grout to fall below 50 degrees Fahrenheit for minimum of 48 hours after placement.

D. Grouting equipment bases, baseplates, soleplates, and skids: As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.

E. Grouting other baseplates:
1. General:
    a. Use non-shrink grout as specified in this Section.

b. Baseplate grouting shall take place from 1 side of baseplate to other in continuous flow of grout to avoid trapping air in grout.
c. Maintain hydrostatic head pressure by keeping level of grout in headbox above bottom of baseplate. Fill headbox to maximum level and work grout down.
d. Vibrate, rod, or chain non-shrink grout to facilitate grout flow, consolidate grout, and remove trapped air.

2. Forms and headboxes:
a. Build forms using material with adequate strength to withstand placement of grouts.
b. Use forms that are rigid and liquid tight. Caulk cracks and joints with elastomeric sealant.
c. Line forms with polyethylene for easy grout release. Coating forms with 2 coats of heavy-duty paste wax is also acceptable.
d. Headbox shall be 4 to 6 inches higher than baseplate and shall be located on 1 side of baseplate.
e. After grout sets, remove forms and trim back grout at 45-degree angle from bottom edges of baseplate.

3.04 FIELD QUALITY CONTROL

A. Non-shrink epoxy grout:
1. Test for 24-hour compressive strength in accordance with ASTM C579, Method B.

B. Non-shrink grout:
1. Test for 24-hour compressive strength in accordance with ASTM C942.

END OF SECTION

SECTION 03_63_01

EPOXIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Epoxy.
   2. Epoxy gel.
   3. Epoxy bonding agent.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C881 - Standard Specification for Epoxy-Resin-Base Systems for Concrete.
   2. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
   3. D638 - Standard Test Method for Tensile Properties of Plastics.
   4. D695 - Standard Test Method for Compressive Properties of Rigid Plastics.

B. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

1.03 SUBMITTALS

A. Submit as specified in Section 01 33 00 - Submittal Procedures.

B. Product data: Submit manufacturer’s data completely describing epoxy materials:
   1. Submit evidence of conformance to ASTM C881. Include manufacturer’s designations of Type, Grade, Class, and Color.
   2. Submit documentation that materials meet or exceed the specified strength and performance characteristics. Indicate test methods and test results.
   3. Submit documentation confirming listing under NSF 61 for products to be used in contact with drinking water.

C. Quality control Submittals:
   1. Manufacturer’s installation instructions.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Performance requirements:
   1. Provide epoxy materials that are new.
   2. Store and use products within limitations in accordance with the manufacturer.
   3. Perform and conduct Work of this Section in a neat, orderly manner.

2.02 MATERIALS

A. General:
   1. Moisture tolerant, water-insensitive, two-component epoxy resin adhesive material containing 100 percent solids, and meeting or exceeding the performance properties specified when tested in accordance with the standards specified.
   2. Listed under NSF 61 for use in direct contact with potable water.

B. Epoxy: Low viscosity product in accordance with ASTM C881; Types I, II, and IV; Grade 1; Class C, except as modified in this Section:
   1. Manufacturers: One of the following, or equal:
      a. Dayton Superior, Unitex Pro-Poxy 100.
      b. Sika Corporation, Sikadur 35 Hi-Mod LV.
   2. Required properties:

Table 1. Material Properties - Epoxy		
Property	**Test Method**	**Required Results ("neat")**
Tensile Strength (7-day)	ASTM D638	7,000 pounds per square inch, minimum.
Compressive Yield Strength (7-day)	ASTM D695	10,000 pounds per square inch, minimum.
Bond Strength (harded concrete to harded concrete after 2-day cure)	ASTM C882	1,000 pounds per square inch, minimum. Concrete failure before failure of epoxy.
Viscosity (mixed)		250 to 550 centipoise
Notes: (1) Testing results are for materials installed and cured at a temperature between 72- and 78-degrees Fahrenheit for 7 days, unless otherwise noted.		

C. Epoxy gel: Non-sagging product in accordance with ASTM C881, Types I and IV, Grade 3, Class C:
   1. Manufacturers: One of the following, or equal:
      a. Sika Corp., Sikadur 31, Hi-Mod Gel.
   2. Required properties:

Table 2. Material Properties - Epoxy Gel		
Property	**Test Method**	**Required Results ("neat")**
Tensile Strength (7-day)	ASTM D638	2,000 pounds per square inch, minimum.
Compressive Yield Strength (7-day)	ASTM D695	8,000 pounds per square inch, minimum.
Bond Strength (14-day)	ASTM C882	1,500 pounds per square inch, minimum.
Notes: (1) Testing results are for materials installed and cured at a temperature between 72- and 78-degrees Fahrenheit for 7 days, unless otherwise noted.		

D. Epoxy bonding agent: Non-sagging product in accordance with ASTM C881, Type II, Grade 3, Class C:
   1. Manufacturers: One of the following, or equal:
      a. Sika Chemical Corp., Sikadur 32 Hi-Mod Gel.
   2. Required properties:

Table 3. Material Properties - Epoxy Bonding Agent		
Property	**Test Method**	**Required Results**
Tensile Strength (7-day)	ASTM D638	3,300 pounds per square inch, minimum.
Compressive Yield Strength (7-day)	ASTM D695	8,300 pounds per square inch, minimum.
Bond Strength (14-days)	ASTM C882	1,800 pounds per square inch, minimum. Concrete failure before failure of epoxy bonding agent.
Pot Life	-	Minimum 75 minutes at 77 degrees Fahrenheit.
Notes: (1) Testing results are for materials installed and cured at a temperature between 72- and 78-degrees Fahrenheit for 7 days, unless otherwise noted.		

PART 3 EXECUTION

3.01 INSTALLATION

A. Install and cure epoxy materials in accordance with the manufacturer's installation instructions.

B. Epoxy:
   1. Apply in accordance with the manufacturer's installation instructions.

C. Epoxy gel:
   1. Apply in accordance with the manufacturer's installation instructions.
   2. Use for vertical or overhead work, or where high viscosity epoxy is required.
   3. Epoxy gel used for vertical or overhead work may be used for horizontal work.

D. Epoxy bonding agent:
   1. Apply in accordance with the manufacturer's installation instructions.
   2. Will not be required for filling form tie holes or for normal finishing and patching of similar sized small defects.

END OF SECTION

SECTION 05_05_24

MECHANICAL ANCHORING AND FASTENING TO CONCRETE AND MASONRY

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Cast-in anchors and fasteners.
   2. Post-installed steel anchors and fasteners.
   3. Appurtenances for anchoring and fastening.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 355.2 - Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary.

B. American National Standards Institute (ANSI):
   1. B212.15 - Cutting Tools - Carbide-tipped Masonry Drills and Blanks for Carbide-tipped Masonry Drills.

C. American Welding Society (AWS):
   1. D1.1 - Structural Welding Code - Steel.
   2. D1.6 - Structural Welding Code - Stainless Steel.

D. ASTM International (ASTM):
   1. A29 - Standard Specification for Steel Bars, Carbon and Alloy, Hot-Wrought, General Requirements for.
   2. A36 - Standard Specification for Carbon Structural Steel.
   3. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   4. A108 - Standard Specification for Steel Bars, Carbon and Alloy, Cold Finished.
   5. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   6. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   7. A240 - Standard Specification for Chromium and Chromium Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

8. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless-Steel Parts, Equipment, and Systems.
9. A1064 - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plan and Deformed, for Concrete.
10. B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
11. B695 - Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
12. E488 - Standard Test Methods for Strength of Anchors in Concrete Elements.
13. F436 - Standard Specification for Hardened Steel Washers.
14. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.
15. F594 - Standard Specification for Stainless Steel Nuts.
16. F1554 - Standard Specification for Anchor Bolts, Steel, 36, 55 and 105-ksi Yield Strength.
17. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.

E. International Code Council Evaluation Service, Inc. (ICC-ES):
1. AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning:
1. Built-in anchor: Headed bolt or assembly installed in position before filling surrounding masonry units with grout.
2. Cast-in anchor: Headed bolt or assembly installed in position before placing plastic concrete around.
3. Overhead installations: Fasteners installed on overhead surfaces where the longitudinal axis of the fastener is more than 45 degrees above a horizontal line, so the fastener resists sustained tension loads.
4. Passivation: Chemical treatment of stainless steel with a mild oxidant for the purpose of enhancing the spontaneous formation of the steel's protective passive film.
5. Post-installed anchor: Fastener or assembly installed in hardened concrete or finished masonry construction, typically by drilling into the structure and inserting a steel anchor assembly.
6. Terms relating to structures or building environments as used with reference to anchors and fasteners:
    a. Corrosive locations: Describes interior and exterior locations as follows:
        1) Locations used for delivery, storage, transfer, or containment (including spill containment) of chemicals used for plant treatment processes.
        2) Exterior and interior locations at the following treatment structures:
            (1) Beltz 8 Site: Buildings and other structures.

b. Wet and moist locations: Describes locations, other than “corrosive locations,” that are submerged, are immediately above liquid containment structures, or are subject to frequent wetting, splashing, or wash down. Includes:
    1) Exterior portions of buildings and structures.
    2) Liquid-containing structures:
        a) Locations at and below the maximum operating liquid surface elevation.
        b) Locations above the maximum operating liquid surface elevation and:
            (1) Below the top of the walls containing the liquid.
            (2) At the inside faces and underside surfaces of a structure enclosing or spanning over the liquid (including walls, roofs, slabs, beams, or walkways enclosing the open top of the structure).
    3) Liquid handling equipment:
        a) Bases of pumps and other equipment that handles liquids.
    4) Indoor locations exposed to moisture, splashing, or routine wash down during normal operations, including floors with slopes toward drains or gutters.
    5) Other locations indicated on the Drawings.
c. Other locations:
    1) Interior dry areas where the surfaces are not exposed to moisture or humidity in excess of typical local environmental conditions.

1.04 DELEGATED DESIGN

A. As specified in Section 01_35_73 - Delegated Design Procedures.

B. Calculations.

1.05 SUBMITTALS

A. General:
    1. Submit as specified in Section 01 33 00 - Submittal Procedures and Section 01 61 00 - Common Product Requirements.

B. Product data:
    1. Cast-in anchors:
        a. Manufacturer’s data, including catalog cuts showing anchor sizes and configuration, materials, and finishes.
    2. Post-installed anchors:
        a. For each anchor type, manufacturer’s data, including catalog cuts showing anchor sizes and construction, materials and finishes, and load ratings.

C. Delegated Design Submittals:
    1. When requesting product substitutions for post installed anchors, submit calculations, indicating the diameter, effective embedment depth and spacing of the proposed anchors, and demonstrating that the substituted product will provide load resistance that is equal to or greater than that provided by the anchors listed in this Section.

D. Samples:
   1. Samples of each type of anchor, including representative diameters and lengths, if requested by the Engineer.

E. Certificates:
   1. Cast-in anchors:
      a. Mill certificates for steel anchors that will be supplied to the Site.
   2. Post-installed anchors:
      a. Manufacturer's statement or certified test reports demonstrating that anchors that will be supplied to the Site comply with the materials properties specified.

F. Test reports:
   1. Post-installed anchors: For each anchor type used for the Work:
      a. Current ICC-ES Report (ESR), or equivalent acceptable to the Engineer and the authority having jurisdiction, demonstrating:
         1) Acceptance of that anchor for use under the California Building Code specified in Division 01.
         2) That testing of the concrete anchor included the simulated seismic tension and shear tests of AC193, and that the anchor is accepted for use in Seismic Design Categories C, D, E, or F, and with cracked concrete.

G. Manufacturer's instructions:
   1. Requirements for storage and handling.
   2. Recommended installation procedures, including details on drilling, hole size (diameter and depth), hole cleaning and preparation procedures, anchor insertion, and anchor tightening.
   3. Requirements for inspection or observation during installation.

H. Qualification statements:
   1. Post-installed anchors: Installer qualifications:
      a. Submit list of personnel performing installations. Include letter of training from manufacturer indicating date of manufacturer's training for each installer.

1.06 QUALITY ASSURANCE

A. Qualifications:
   1. Post installed anchors shall be in accordance with the California Building Code specified in Division 01.
   2. Installers: Post-installed mechanical anchors:
      a. Installations shall be performed by trained installers having at least 3 years of experience performing similar installations with similar types of anchors.

B. Special inspection:
   1. Provide special inspection of post-installed anchors as specified in Section 01_45_24 - Regulatory Quality Assurance and this Section.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01 61 00 - Common Product Requirements.

B. Deliver post-installed anchors in manufacturer's standard packaging with labels visible and intact. Include manufacturer's installation instructions.

C. Handle and store anchors and fasteners in accordance with manufacturers' recommendations and as required to prevent damage.

D. Protect anchors from weather and moisture until installation.

1.08 PROJECT CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

B. Seismic Design Category (SDC) for structures is indicated on the Drawings.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. General:
   1. Furnish threaded fasteners with flat washers and hex nuts fabricated from materials corresponding to the material used for threaded portion of the anchor:
      a. Cast-in anchors: Provide flat washers and nuts as listed in the ASTM standard for the anchor materials specified.
      b. Post-installed anchors: Provide flat washers and nuts supplied for that product by the manufacturer of each anchor.
   2. Size of anchors and fasteners, including diameter and length or minimum effective embedment depth: As indicated on the Drawings or as specified in this Section. In the event of conflicts, contact the Engineer for clarification.
   3. Where anchors and connections are not specifically indicated on the Drawings or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.

B. Materials:
   1. Provide and install anchors of materials as specified in this Section.

2.02 CAST-IN ANCHORS AND FASTENERS

A. Anchor bolts:
   1. Straight steel rod having one end with an integrally forged head, and one threaded end. Embedded into concrete with the headed end cast into concrete at the effective embedment depth indicated on the Drawings or specified, and with the threaded end left to project clear of concrete face as required for the connection to be made.

2. Furnish anchor bolts with heavy hex forged head or equivalent acceptable to the Engineer:
    a. Rods or bars with angle bend for embedment in concrete (i.e., “L” or “J” shaped anchor bolts) are not permitted in the Work.
3. Materials:
    a. Ship anchor bolts with properly fitting nuts attached.
    b. Type 316 stainless steel:
        1) Surfaces descaled, pickled, and passivated in accordance with ASTM A380.
        2) Bolts: ASTM F593, Group 2, Condition CW, coarse threads.
        3) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of bolts.
        4) Washers: Type 316 stainless steel.
    c. Type 304 stainless steel:
        1) Surfaces descaled, pickled, and passivated in accordance with ASTM A380.
        2) Bolts: ASTM F593, Group 1, Condition CW, coarse threads.
        3) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of bolts.
        4) Washers: Type 304 stainless steel.
    d. Galvanized steel:
        1) Hot-dip galvanized coating in accordance with ASTM F2329.
        2) Bolts: ASTM F1554, Grade 36, heavy hex, coarse thread.
        3) Nuts: ASTM A563, Grade A, heavy hex, threads to match bolt.
        4) Washers: ASTM F436, Type 1.

2.03 POST-INSTALLED ANCHORS AND FASTENERS - ADHESIVE

A. Epoxy bonding of reinforcing bars, all thread rods, and threaded inserts in concrete: As specified in Section 03_21_17 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.

2.04 POST-INSTALLED ANCHORS AND FASTENERS - MECHANICAL

A. General:
    1. Post-installed anchors shall hold a current ICC Evaluation Service Report demonstrating acceptance for use under the California Building Code specified in Division 01. Reports prepared by other recognized evaluation agencies may be submitted for consideration if acceptable to the Engineer and to the authority having jurisdiction:
        a. Acceptance report shall indicate acceptance of the product for use under the following conditions:
            1) In regions of concrete where cracking has occurred or may occur.
            2) To resist short-term loads due to wind forces.
            3) To resist short-term loading due to seismic forces for the Seismic Design Category of the structure where the product will be used.

B. Concrete anchors:
    1. Post-installed anchor assembly consisting of a threaded stud and a surrounding wedge expansion sleeve that is forced outward by torquing the center stud to

transfer loads from the stud to the concrete through bearing, friction, or both. Sometimes referred to as “expansion anchors” or “wedge anchors”:
    a. Do not use slug-in, lead cinch, and similar systems relying on deformation of lead alloy or similar materials to develop holding power.
2. Concrete expansion bolts for anchorage to concrete:
    a. Shall have a current ICC-ES Report demonstrating that the anchors have been tested and qualified for performance in both cracked and un-cracked concrete, and for short-term loading due to wind and seismic forces for Seismic Design Categories A through F in accordance with ACI 355.2 and with ICC-ES AC193 (including all mandatory tests and optional tests for seismic tension and shear in cracked concrete).
    b. Performance in the current ICC-ES Report shall be “Category 1” as defined in ACI 355.2.
    c. Manufacturers: One of the following:
        1) Hilti, Kwik Bolt TZ2 Wedge Anchor.
        2) Simpson Strong-Tie, Strong-Bolt 2 Wedge Anchor.
    d. Materials. Integrally threaded stud, wedge, washer, and nut:
        1) Stainless steel: Type 316.
            a) Type 304 stainless steel acceptable for use at wet and moist locations when accepted in writing by the Engineer.
        2) Galvanized: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5).

C. Flush shells:
1. Post-installed anchor assembly consisting of an internally threaded mandrel that is forced into a pre-drilled concrete hole with a setting tool until the top of the anchor is flush with the face of the concrete. Once installed, a removable threaded bolt is installed in the mandrel.
2. Flush shell anchors are not permitted in the Work.

2.05 APPURTENANCES FOR ANCHORING AND FASTENING

A. Anchor bolt sleeves:
1. Fabricated steel sleeves:
    a. Construct as specified in Section 05_50_00 - Metal Fabrications.
    b. Fabricate to the following dimensions unless otherwise indicated on the Drawings:
        1) Inside diameter: At least 2 inches greater than bolt diameter.
        2) Inside length: Not less than 10-bolt diameters.
        3) Bottom plate:
            a) Square plate with dimensions equal to the outside diameter of the sleeve plus 1/2 inch each side.
            b) Thickness equal to or greater than one-half of the anchor bolt diameter.
    c. Carbon steel:
        1) Fabricated from ASTM A36 plate and ASTM A53, Grade B pipe.
        2) Welded connections: Conform to requirements of AWS D1.1.
        3) Hot dip galvanized in accordance with ASTM A153.
    d. Stainless steel:
        1) Fabricated from ASTM A240 plate and pipe. Type 304L or Type 316L to match type of the anchor bolt.

2) Welded connections: In accordance with AWS D1.6.

2. Plastic sleeves:
   a. Use of plastic sleeves is conditional on acceptance by the Engineer.
   b. High-density polyethylene, corrugated sleeve, threaded to provide adjustment of location on the anchor bolt.
   c. Manufacturers: The following or equal:
      1) Portland Bolt & Manufacturing Co.

B. Isolating sleeves and washers:
   1. Manufacturers: One of the following or equal:
      a. Allied Corrosion Industries.
      b. Central Plastics Co.
   2. Sleeves: Mylar, 1/32-inch thick, 4,000 volts per mil dielectric strength, of proper size to fit bolts and extending halfway into both steel washers.
   3. One sleeve required for each bolt.
   4. Washers: Inside diameter of washers shall fit over the isolating sleeve, and both the steel and isolating washers shall have the same inside diameter and outside diameter:
      a. Proper size to fit bolts.
      b. Two 1/8-inch-thick steel washers for each bolt.
      c. G3 Phenolic: 2 insulating washers are required for each bolt:
         1) Thickness: 1/8 inch.
         2) Base material: Glass.
         3) Resin: Phenolic.
         4) Water absorption: 2 percent.
         5) Hardness (Rockwell): 100.
         6) Dielectric strength: 450 volts per mil.
         7) Compression strength: 50,000 pounds per square inch.
         8) Tensile strength: 20,000 pounds per square inch.
         9) Maximum operating temperature: 350 degrees Fahrenheit.

C. Coating for repair of galvanized surfaces:
   1. Manufacturers: The following or equal:
      a. Jelt, Galvinox.

D. Thread coating: For use with threaded stainless-steel fasteners:
   1. Manufacturers: One of the following or equal:
      a. Bostik, Never-Seez.
      b. Oil Research, Inc., WLR No. 111.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

3.02 INSTALLATION - GENERAL

A. Where anchors and fasteners are not specifically indicated on the Drawings or specified, make attachments with materials specified in this Section.

B. Substitution of anchor types:
   1. Post-installed anchors may not be used as an alternative to cast-in/built-in anchors at locations where the latter are indicated on the Drawings.
   2. Cast-in/built-in anchors may be used as an alternative to post-installed mechanical anchors at locations where the latter are indicated on the Drawings.

C. Protect products from damage during installation. Protect threads and threaded ends.

D. Accurately locate and position anchors and fasteners:
   1. Unless otherwise indicated on the Drawings, install anchors perpendicular to the surfaces from which they project.
   2. Install anchors so that at least 2 threads, but not more than 1/2 inch of threaded rod, projects past the top nut.

E. Interface with other products:
   1. Where steel anchors come in contact with dissimilar metals (aluminum, stainless steel, etc.), use stainless steel anchors and separate or isolate dissimilar metals using isolating sleeves and washers.
   2. Prior to installing nuts, coat threads of stainless-steel fasteners with thread coating to prevent galling of threads.

3.03 INSTALLATION - CAST-IN ANCHORS

A. General:
   1. Accurately locate cast-in and built-in anchors:
      a. Provide anchor setting templates to locate anchor bolts and anchor rods. Secure templates to formwork.
      b. Brace or tie off embedments as necessary to prevent displacement during placement of plastic concrete or of surrounding masonry construction.
      c. Position and tie cast-in and built-in anchors in place before beginning placement of concrete or grout. Do not “stab” anchors into plastic concrete, mortar, or grout.
      d. Do not allow cast-in anchors to touch reinforcing steel. Where cast-in anchors are within 1/4 inch of reinforcing steel, isolate the metals by wrapping the anchors with a minimum of 4 wraps of 10-mil polyvinyl chloride tape in area adjacent to reinforcing steel.
   2. For anchoring at machinery bases subject to vibration, use 2 nuts, with 1 serving as a locknut.
   3. Where anchor bolts or anchor rods are indicated on the Drawings as being for future use, thoroughly coat exposed surfaces that project from concrete or masonry with non-oxidizing wax. Turn nuts down full length of the threads, and neatly wrap the exposed thread and nut with a minimum of 4 wraps of 10-mil waterproof polyvinyl tape.

B. Anchor bolts:
   1. Minimum effective embedment: 10-bolt diameters, unless a longer embedment is indicated on the Drawings.
   2. Where indicated on the Drawings, set anchor bolts in galvanized steel or stainless-steel sleeves to allow for adjustment. Plastic sleeves may be used if accepted by the Engineer:
      a. Seal top of sleeve to prevent grout from filling sleeve.
      b. Fill sleeves with grout when a machine or other equipment is grouted in place.

C. Anchor rods:
   1. Install as specified for anchor bolts.

D. Concrete inserts:
   1. Provide inserts with minimum clear concrete cover not less than that specified for reinforcing bars.

E. Deformed bar anchors:
   1. Butt weld to steel fabrications with automatic stud welding gun as recommended by the manufacturer.
   2. Ensure that butt weld develops the full strength of the anchor.

F. Welded studs:
   1. Butt weld to steel fabrications with automatic stud welding gun as recommended by the manufacturer.
   2. Ensure that butt weld develops full strength of the stud.

3.04 INSTALLATION - POST-INSTALLED ADHESIVE ANCHORS

A. Epoxy and acrylic adhesive bonding of reinforcing bars, all thread rods, and internally threaded inserts in concrete: As specified in Section 03_21_17 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.

3.05 INSTALLATION - POST-INSTALLED MECHANICAL ANCHORS

A. General:
   1. Install anchors in accordance with the manufacturer's instructions, ACI 355.2, the anchor's ICC-ES Report. Where conflict exists between the ICC-ES Report and the requirements specified in this Section, the requirements of the ICC-ES Report shall control.
   2. Where anchor manufacturer recommends the use of special tools and/or specific drill bits for installation, provide and use such tools.
   3. After anchors have been positioned and inserted into concrete or masonry, do not:
      a. Remove and reuse/reinstall anchors.
      b. Loosen or remove bolts or studs.

B. Holes drilled into concrete and masonry:
   1. Do not drill holes in concrete or masonry until the material has achieved its minimum specified compression strength (f'c or f'm).

2. Accurately locate holes:
    a. Before drilling holes, use a reinforcing bar locator to identify the position of reinforcing steel, conduit, and other embedded items within a 6-inch radius of each proposed hole.
    b. If the hole depth exceeds the range of detection for the rebar locator, the Engineer may require radiographs of the area designated for investigation before drilling commences.
3. Exercise care to avoid damaging existing reinforcement and other items embedded in concrete and masonry:
    a. If embedments are encountered during drilling, immediately stop work and notify the Engineer. Await the Engineer's instructions before proceeding.
4. Unless otherwise indicated on the Drawings, drill holes perpendicular to the concrete surface into which they are placed.
5. Drill using anchor manufacturer's recommended equipment and procedures:
    a. Unless otherwise recommended by the manufacturer, drill in accordance with the following:
        1) Drilling equipment: Electric or pneumatic rotary type with light or medium impact. Where edge distances are less than 2 inches, use lighter impact equipment to prevent micro-cracking and concrete spalling during drilling process.
        2) Drill bits: Carbide-tipped in accordance with ANSI B212.15. Hollow drills with flushing air systems are preferred.
6. Drill holes at manufacturer's recommended diameter and to depth required to provide the effective embedment indicated.
7. Clean and prepare holes as recommended by the manufacturer and as required by the ICC-ES Report for that anchor:
    a. Unless otherwise recommended by anchor manufacturer, remove dust and debris using brushes and clean compressed air.
    b. Repeat cleaning process as required by the manufacturer's installation instructions.
    c. When cleaning holes for stainless steel anchors, use only stainless steel or non-metallic brushes.

C. Insert and tighten (or torque) anchors in compliance with the manufacturer's installation instructions.
    1. Once anchor is tightened (torque), do not attempt to loosen or remove its bolt or stud.

D. Concrete anchors: Minimum effective embedment lengths unless otherwise indicated on the Drawings:

Concrete Anchors			
	Minimum Effective Embedment Length		**Minimum Member Thickness**
Nominal Diameter	**In Concrete**	**In Grouted Masonry**	
3/8 inch	2-1/2 inch	2-5/8 inch	8 inch
1/2 inch	3-1/2 inch	3-1/2 inch	8 inch
5/8 inch	4-1/2 inch	4-1/2 inch	10 inch
3/4 inch	5 inch	5-1/4 inch	12 inch

E. Flush shell anchors:
   1. Not permitted in the Work.
   2. If equipment manufacturer's installation instructions recommend the use of flush shell anchors, contact the Engineer for instructions before proceeding.

F. Sleeve anchors:
   1. Minimum effective embedment lengths unless otherwise indicated on the Drawings:

Sleeve Anchors			
	Minimum Effective Embedment Length		Minimum Member Thickness
Nominal Diameter	In Concrete	In Grouted Masonry	
M8 (1/2 inch)	70 mm (2-3/4 inch)	Not accepted	100 mm (8 inch)
M10 (5/8 inch)	76 mm (3 inch)	Not accepted	250 mm (10 inch)
M12 (3/4 inch)	80 mm (3-1/4 inch)	Not accepted	300 mm (12 inch)

   2. Install with the sleeve fully engaged in the base material.

G. Screw anchors:
   1. Minimum effective embedment lengths unless otherwise indicated on the Drawings:

Screw Anchors			
	Minimum Effective Embedment Length		Minimum Member Thickness
Nominal Diameter	In Concrete	In Grouted Masonry	
3/8 inch	2-1/2 inch	3-1/4 inch	8 inch
1/2 inch	3-1/4 inch	4-1/2 inch	8 inch
5/8 inch	4 inch	5 inch	10 inch
3/4 inch	5-1/2 inch	6-1/4 inch	12 inch

   2. Install using equipment and methods recommended by the manufacturer. Continue driving into hole until the washer head is flush against the item being fastened.

H. Undercut concrete anchors:
   1. Minimum effective embedment lengths unless otherwise indicated on the Drawings:

Undercut Anchors			
Nominal Diameter (bolt)	Minimum Effective Embedment Length		Minimum Member Thickness(1)
	In Concrete	In Grouted Masonry	
M10 (3/8 inch)	100 mm (4 inch)	Not accepted	200 mm (8 inch)
M12 (1/2 inch)	125 mm (5 inch)	Not accepted	350 mm (14 inch)
M16 (5/8 inch)	190 mm (7-1/2 inch)	Not accepted	460 mm (18 inch)
M20 (7/8 inch)	250 mm (10 inch)	Not accepted	510 mm (20 inch)

Notes:
(1) Thickness indicated is for pre-set units. If through-set units are accepted, obtain minimum member thickness requirements from the Engineer.

2. Installations of undercut anchors shall not be allowed where edge distances are less than 12 times the nominal diameter of the anchor stud.
3. Undercut bottom of hole using cutting tools manufactured for this purpose by the manufacturer of the undercut anchors being placed.

3.06 FIELD QUALITY CONTROL

A. Provide quality control over the Work of this Section as specified in Section 01 43 05 - Quality Assurance and Quality Control Requirements.
   1. Expenses associated with Work described by the following paragraphs shall be paid by the Contractor.

B. Post-installed anchors:
   1. Review anchor manufacturer's installation instructions and requirements of the Evaluation Service Report (hereafter referred to as "installation documents") for each anchor type and material.
   2. Observe hole-drilling and cleaning operations for conformance with the installation documents.
   3. Certify in writing that the depth and location of anchor holes, and the torque applied for setting the anchors conforms to the requirements of the installation documents.

3.07 FIELD QUALITY ASSURANCE

A. City's Representative will provide on-site observation and field quality assurance for the Work of this Section:
   1. Expenses associated with work described by the following paragraphs shall be paid by the Owner.

B. Field inspections and special inspections:
   1. Required inspections: Observe construction for conformance to the approved Contract Documents, the accepted Submittals, and the manufacturer's installation instructions for the products used.
   2. Record of inspections:
      a. Maintain record of each inspection.
      b. Submit copies to the Engineer upon request.
   3. Statement of special inspections: At the end of the Project, prepare and submit to the Engineer and the authority having jurisdiction inspector's statement that the Work was constructed in general conformance with the approved Contract Documents, and that deficiencies observed during construction were resolved.

C. Special inspections: Anchors cast into concrete and built into masonry:
   1. Provide special inspection during positioning of anchors and placement of concrete or masonry (including mortar and grout) around the following anchors:
      a. Anchor bolts.
      b. Concrete inserts (all types).
      c. Deformed bar anchors.
      d. Welded studs.

2. During placement, provide continuous special inspection at each anchor location to verify that the following elements of the installation conform to the requirements of the Contract Documents:
    a. Anchor:
        1) Type and dimensions.
        2) Material: Galvanized steel, Type 304 stainless steel or Type 316 stainless steel, as specified in this Section or indicated on the Drawings.
        3) Positioning: Spacing, edge distances, effective embedment, and projection beyond the surface of the construction.
        4) Reinforcement at anchor: Presence, positioning, and size of additional reinforcement at anchors indicated on the Drawings.
3. Following hardening and curing of the concrete or masonry surrounding the anchors, provide periodic special inspection to observe and confirm the following:
    a. Base material (concrete or grouted masonry):
        1) Solid and dense concrete or grouted masonry material within required distances surrounding anchor.
        2) Material encapsulating embedment is dense and well-consolidated.

D. Special inspections: Post-installed mechanical anchors placed in hardened concrete and in grouted masonry:
1. Provide special inspection during installation of the following anchors:
    a. Concrete anchors.
    b. Sleeve anchors.
    c. Screw anchors.
    d. Undercut concrete anchors.
2. Unless otherwise noted, provide periodic special inspection during positioning, drilling, placing, and torquing of anchors:
    a. Provide continuous special inspection for post-installed anchors in “overhead installations” as defined in this Section.
3. Requirements for periodic special inspection:
    a. Verify items listed in the following paragraphs for conformance to the requirements of the Contract Documents and the Evaluation Report for the anchor being used. Observe the initial installation of each type and size of anchor, and subsequent installation of the same anchor at intervals of not more than 4 hours:
        1) Any change in the anchors used, in the personnel performing the installation, or in procedures used to install a given type of anchor shall require a new “initial inspection.”
    b. Substrate: Concrete or masonry surfaces receiving the anchor are sound and of a condition that will develop the anchor’s rated strength.
    c. Anchor:
        1) Manufacturer, type, and dimensions (diameter and length).
        2) Material (galvanized, Type 304 stainless steel, or Type 316 stainless steel).
    d. Hole:
        1) Positioning: Spacing and edge distances.
        2) Drill bit type and diameter.
        3) Diameter, and depth.

4) Hole cleaned in accordance with the manufacturer's required procedures. Confirm multiple repetitions of cleaning when recommended by the manufacturer.
5) Anchor's minimum effective embedment.
6) Anchor tightening/installation torque.

4. Requirements for continuous special inspection:
   a. Special inspector shall observe all aspects of anchor installation, except that holes may be drilled in their absence provided that they confirm the use of acceptable drill bits before drilling, and later confirms the diameter, depth, and cleaning of drilled holes.

E. Field tests:
1. City's Representative may, at any time, request testing to confirm that materials being delivered and installed conform to the requirements of the Specifications:
   a. If such additional testing shows that the materials do not conform to the specified requirements, the Contractor shall pay the costs of these tests.
   b. If such additional testing shows that the materials do conform to the specified requirements, the Owner shall pay the costs of these tests.

3.08 NON-CONFORMING WORK

A. Remove misaligned or non-performing anchors.

B. Fill empty anchor holes and repair failed anchor locations as specified in Section 03_60_00 - Grouting using high-strength, non-shrink, non-metallic grout.

C. If more than 10 percent of all tested anchors of a given diameter and type fail to achieve their specified torque or proof load, the Engineer will provide directions for required modifications. Make such modifications, up to and including replacement of all anchors, at no additional cost to the Owner.

3.09 SCHEDULES

A. Stainless steel: Provide and install stainless steel anchors at the following locations:
1. "Corrosive locations" as defined in this Section: Type 316 stainless steel.
2. "Wet and moist locations" as defined in this Section: Type 316 stainless steel.
3. "Other locations":
   a. For connecting steel or stainless-steel members to concrete or masonry: Type 304 stainless steel.
   b. For connecting aluminum members to concrete or masonry.
   c. For connecting fiber-reinforced plastic (FRP) members to concrete or masonry.
4. At locations indicated on the Drawings.

B. Galvanized: Provide and install galvanized carbon steel anchors at the following locations:
1. Locations not requiring stainless steel.
2. At locations indicated on the Drawings.

END OF SECTION

SECTION 05_50_00

METAL FABRICATIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Concrete inserts.
   2. Ladders.
   3. Manhole frames and covers.
   4. Metal gratings.
   5. Metal tread plate.
   6. Preformed channel pipe supports.
   7. Miscellaneous metals.
   8. Associated accessories to the above items.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. Aluminum Association (AA):
   1. DAF-45: Designations from Start to Finish:
      a. M12-C22-A41.

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

C. ASTM International (ASTM):
   1. A36 - Standard Specification for Carbon Structural Steel.
   2. A48 - Standard Specification for Gray Iron Castings.
   3. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
   4. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   5. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels for General Applications.
   6. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   7. A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
   8. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless-Steel Parts, Equipment, and Systems.
   9. A489 - Standard Specification for Carbon Steel Lifting Eyes.

10. A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
11. A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
12. A635 - Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Alloy, Carbon, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability, General Requirements for.
13. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
14. A992 - Standard Specification for Structural Steel Shapes.
15. B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
16. B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
17. B308 - Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
18. B429 - Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
19. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.
20. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.

D. American Welding Society (AWS):
   1. A2.4 - Standard Symbols for Welding, Brazing, and Nondestructive Examination.

E. National Association of Architectural Metal Manufacturers (NAAMM):
   1. Metal Finishes Manual.

F. Occupational Safety and Health Administration (OSHA).

1.03 DEFINITIONS

A. Passivation: Removal of exogenous iron or iron compounds from the surface of a stainless steel by means of chemical dissolution resulting from treatment with an acid solution that removes the surface contamination but does not significantly affect the stainless steel itself.

1.04 SUBMITTALS

A. Product Data:
   1. Concrete inserts.
   2. Ladders.
   3. Manhole frames and covers.
   4. Metal gratings.
   5. Metal tread plate.
   6. Preformed channel pipe supports.
   7. Miscellaneous metals.

B. Shop drawings:
   1. Ladders.
   2. Metal grating.
   3. Metal tread plate.
   4. Miscellaneous metals.

C. Quality control submittals:
   1. Design data.
   2. Test reports:
      a. Gratings:
         1) Grating manufacturers' calculations showing that gratings will meet specified design load, stress, and deflection requirements for each size grating for each span.
         2) Reports of tests performed.

PART 2 PRODUCTS

2.01 MATERIALS

A. General: Unless otherwise specified or indicated on the Drawings, structural and miscellaneous metals in accordance with the standards of the ASTM, including the following:

Item	ASTM Standard No.	Class, Grade Type or Alloy No.
Cast Iron		
Cast Iron	A48	Class 40B
Steel		
Galvanized sheet iron or steel	A653	Coating G90
Coil (plate)	A635	--
Structural plate, bars, rolled shapes, and miscellaneous items (except W shapes)	A36	--
Rolled W shapes	A992	Grade 50
Standard bolts, nuts, and washers	A307	--
High strength bolts, nuts, and hardened flat washers	F3125, Grade A325	--
Eyebolts	A489	Type 1
Tubing, cold-formed	A500	--
Tubing, hot-formed	A501	--
Steel pipe	A53	Grade B

Item	ASTM Standard No.	Class, Grade Type or Alloy No.
Stainless Steel		
Plate, sheet, and strip	A240	Type 304* or 316**
Bars and shapes	A276	Type 304* or 316**
Bolts (Type 304)	F593	Group 1 Condition CW
Bolts (Type 316)	F593	Group 2 Condition CW
Aluminum		
Flashing sheet aluminum	B209	Alloy 5005-H14, 0.032 inches minimum thickness
Structural sheet aluminum	B209	Alloy 6061-T6
Structural aluminum	B209 B308	Alloy 6061-T6
Extruded aluminum	B221	Alloy 6063-T42
* Use Type 304L if material will be welded. ** Use Type 316L if material will be welded.		

1. Stainless steels are designated by type or series defined by ASTM.
2. Where stainless steel is welded, use low-carbon stainless steel.

2.02 MANUFACTURED UNITS

A. Concrete inserts:
   1. Concrete inserts for supporting pipe and other applications are specified in Section 40_05_07.01 - Pipe Supports.

B. Ladders:
   1. General:
      a. Type: Safety type conforming to local, State, and OSHA standards as minimum. Furnish guards for ladder wells.
      b. Size: 18 inches wide between side rails of length, size, shape, detail, and location indicated on the Drawings.
   2. Aluminum ladders:
      a. Materials: 6063-T5 aluminum alloy.
      b. Rungs:
         1) 1-inch minimum solid square bar with 1/8-inch grooves in top and deeply serrated on all sides.
         2) Capable of withstanding 1,000-pound load without failure.
      c. Side rails: Minimum 4-inch by 1/2-inch flat bars.
      d. Finish of aluminum components:
         1) Anodized finish, 0.7 mil thick, applied to exposed surfaces after cutting. Aluminum Association Specification M12-C22-A41, mechanical finish non specular as fabricated, chemical finish-medium matte, anodic coating-clear Class I Architectural.
         2) Pretreat aluminum for cleaning and removing markings before anodizing.

e. Fabrication:
    1) Welded construction, of size, shape, location, and details indicated on the Drawings.
    2) For ladders over 20 feet high, furnish standard ladder cages or fall prevention system designed in accordance with State and OSHA requirements.
f. Fall prevention system: Include but not limit to railing, brackets, clamps, 2 sleeves, and 2 belts, satisfying OSHA safe climbing requirements:
    1) Manufacturers: One of the following or equal:
        a) North Consumer Products, Saf-T-Climb.
        b) Swager Communications, Climbers Buddy System.

C. Manhole frames and covers:
1. Material: Gray iron castings, in accordance with ASTM A48, Class 30-B.
2. Type: Heavy-duty traffic type, with combined minimum set weight of 265 pounds.
3. Machine horizontal and vertical bearing surfaces to fit neatly, with easily removable cover bearing firmly in frame without rocking.
4. Frame:
    a. Bottom flange type.
    b. Approximately 4-1/2 inches frame height.
    c. Dimensions as indicated on the Drawings:
        1) Minimum inside clear dimension may not be smaller than nominal diameter minus 2 inches.
5. Cover:
    a. Skid-resistant grid pattern design stamped with name of utility service provided by manhole, such as “ELECTRICAL,” “SEWER,” “TELEPHONE,” or “WATER.”
    b. Solid type without ventilation holes.
6. Finish: Unpainted.

D. Metal gratings:
1. General:
    a. Fabricate grating to cover areas indicated on the Drawings.
    b. Unless otherwise indicated on the Drawings, grating over an opening shall cover entire opening.
    c. Make cutouts in grating where required for equipment access or protrusion, including valve operators or stems, and gate frames.
    d. Band ends of grating and edges of cutouts in grating:
        1) End banding: 1/4 inch less than height of grating, with top of grating and top edge of banding flush.
        2) Cutout banding: Full height of grating.
        3) Use banding of same material as grating.
        4) Panel layout: Enable installation and subsequent removal of grating around protrusions or piping.
        5) Openings 6 inches and larger: Lay out grating panels with edges of two adjacent panels located on centerline of opening.
        6) Openings smaller than 6 inches: Locate opening at edge of single panel.

7) Where an area requires more than 1 grating section to cover area, clamp adjacent grating sections together at 1/4-points with fasteners acceptable to Engineer.
8) Fabricate steel grating sections in units weighing not more than 50 pounds each.
9) Fabricate aluminum grating sections in units of weighing not more than 50 pounds each.
10) Gaps between adjacent grating sections shall not be more than the clear spacing between bearing bars.

e. When requested by Engineer, test 1 section of each size grating for each span length involved on the job under full load:
1) Furnish a suitable dial gauge for measuring deflections.

f. Grating shall be aluminum, unless otherwise specified or indicated on the Drawings.

2. Aluminum grating:
a. Material for gratings, shelf angles, and rebates: 6061-T6 or 6063-T6 aluminum alloy, except crossbars may be 6063-T5 aluminum alloy.
b. Shelf angle concrete anchors: Type 304 or Type 316 stainless steel.
c. Grating rebate rod anchors: 6061-T6 or 6063-T6 aluminum alloy.
d. Bar size and spacing: As determined by manufacturer to enable grating to support design load.
e. Design live load: A minimum of 100 pounds per square foot uniform live load on entire grating area, but not less than the live load indicated on the Drawings for the area where grating is located.
f. Maximum fiber stress for design load: 12,000 pounds per square inch.
g. Maximum deflection due to design load: 1/240 of grating clear span.
h. Maximum spacing of main grating bars: 1-1/8 inches clear between bars.
i. Minimum grating height: 1-1/2 inches.
j. Manufacturers: The following or equal:
1) Harsco Industrial IKG, Swaged Aluminum I-Bar with striated finish.

3. Steel gratings:
a. Hot-dip galvanized in accordance with ASTM A123.
b. Bar size and spacing: As determined by the manufacturer to support design load.
c. Design live load: A minimum of 100 pounds per square foot uniform live load on the entire area of the grating area, but not less than the live load indicated on the Drawings for the area where the grating is located.
d. Maximum fiber stress for design load: 18,000 pounds per square inch.
e. Maximum deflection under design load: 1/240 of grating clear span.
f. Bar spacing: Maximum of 1-1/8 inches clear between bars.
g. Manufacturers: The following or equal:
1) Harsco Industrial IKG, IKG Weldforged.

4. Heavy-duty steel grating:
a. Heavy-duty type, fabricated from structural steel and designed in accordance with AASHTO Standard Specifications for Highway Bridges, using H-20 loading.
b. Hot-dip galvanized after fabrication in accordance with ASTM A123.
c. Manufacturers: One of the following or equal:
1) Reliance Steel Products Co., Heavy-Duty Steel Grating.
2) Seidelhuber Metal Products, Inc., equivalent product.

E. Metal tread plate:
   1. Plate having a raised figured pattern on 1 surface to provide improved traction.

F. Preformed channel pipe supports:
   1. Preformed channel pipe supports for pipe supports and other applications are specified in Section 40_05_07.03 - Preformed Channel Pipe Support System.

G. Miscellaneous aluminum:
   1. Fabricate aluminum products, not covered separately in this Section, in accordance with the best practices of the trade and field assemble by riveting or bolting.
   2. Do not weld or flame cut.

H. Miscellaneous cast iron:
   1. General:
      a. Tough, gray iron, free from cracks, holes, swells, and cold shuts.
      b. Quality such that hammer blow will produce indentation on rectangular edge of casting without flaking metal.
      c. Before leaving the foundry, clean castings and apply 16-mil dry film thickness coating of coal-tar epoxy, unless otherwise specified or indicated on the Drawings.

I. Miscellaneous stainless steel:
   1. Provide miscellaneous stainless-steel items not specified in this Section as indicated on the Drawings or specified elsewhere.
      a. Fabricate and install in accordance with the best practices of the trade.
   2. Cleaning and passivation:
      a. Following shop fabrication of stainless-steel members, clean and passivate fabrications.
      b. Finish requirements: Remove free iron, heat tint oxides, weld scale and other impurities, and obtain a passive finished surface.
      c. Provide quality control testing to verify effectiveness of cleaning agents and procedures and to confirm that finished surfaces are clean and passivated:
         1) Conduct sample runs using test specimens with proposed cleaning agents and procedures as required to avoid adverse effects on surface finishes and base materials.
      d. Pre-clean, chemically descale (pickle), and final clean fabrications in accordance with the requirements of ASTM A380 to remove deposited contaminants before shipping:
         1) Passivation by citric acid treatment is not allowed:
            a) If degreasing is required before cleaning to remove scale or iron oxide, cleaning (pickling) treatments with citric acid are permissible; however, these treatments shall be followed by inorganic cleaners such as nitric-hydrofluoric acid.
         2) Provide acid descaling (pickling) in accordance with Table A1.1 of Annex A1 of ASTM A380.
         3) After pickling, final cleaning of stainless steel shall conform to Part II of Table A2.1 of Annex A2 of ASTM A380.
      e. After cleaning, inspect using methods specified for “gross inspection” in ASTM A380.

f. Improperly or poorly cleaned and passivated materials shall not be shipped and will not be accepted at the job site.

J. Miscellaneous structural steel:
1. Provide miscellaneous steel items not specified in this Section as indicated on the Drawings or specified elsewhere.
a. Fabricate and install in accordance with the best practices of the trade.

K. Isolating sleeves and washers:
1. As indicated on the Drawings and as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions:
1. Examine work in place to verify that it is satisfactory to receive the work of this Section.
2. If unsatisfactory conditions exist, do not begin this work until such conditions have been corrected.

3.02 INSTALLATION

A. General:
1. Install products as indicated on the Drawings, and in accordance with shop drawings and manufacturer's printed instructions, as applicable except where specified otherwise.
2. Interface between materials:
a. Dissimilar metals: Where steel comes in contact with dissimilar metals (aluminum, stainless steel, etc.), separate or isolate the dissimilar metals.
1) Make application so that the isolating or protective barrier is not visible in the completed construction.
2) Isolating sleeves and washers: As specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
b. Aluminum in contact with concrete or masonry: Coat aluminum surfaces as specified in Section 09_96_01 - High Performance Coatings.
c. Aluminum in contact with concrete or masonry.

B. Ladders:
1. Secure to supporting surface with bent plate clips providing minimum 8 inches between supporting surface and center of rungs.
2. Where exit from ladder is forward over top rung, extend side rails 3 feet 3 inches minimum above landing, and return the rails with a radius bend to the landing.
3. Where exit from ladder is to side, extend ladder 5 feet 6 inches minimum above landing and rigidly secure at top.
4. Erect rail straight, level, plumb, and true to position indicated on the Drawings:
a. Correct deviations from true line or grade which are visible to the eye.

C. Manhole frames and covers:
    1. Installation: As recommended by Manufacturer.

D. Metal gratings:
    1. General:
        a. Allow 1/8-inch maximum clearance between ends of grating and inside face of vertical leg of shelf angles.
        b. Horizontal bearing leg of shelf angles shall be 2 inches minimum.
        c. Install aluminum plate or angles where necessary to fill openings at changes in elevation and at openings between equipment and grating.
        d. Install angle stops at ends of grating.
        e. Installed grating shall not slide out of rebate or off support.
        f. Weld stops in place, unless otherwise specified or indicated on the Drawings.
        g. Top surfaces of grating sections adjacent to each other shall lie in same plane.
    2. Aluminum grating:
        a. Aluminum grating: Support on aluminum shelf angles or rebates.
    3. Steel grating:
        a. Support on hot-dip galvanized structural steel shelf angles or rebates.
    4. Heavy-duty steel grating:
        a. Support on hot-dip galvanized structural steel rebates embedded and anchored in concrete.
        b. Use for roadways, traffic areas, and where indicated on the Drawings.

E. Stainless Steel:
    1. Welding:
        a. Passivate field-welded surfaces:
            1) Provide cleaning, pickling and passivating as specified in this Section.
            2) Clean using Derustit Stainless Steel Cleaner, or equal.

END OF SECTION

SECTION 07_11_00

DAMPPROOFING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Dampproofing.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D1227 - Standard Specification for Emulsified Asphalt Used as a Protective Coating for Roofing.

B. California Air Resources Board (ARB):
   1. Architectural Coatings Suggested Control Measure.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Pre-installation meeting:
   1. As specified in Section 01 31 19 - Project Meetings.
   2. Prior to beginning Work, convene a meeting to review conditions, installation procedures, schedules, and coordination with other Work.
   3. Convene a minimum of 2 weeks prior to starting Work.

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Product data.
   1. Manufacturer’s data sheets on each product to be used, including:
      a. Preparation instructions and recommendations.
      b. Storage and handling requirements and recommendations.
      c. Installation methods.

C. Warranty:
   1. Sample warranty identifying the terms and conditions stated in the warranty article.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Store materials in original, unopened containers in accordance with the manufacturer’s printed instructions.

1.06 ENVIRONMENTAL REQUIREMENTS

A. In accordance with volatile organic compound limits specified in Table 1 of the California ARB Architectural Coatings Suggested Control Measure.

B. Do not apply bituminous dampproofing when temperatures are 40 degrees Fahrenheit or lower, or when rain is forecast for the 24 hours following application.

PART 2 PRODUCTS

2.01 MATERIALS

A. Dampproofing: ASTM D1227, Asbestos Free, Emulsified Asphalt Coatings:
   1. Manufacturers: One of the following or equal:
      a. Karnak Corp., Karnak 220 AF.
      b. W.R. Meadows, Inc., Sealmastic Type 2 Asphalt Emulsion Dampproofing.

B. Sealing mastic:
   1. Compatible with dampproofing and free of toxic solvents with thick mastic consistency and smooth and uniform in composition.
   2. As recommended by the dampproofing manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that conditions are satisfactory for application of products in accordance with the manufacturer's recommendations.

B. Verify that surfaces to receive dampproofing are clean, dry, reasonably smooth, free of dust, dirt, voids, cracks, or sharp projections.

3.02 APPLICATION

A. Completely cover surfaces to receive dampproofing with 2 coats:
   1. Applied by brush or spray.
   2. Apply dampproofing at the manufacturer's recommended rate of application or minimum 2 gallons per 100 square feet, whichever is greater.

B. Extend dampproofing to 6 inches above finish grade.

C. Apply each coat evenly so surfaces have uniform black appearance.

D. Apply second coat at right angles to first, allowing not less than 24 hours between coats.

E. Seal around items and services projecting through dampproofing surfaces in accordance with the manufacturer's recommendations.

F. Ensure sealed areas are moisture tight.

G. Backfill completely against dampproofing application within time recommended by the manufacturer.

END OF SECTION

SECTION 07_92_00

JOINT SEALANTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Acrylic-Latex sealant.
   2. Precast concrete joint sealant.
   3. Silicone sealant.
   4. Synthetic rubber sealing compound.
   5. Synthetic sponge rubber filler.
   6. Related materials.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. M198 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.

B. ASTM International (ASTM):
   1. C920 - Standard Specification for Elastomeric Joint Sealants.
   2. C990 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
   3. C1330 - Standard Specification for Cylindrical Sealant Backing for Use with Cold Liquid-Applied Sealants.
   4. C1521 - Standard Practice for Evaluating Adhesion of Installed Weatherproofing Sealant Joints.
   5. D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension.
   6. D624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomer.

1.03 SUBMITTALS

A. Product data.

B. Samples include color selections.

C. Manufacturer's Installation Instructions.

D. Warranty.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of proposed product for minimum 5 years with satisfactory performance record.

B. Installer qualifications: Manufacturer approved installer of products similar to specified products on minimum 5 projects of similar scope as Project with satisfactory performance record.

1.05 PROJECT/SITE CONDITIONS

A. Environmental requirements: Do not apply sealant on wet or frosty surfaces or when surface temperature is higher than 100 degrees Fahrenheit or lower than recommended by the manufacturer.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products in accordance with manufacturer's recommendations.

B. Code date packages. Do not use material older than manufacturer’s published shelf life. Store materials at temperatures lower than 80 degrees Fahrenheit. Condition materials in accordance with manufacturer’s instructions prior to installation.

1.07 SEQUENCING AND SCHEDULING

A. Caulk joints prior to painting.

1.08 WARRANTY

A. Warrant to correct defective products for minimum 1 year in accordance with manufacturer's standard warranty.

PART 2 PRODUCTS

2.01 SEALANTS

A. General:
   1. Provide colors matching materials being sealed.
   2. Where compound is not exposed to view in finished work, provide manufacturer's color which has best performance.
   3. Nonsagging sealant for vertical and overhead horizontal joints.
   4. Sealants for horizontal joints: Self-leveling pedestrian/traffic grade.
   5. Joint cleaner, primer, bond breaker: As recommended by sealant manufacturer.
   6. Sealant backer rod and/or compressible filler made from closed cell polyethylene, polyethylene jacketed polyurethane foam, or other flexible, nonabsorbent, non-bituminous material recommended by sealant manufacturer to:
      a. Control joint depth.

b. Break bond of sealant at bottom of joint.
c. Provide proper shape of sealant bead.
d. Serve as expansion joint filler.

2.02 ACRYLIC-LATEX SEALANT

A. Permanently flexible, nonstaining, and nonbleeding latex modified acrylic sealant compound, colors as selected by Engineer from manufacturer's standard options:
1. Manufacturers: One of the following or equal:
a. Tremco, Tremflex 834.
b. Pecora Corp., Number AC-20.
c. Sonneborn, Sonolac.

2.03 PRECAST CONCRETE JOINT SEALANT

A. Preformed, cold-applied, ready-to-use, flexible joint sealant in accordance with ASTM C990 and AASHTO M 198:
1. Manufacturers: One of the following or equal:
a. Henry Corp., Ram-Nek.
b. Concrete Sealants Division, ConSeal.

2.04 SILICONE SEALANT

A. ASTM C920, Type S, Grade NS, Class 25, single component silicone sealant:
1. Manufacturers: One of the following or equal:
a. Tremco, Proglaze.
b. Pecora Corp., Number 864.
c. Dow Corning, Number 795.
d. General Electric, Number 1200 Series.

2.05 SYNTHETIC RUBBER SEALING COMPOUND

A. Manufacturer: One of the following or equal:
1. Sika Corporation, Sikaflex 2c NS or SL.
2. Sika Corporation, Sikaflex 2c NS EZ Mix.
3. Pacific Polymers, Elastothane 227R.

B. Material: In accordance with ASTM C920 Type M, Grade P (pourable), Class 25 and Type M, Grade NS (non-sag), Class 25; multi-part polyurethane; able to cure at room temperature to firm, highly resilient polymer; able to perform satisfactory when continuously submerged in water or sewage and exposed to direct sunlight in dry condition; with the following properties determined at 75 degrees Fahrenheit and 50 percent relative humidity:
1. Base: Polyurethane rubber.
2. Application time: Minimum two hours.
3. Cure time: Maximum three days.
4. Tack free time: Maximum 24 hours.
5. Ultimate hardness: Non-sag 25, Pourable/SL 40, within 5 Shore A.
6. Tensile strength: Non-sag 95 pounds per square inch minimum and self-leveling minimum 170 pounds per square inch when tested in accordance with ASTM D412.

7. Ultimate elongation: Minimum 340 percent when tested in accordance with ASTM D412.
8. Tear resistance: Non-sag 45 pounds per inch minimum and self-leveling minimum 85 pounds per inch when tested in accordance with ASTM D624, Die C.
9. Service temperature range: Minus 25 degrees to 158 degrees Fahrenheit.

C. Color: Gray to match concrete, unless indicated on the Drawings.

2.06 SYNTHETIC SPONGE RUBBER FILLER

A. Closed-cell expanded sponge rubber manufactured from synthetic polymer neoprene base, or resilient polyethylene foam backer rod. In accordance with ASTM C1330, Type C:
1. Manufacturers: The following or equal:
a. Presstite, No. 750.3 Ropax Rod Stock.

B. Characteristics:
1. Suitable for application intended.
2. Strength: As necessary for supporting sealing compound during application.
3. Resiliency: Resistance to environmental conditions of installation.
4. Bonding: No bonding to the sealing compound.
5. Structure: Cellular, prevents absorption of water.
6. Compatibility with other materials in joint and acceptance by manufacturer of sealing compound.
7. Size: Minimum 25 percent greater than nominal joint width.

2.07 RELATED MATERIALS

A. Primer: Nonstaining type, recommended by sealant manufacturer to suit application.

B. Joint cleaner: Noncorrosive, nonstaining, compatible with joint forming materials and as recommended by sealant manufacturer.

C. Bond breaker tape: Pressure-sensitive tape recommended by sealant manufacturer to suit application.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify acceptability of joint dimensions, physical, and environmental conditions.

B. Verify that surfaces are dry, clean, and free of dirt, grease, curing compound, and other residue which might interfere with adhesion of sealants.

3.02 PREPARATION

A. Allow concrete to cure thoroughly before caulking.

B. Synthetic sponge rubber filler:
   1. Prepare surfaces designated to receive filler in accordance with manufacturer's installation instructions.
   2. Do not stretch filler beyond its normal length during installation.

C. Caulking:
   1. Verify that surfaces are dry, clean, and free of dirt, grease, curing compounds, and other residue that might interfere with adhesion of sealant.
   2. Concrete, masonry, wood, and steel surfaces: Clean and prime in accordance with manufacturer's instructions prior to caulking.

D. Synthetic rubber sealing compound:
   1. Ensure surfaces to which synthetic rubber must bond are dry and free of dust, dirt, and other foreign residue.
   2. Heavy sandblasted caulking groove to sound surface, and prime with manufacturer's recommended primer for particular surface.

E. For sidewalks, pavements, and similar joints sealed with elastomeric sealants and subject to traffic and other abrasion and indentation exposures, fill joints to depth equal to 75 percent of joint width, but neither more than 5/8 inches deep nor less than 3/8 inches deep.

F. For normal moving building joints sealed with elastomeric sealants not subject to traffic, fill joints to depth equal to 50 percent of joint width, but neither more than 1/2 inch deep nor less than 1/4 inch deep.

G. For joints sealed with acrylic-latex sealants, fill joints to depth in range of 75 percent to 125 percent of joint width.

H. Use joint filler to achieve required joint depths, to allow sealants to perform properly.

I. Prepare surfaces and install synthetic sponge rubber filler in accordance with manufacturer's recommendations.

J. Do not stretch filler beyond normal length during installation.

K. Apply bond breaker when recommended by joint sealer manufacturer.

3.03 INSTALLATION

A. Synthetic sponge rubber filler: Install filler in accordance with manufacturer's installation instructions.

B. Caulking, joints, and sealing:
   1. Construct expansion, contraction, and construction joints as indicated on the Drawings.
   2. Install pipe and conduit in structures as indicated on the Drawings.
   3. Caulk doors, windows, louvers, and other items installed in or over concrete openings inside and out.

4. Use synthetic rubber sealing compound for caulking where indicated on the Drawings or as specified, except for masonry construction and where specified otherwise.
5. Complete caulking prior to painting.
6. Verify that concrete is thoroughly cured prior to caulking.
7. When filler compressible material is used, use untreated type.
8. Apply caulking with pneumatic caulking gun.
9. Use nozzles of proper shape and size for application intended.
10. Maintain continuous bond between caulking and sides of joint to eliminate gaps, bubbles, or voids and fill joint in continuous operation without layering of compound.
11. Employ experienced applicators to caulk joints and seams in neat workmanlike manner.
12. To hasten curing of compound when used on wide joints subject to movement, apply heat with infrared lamps or other convenient means.
13. Apply synthetic rubber sealing compound with pneumatic caulking tool or other acceptable method.

3.04 CLEANING

A. Clean surfaces adjacent to sealant as work progresses.

B. Remove excess uncured sealant by soaking and scrubbing with sealant cleaning solvent.

C. Remove excess cured sealant by sanding with Number 80 grit sandpaper.

D. Leave finished work in neat, clean condition.

3.05 SCHEDULE

A. Acrylic latex:
1. Use where indicated on the Drawings.
2. Interior joints with movement less than 7.5 percent and not subject to wet conditions.

B. Silicone:
1. Use where indicated on the Drawings.
2. Joints and recesses formed where window, door, louver and vent frames, and sill adjoin masonry, concrete, stucco, or metal surfaces.
3. Door threshold bedding.
4. Moist or wet locations, including joints around plumbing fixtures.
5. Stainless steel doors and frames, including joints between applied stops and frames, and around anchor bolts.
6. Plenum joints.

C. Synthetic rubber sealing compound, non-sag Type II:
1. Use where indicated on the Drawings.
2. Water-bearing and earth-bearing concrete structures.
3. Joints in masonry, concrete vertical surfaces, and metal-faced panels in vertical surfaces.

4. Joints between sheet metal flashing and trim.
5. Joints between sheet metal flashing and trim, and vertical wall surfaces.
6. Small voids between materials requiring filling for weathertight performance in vertical surfaces.
7. Perimeters of frames of doors, windows, louvers, and other openings where bonding is critical to airtight performance.
8. Expansion and control joints in masonry vertical surfaces.

D. Synthetic rubber sealing compound, self-leveling Type I:
1. Use where indicated on the Drawings.
2. Expansion and control joints in masonry, concrete horizontal surfaces, and metal panels in horizontal surfaces.
3. Small voids between materials requiring filling for weathertight performance in horizontal surfaces.
4. Pavement joints.
5. Perimeters of frames of doors, windows, louvers, and other openings in horizontal surfaces where bonding is critical to airtight performance.

3.06 FIELD QUALITY CONTROL

A. Adhesion testing:
1. Perform adhesion tests in accordance with ASTM C1521 per the following criteria:
a. Water bearing structures: One test per every 1,000 LF of joint sealed.
b. Exterior precast concrete wall panels: One test per every 2,000 LF of joint sealed.
c. Chemical containment areas: One test per every 1,000 LF of joint sealed.
d. Building expansion joints: One test per every 500 LF of joint sealed.
e. All other type of joints except butt glazing joints: One test per every 3,000 LF of joint sealed.
f. Manufacturer's authorized factory representative provide written recommendations for remedial measures on failing tests.

END OF SECTION

SECTION 09_96_01

HIGH-PERFORMANCE COATINGS

TABLE OF CONTENTS

PART 1 GENERAL 2

1.01 SUMMARY 2
1.02 REFERENCES 2
1.03 TERMINOLOGY 4
1.04 SUBMITTALS 5
1.05 QUALITY ASSURANCE 7
1.06 DELIVERY, STORAGE, AND HANDLING 10
1.07 PROJECT CONDITIONS 11
1.08 MAINTENANCE 13
1.09 CTR RESPONSIBILITIES 13

PART 2 PRODUCTS 14

2.01 DESIGN AND PERFORMANCE CRITERIA 14
2.02 MATERIALS 14
2.03 COATING SYSTEMS IDENTIFICATION 15
2.04 PRODUCTS FOR COATING SYSTEMS 15

PART 3 EXECUTION 16

3.01 GENERAL PROTECTION REQUIREMENTS 16
3.02 GENERAL SURFACE PREPARATION REQUIREMENTS 17
3.03 MECHANICAL AND ELECTRICAL EQUIPMENT PREPARATION 17
3.04 CLEANING OF NEW AND PREVIOUSLY COATED OR NEW SURFACES 18
3.05 BLAST CLEANING 18
3.06 PREPARATION REQUIREMENTS FOR CONCRETE SURFACES 19
3.07 GENERAL PREPARATION REQUIREMENTS FOR METALLIC SURFACES 21
3.08 PREPARATION REQUIREMENTS BY SURFACE TYPE 22
3.09 APPLICATION REQUIREMENTS 23
3.10 APPLICATION REQUIREMENTS FOR CONCRETE COATING SYSTEMS 27
3.11 COATING SYSTEM SCHEDULE 28
3.12 SURFACES NOT REQUIRING COATING 28
3.13 QUALITY CONTROL 28
3.14 CORRECTIVE MEASURES 29
3.15 CLEANUP 29
3.16 FINAL INSPECTION 30

ATTACHMENT A - SCHEDULE OF SURFACES TO BE COATED

ATTACHMENT B - COATING DETAIL SHEETS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Coatings, including coating systems, surface preparation, application requirements, and quality control requirements.

1.02 REFERENCES

A. Abbreviations:
   1. CMU - Concrete masonry units.
   2. CSA - Coating system applicator. Specialty subcontractor retained by the Contractor to install the coating systems specified in this Section.
   3. CSM - Coating system manufacturer.
   4. CTR - Coating system manufacturer's technical representative.
   5. DFT - Dry-film thickness. Thickness of cured film, usually expressed in mils (0.001 inch).
   6. VOC - Volatile organic compound. Portion of the coating that is a compound of carbon, is photochemically reactive, and evaporates during drying or curing; expressed in grams per liter (g/l) or pounds per gallon (lb/gal). VOC is determined by EPA Method 24.
   7. WFT - Wet film thickness. Coating thickness as measured immediately after application. Usually expressed in mils (0.001 inch).

B. Standards:
   1. ASTM International (ASTM):
      a. D16 - Standard Terminology for Paint, Related Coatings, Materials, and Applications.
      b. D2200 - Standard Practice for Use of Pictorial Surface Preparation Standards and Guides for Painting Steel Surfaces.
      c. D3359 - Standard Test Methods for Rating Adhesion by Tape Test.
      d. D3960 - Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings.
      e. D4262 - Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces.
      f. D4263 - Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.
      g. D4285 - Standard Test Method for Indicating Oil or Water in Compressed Air.
      h. D4414 - Standard Practice for Measurement of Wet Film Thickness by Notch Gages.
      i. D4417 - Standard Test Methods for Field Measurement of Surface Profile of Blast-Cleaned Steel.
      j. D4541 - Standard Test Methods for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
      k. D4787 - Standard Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates.
      l. D5162 - Standard Practice for Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates.

m. D7234 - Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers.
n. E337 - Standard Test Method for Measuring Humidity with a Psychrometer (the Measurement of Wet- and Dry-Bulb Temperatures).
o. F1869 - Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.
p. F2170 - Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using In-situ Probes.

2. International Concrete Repair Institute (ICRI):
   a. 310.2 - Guideline for Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.
3. NACE International (NACE):
   a. SP0178 - Design, Fabrication, and Surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service.
   b. SP0188 - Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.
4. National Association of Pipe Fabricators (NAPF):
   a. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.
5. NSF International (NSF):
   a. 61 - Drinking Water System Components - Health Effects.
6. Occupational Safety and Health Administration (OSHA).
7. Society of Protective Coatings (SSPC):
   a. Glossary - SSPC Protective Coatings Glossary.
   b. Guide 6 - Guide for Containing Surface Preparation Debris Generated during Paint Removal Operations.
   c. PA 1 - Shop, Field, and Maintenance Painting of Steel.
   d. PA 2 - Procedure for Determining Conformance to Dry Coating Thickness Requirements.
   e. PA 9 - Measurement of Dry Coating Thickness Using Ultrasonic Gages.
   f. QP 1 - Standard Procedure for Evaluating the Qualifications of Industrial/Marine Painting Contractors.
   g. SP 1 - Solvent Cleaning.
   h. SP 3 - Power Tool Cleaning.
   i. SP 5 - White Metal Blast Cleaning.
   j. SP 10 - Near-White Metal Blast Cleaning.
   k. SP 11 - Power Tools Cleaning to Bare Metal.
   l. SP 13 - Surface Preparation of Concrete.
   m. SP 16 - Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals.
   n. SP COM - Surface Preparation Commentary.
   o. SP VIS 1 - Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning.
   p. SP WJ-1 - Waterjet Cleaning of Metals—Clean to Bare Substrate.
   q. SP WJ-2 - Waterjet Cleaning of Metals—Very Thorough Cleaning.
   r. SP WJ-3 - Waterjet Cleaning of Metals—Thorough Cleaning.
   s. SP WJ-4 - Waterjet Cleaning of Metals—Light Cleaning.

1.03 TERMINOLOGY

A. Definitions used in this Section are in accordance with definitions referenced in ASTM D16, ASTM D3960, and SSPC Glossary of Definitions.

B. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning:
   1. Abrasive: Material used for blast cleaning, such as sand, grit, or shot.
   2. Abrasive Blast Cleaning: Cleaning/surface preparation by abrasive propelled at high speed.
   3. Anchor Pattern: Profile or texture of prepared surface(s).
   4. Biogenic Sulfide Corrosion: Corrosion caused by sulfuric acid formed when *Thiobacillus* bacteria metabolizes hydrogen sulfide.
   5. Bug Holes: Small cavities resulting when air bubbles are entrapped in the surface of formed concrete during placement and consolidation.
   6. Coating/Paint/Lining Thickness: Total thickness of primer, intermediate, and/or finish coats after drying or curing.
   7. Dew point: Temperature a given air/water vapor mixture starts to condense.
   8. Dry to Recoat: Time interval between material application and its ability to receive the next coat.
   9. Dry to Touch: Time interval between material application and its ability to tolerate a light touch without coating damage.
   10. Drying Time: Time interval between application and material curing.
   11. Exposed Surface: Any indoor or outdoor surface not buried or encased.
   12. Feather Edging: Reducing coating thickness at its edge to blend with existing surrounding coating.
   13. Feathering: Tapering off a wet edge with a comparatively dry brush.
   14. Ferrous: Cast iron, ductile iron, wrought iron, and all steel alloys except stainless steel.
   15. Field Coat: Application of a surface coating system at the work site.
   16. Finish Coat: Final coat in a paint system, including texture, color, smoothness of surface, and other properties affecting appearance.
   17. Hold Point: A defined point, specified in this Section, at which work shall be halted for inspection.
   18. Holiday: A discontinuity, skip, void, or pinhole in coating or coating system film that exposes the substrate.
   19. Honeycomb: Segregated and porous surface of hardened concrete due to insufficient consolidation.
   20. Hydroblast: High or ultra-high-pressure water jet surface preparation.
   21. Immersed/Immersion: A service condition in which substrate is submerged, is immediately above liquids, or is subject to frequent wetting, splashing, or washdown.
   22. Incompatibility: One coating’s inability to overlay another coating or surface as evidenced by bleeding, poor bonding, or lifting of old coating; inability of a coating to bond to a substrate.
   23. Laitance: A thin, weak, brittle layer of cement and aggregate fines on a concrete surface.
   24. Mil: 0.001 inch.
   25. Overspray: Dry spray, particularly paint bonded to an unintended surface.
   26. Pinhole: A small diameter discontinuity in a coating or coating system film, created by offgassing from a void in a concrete or masonry substrate causing

a void between coats or exposing the substrate. Usually caused by coating application while temperature is rising.

27. Pot Life: Time interval after components are mixed and coating can be satisfactorily applied.
28. Prime Coat: First full paint coat applied to a surface when using a multicoat system. Primers adhere to a new substrate, protect the substrate, and promote adhesion of subsequent coats of paint. The prime coat on metal surfaces is the first full coat and does not include solvent wash, grease emulsifiers, or other pretreatment applications.
29. Resurfacer/Resurfacing Material: A layer of cementitious and/or resin-based material used to fill or otherwise restore surface continuity to worn or damaged concrete surfaces.
30. Shelf Life: Maximum storage time a material may be stored without losing its usefulness.
31. Shop Coat: 1 or more coats applied in an off-site shop or plant before shipment to work site where field or finishing coat(s) are applied.
32. Spreading Rate: Area covered by a unit volume of paint at a specific thickness.
33. Stripe Coat: A separate brush coat of paint applied to all weld seams, pits, nuts/bolts/washers, and edges. This coat shall not be applied until previous coats have cured. Once applied, the coat shall be allowed to cure before subsequent coats are applied.
34. System: Protective film with 1 or more coats applied in a predetermined order, including surface preparation and quality control requirements.
35. Thick Film Coating System: A coating system applied with a minimum dry film thickness of 25 mils.
36. Tie Coat: An intermediate coat that bonds different types of paint material, improving succeeding coat adhesion.
37. Touch-Up Painting: Application of paint on previously painted surfaces to repair marks, scratches, and deteriorated or damaged areas to restore the appearance and performance of the coating.
38. Water Blast: An alternative to air abrasive blast cleaning that can be used with or without abrasive injection. Water cleaning at pressures up to 5,000 pounds per square inch is called low-pressure water cleaning or power washing. High-pressure water cleaning uses water pressures between 5,000 and 10,000 pounds per square inch. Water jetting is water blasting with added abrasive at pressures between 10,000 and 25,000 pounds per square inch. Ultra-high-pressure water jetting is water blasting at pressures above 25,000 pounds per square inch.
39. Weld Splatter: Beads of non-structural weld metal that adhere to the surrounding surface, removed as part of surface preparation.

1.04 SUBMITTALS

A. As specified in Section 01 33 00 - Submittal Procedures, submit the following:
   1. Schedule of proposed coating materials.
   2. Schedule of surfaces to be coated with each coating material.
   3. Dehumidification and heating plan.
   4. Product data:
      a. Physical properties of coatings, including the following:
         1) Solids content.
         2) Ingredient analysis.

3) VOC content.
4) Temperature resistance.
5) Typical exposures and limitations.
6) Manufacturer's standard color chips.

b. Compliance with regulatory requirements:
1) VOC limitations.
2) Lead compounds and polychlorinated biphenyls.
3) Abrasives and abrasive blast cleaning techniques and disposal.
4) Methods for tenting blasting areas and methods to protect existing equipment from dust and debris.
5) NSF certification of coatings for potable water supply systems.

c. CSM's current printed recommendations and product datasheets for coating systems, including:
1) Surface preparation recommendations.
2) Primer type.
3) Maximum dry and wet-mil thickness per coat and number of coats:
a) Coating coverage worksheets.
4) Minimum and maximum curing time between coats, including atmospheric conditions for each.
5) Curing time before submergence in liquid.
6) Thinner to be used for each coating.
7) Ventilation requirements.
8) Minimum and maximum atmospheric conditions during which the paint shall be applied.
9) Allowable application methods.
10) Maximum allowable substrate moisture content.
11) Maximum shelf life.
12) Requirements for transportation and storage.
13) Mixing instructions.
14) Shelf life.
15) Material Pot life.
16) Precautions for applications free of defects.
17) Method of application.
18) Drying time of each coat, including prime coat.
19) Compatible prime coats.
20) Limits of ambient conditions during and after application.
21) Required protection from sun, wind, and other conditions.
22) Touch-up requirements and limitations.
23) Minimum adhesion of each system submitted in accordance with ASTM D4541 and ASTM D7234.

d. Samples: Include 8-inch square drawdowns or brushouts of topcoat finish when requested. Identify each sample as to finish, formula, color name and number, sheen name, and gloss units.

e. Affidavits signed by an officer of the CSM's corporation attesting to full compliance of each coating system component with current federal, state, and local air pollution control regulations and requirements.

f. List of cleaning and thinner solutions allowed by the CSMs.

g. Storage requirements, including temperature, humidity, and ventilation for Coating System Materials as recommended by the CSMs.

h. Thick film coating systems (greater than 25 mils):
    1) CSM's detailed written instructions for coating system treatment and graphic details for coating system terminations in coated structures, including pipe penetrations, metal embedments, gate frames, and other terminations encountered.
    2) Include detail treatment for coating system at concrete joints.
    3) Manufacturer's Representative's (CTR) Field Reports.

5. Quality assurance Submittals:
    a. Quality assurance plan.
    b. Qualifications of CSA, including:
        1) List of Similar Projects:
            a) Name and address of project.
            b) Year of installation.
            c) Year placed in operation.
            d) Point of contact: Name and phone number.
        2) Provide a minimum of 5 project references, each including contact name, address, and telephone number where similar coating work has been performed by their company in the past five years.
    c. CSA Reports:
        1) Written daily quality control inspection reports.
    d. CTR Reports:
        1) Reports on visits to project site to view and approve surface preparation of structures to be coated.
        2) Reports on visits to project site to observe and approve coating application procedures.
        3) Reports on visits to coating plants to observe and approve surface preparation and coating application on shop-coated items.

1.05 QUALITY ASSURANCE

A. CSA qualifications:
    1. Minimum of five years of experience applying specified type or types of coatings under conditions similar to those of the Work:
        a. Provide qualifications of applicator and references listing five similar projects completed in the past five years.
    2. SSPC-QP 1 certified.
    3. Manufacturer-approved applicator when manufacturer has approved applicator program or when required in these specifications.

B. CTR qualifications:
    1. Certification, one of the following:
        a. NACE Level 2 or 3 Certified Coating Inspector.
        b. SSPC Level 3 Protective Coatings Inspector.
    2. Minimum of five years of experience evaluating application of manufacturer's coatings under conditions similar to those of the Work:
        a. Provide CTR qualifications and references listing five similar projects completed in the past five years.

C. Regulatory requirements: Comply with governing agencies' regulations by using coatings in accordance with to their VOC limits:
   1. Lead-based coatings are not permitted.
   2. Do not use coal-tar epoxy in contact with drinking water or exposed to ultraviolet radiation.

D. Pre-installation conference: Conduct as specified in Section 01 31 19 - Project Meetings:
   1. Coordinate Hold Point schedule.

E. Field samples:
   1. Prepare and coat a minimum 100-square-foot area of each system between corners or limits such as control or construction joints.
   2. Approved field sample may be part of the Work.

F. Obtain approval before coating other surfaces. Use products by same manufacturer for prime coats, intermediate coats, and finish coats on same surface, unless specified otherwise.

G. CSM services:
   1. CSA shall arrange for CTR to attend pre-installation conferences.
   2. Visit the project site periodically to consult on and inspect specified surface preparation and application Hold Points.
   3. Visit coating plants to observe and approve surface preparation procedures and coating application of items to be shop primed and coated.
   4. CTR shall provide written inspection reports.

H. Quality control requirements:
   1. Contractor shall be responsible for the workmanship and quality of the coating system installation:
      a. Inspections by Owner, Engineer, CSA, or CTR will not relieve or limit Contractor's responsibilities.
   2. In accordance with this specification's requirements and the standards referenced in this Section. Changes in the coating system application requirements will be allowed only with the Engineer's written acceptance.
   3. Specially trained crews with experience applying the specified coating system coating are required for:
      a. Coating application using plural component spray equipment or other specialty equipment.
      b. Coating with specialty linings for severe service conditions, including floor coatings, and with linings for corrosive headspaces or secondary containment areas.
   4. CTR shall specially train personnel for coating systems as specified in Attachment B - Coating Detail Sheets:
      a. CSM shall approve personnel in writing applying the coating system.
   5. Do not use contaminated, outdated, diluted materials, and/or materials from previously opened containers.
   6. Identify inspection access points used by Owner's or Engineer's personnel.
   7. Provide ventilation, ingress, egress, or other means as necessary for Owner's or Engineer's personnel to safely access the work areas.

8. Conduct and continually inspect work so the coating system is installed as specified. CSM shall provide written directions to correct coating work not in accordance with the specifications or is otherwise unacceptable.
9. Provide written daily reports summarizing test data, work progress, surfaces covered, ambient conditions, quality control inspection test findings, and other information pertinent to the coating system application:
    a. Determine relative humidity in accordance with ASTM E337. Confirm other conditions, such as proper protective measures for surfaces not to be coated and safety requirements for personnel:
        1) Measure daily at shift's beginning and end and at intervals not to exceed 4 hours during the shift.
        2) Determine the acceptability of weather and/or environmental conditions within the structure in accordance with the CSM's requirements.
    b. Monitoring surface preparation: Spot check cleanliness, surface profile, and surface pH testing at least 3 times daily. Check each surface at least once. In accordance with:
        1) ASTM D4262.
        2) ASTM D4263.
        3) ASTM D4417.
        4) ICRI 310.2 requirements.
        5) SSPC Surface Preparation Standards.
    c. Confirm that compressed air used for surface preparation or blow-down cleaning is free of oil and moisture.
    d. Monitor surface preparation daily at shift's beginning and end and at intervals not to exceed 4 hours during the shift.
    e. Do not apply coatings when environmental conditions are outside of the CSM's published limits.
    f. Monitoring coatings application: Continuously inspect, measure, and record the wet film thickness and general film quality (visual inspection) for runs, sags, pinholes, holidays, etc., during coating.
        1) Perform WFT measurements in accordance with ASTM D4414.
    g. Post cure evaluation: Measure and inspect the overall dry film thickness on all surfaces:
        1) Conduct a DFT survey and perform adhesion testing, holiday detection, or cure testing as required in this Section and/or the CSM's written instructions.
        2) Perform applicable tests in accordance with ASTM D4541, ASTM D4787, ASTM D5162, ASTM D7234, SSPC-PA 1, SSPC-PA 2, SSPC-PA 9, and other pertinent standards and recommended practices.

I. Inspection at Hold Points:
    1. Conduct inspections at Hold Points during the coating system application and record the results.
    2. Coordinate Hold Points with the Engineer so the Engineer can observe Contractor's inspections on a scheduled basis.
    3. Provide the Engineer a minimum of 24 hours of notice before conducting Hold Point Inspections.

4. Hold Points shall be as follows:
    a. Conditions before surface preparation: Before starting surface preparation, observe, record, and confirm that oil, grease, and/or soluble salts are gone from the surface.
    b. Post surface preparation: After completing surface preparation, measure and inspect for cleanliness and proper surface profile as specified in this Section and in the CSM's written instructions.
    c. Coatings application: At the beginning of any coating system application, measure, record, and confirm acceptability of surface and ambient air temperature and humidity. Inspect applicator's equipment for serviceability and suitability for coatings application.
    d. Post application inspection: Identify defects in application work on all surfaces, including pinholes, holidays, excessive runs or sags, inadequate or excessive film thickness, and other problems.
    e. Follow-up corrective actions and final inspection: Measure and re-inspect corrective coating work performed to repair defects at prior Hold Points and repeat until the surface condition is acceptable. Conduct final visual inspection with follow-up tests, such as holiday detection, adhesion tests, and DFT surveys.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products as specified in Section 01 61 00 - Common Product Requirements.

B. Immediately remove unspecified and unapproved coatings from Project site.

C. Deliver new labeled, unopened containers:
    1. Do not deliver materials after manufacturer's expiration date or over 12 months from manufacturing date, whichever is more stringent. Store materials in well-ventilated enclosed structures and protect from weather and excessive heat or cold in accordance with the CSM's recommendations:
        a. Store flammable materials in accordance with federal, state, and local requirements.
        b. Store rags and cleanup materials appropriately to prevent fire and spontaneous combustion.
    2. Store and dispose of hazardous waste in accordance with federal, state, and local requirements. This requirement specifically applies to waste solvents and coatings.
    3. Container labels shall show the following:
        a. Brand name or product title.
        b. CSM's batch number.
        c. CSM's manufacture date.
        d. CSM's name.
        e. Generic material type.
        f. Application and mixing instructions.
        g. Hazardous material identification label.
        h. Shelf-life expiration date.

i. Color.
j. Mixing and reducing instructions.

4. Clearly mark containers to indicate safety hazards associated with the use of or exposure to materials.

1.07 PROJECT CONDITIONS

A. Apply coatings to dry surfaces:
1. Surface moisture: Comply with manufacturer's requirements or as specified in this Section:
a. Plaster and gypsum wallboard: 12 percent.
b. Masonry and concrete block: 12 percent.
c. Interior located wood: 15 percent.
d. Concrete floors: Moisture vapor transmission rate of no more than 3.0 pounds per 1,000 square feet per 24 hours in accordance with ASTM F1869 or relative humidity no greater than 80 percent if tested in accordance with ASTM F2170 unless the CSM's recommendations are more restrictive.
e. Concrete structures: Negative results from Plastic Sheet Test in accordance with ASTM D4263, and maximum of 80 percent relative humidity in accordance with ASTM F2170.

B. Do not apply coatings when the following conditions exist. If such conditions exist, provide containment, covers, environmental controls, and other necessary measures:
1. During rainy, misty, or damp weather, or to surfaces with frost or condensation.
2. When the surface temperature is below 10 degrees Fahrenheit above the dew point.
3. When ambient or surface temperature:
a. Is less than 55 degrees Fahrenheit unless manufacturer allows a lower temperature.
b. Is less than 65 degrees Fahrenheit for clear finishes unless manufacturer allows a lower temperature.
c. Exceeds 90 degrees Fahrenheit unless manufacturer allows a higher temperature.
d. Exceeds manufacturer's recommendation.
4. When relative humidity is higher than 85 percent.
5. Under dusty or adverse environmental conditions.
6. When light on surfaces measures less than 15 foot-candles.
7. When wind speed exceeds 15 miles per hour.

C. Apply coating only under evaporation conditions rather than condensation:
1. Use dehumidification equipment, fans, and/or heaters inside enclosed areas to maintain required atmospheric and surface temperature requirements for proper coating application and cure.
2. Measure and record relative humidity and air and surface temperatures at the start and end of each shift to confirm proper humidity and temperature levels inside the work area:
a. Submit test results.

D. Continuously ventilate, dehumidify, and heat enclosed spaces with high humidity during surface preparation, coating application, and curing:
   1. Maintain minimum air temperature of 55 degrees Fahrenheit and 10 degrees Fahrenheit above the dew point.
   2. Maintain dew point of at least 10 degrees Fahrenheit less than the temperature of the coldest part of the structure where work is performed.
   3. Reduce dew point temperature in conditioned space by at least 10 degrees Fahrenheit within 20 minutes.
   4. Seal work areas and maintain positive pressure per dehumidification equipment supplier's recommendations.
   5. Maintain these conditions before, during, and after application to ensure proper adhesion and cure of coatings for no less than:
      a. Entire curing period.
      b. 8 hours after coating.

E. Systems:
   1. Site electrical power availability as specified in Section 01 51 05 - Temporary Utilities and Temporary Facilities.
   2. Internal combustion engine generators may be used:
      a. Obtain required permits and provide air pollution and noise control devices on equipment as required by permitting agencies require.
      b. Comply with state, federal, and local fire and explosion protection measures when locating and operating generator.
      c. Locate engine generator outside hazardous classified areas in accordance with NFPA 820.
      d. Provide daily fuel service for generator for duration of use.
   3. Dehumidification:
      a. Provide desiccant or refrigeration drying.
      b. Use only desiccant types with a rotary desiccant wheel capable of continuous operation.
      c. Liquid, granular, or loose lithium chloride drying systems are not acceptable.
   4. Heating:
      a. Use electric, indirect combustion, or steam coil.
      b. Direct-fired combustion heaters are not acceptable heat sources during abrasive blasting, coating application, or coating cure.
   5. Filters:
      a. Use a filtration system for dust removal designed to not interfere with dehumidification equipment's ability to control dew point and relative humidity inside the reservoir.
      b. Do not allow air from the working area or dust filtration equipment to recirculate through the dehumidifier during coating application or when solvent vapors are present.
   6. Design and Submittals:
      a. Prepare and submit dehumidification and heating plan, including all equipment and operating procedures.
      b. Suppliers of services and equipment shall have at least 3 years of experience in similar applications.

F. Provide containment and ventilation system components in accordance with SSPC-Guide 6, Level 3 and as required for hazardous materials.

1.08 MAINTENANCE

A. Provide table of products applied organized by surface type. List coating manufacturer, color, color formulation, distributor name, telephone number, and address.

1.09 CTR RESPONSIBILITIES

A. General:
   1. Attend pre-installation conference.
   2. Perform onsite application training.
   3. Periodically inspect coating system application.

B. Coating system installation training:
   1. Provide a minimum of 8 hours of classroom and off-site training for application personnel and supervisory personnel in one of the following ways:
      a. Train a minimum of 2 supervisory personnel and 2 application personnel.
      b. Submit a letter from the CSM stating that CSM approves the supervisory and application personnel, listed by name and responsibility, and no additional training is required.
   2. CTR can train up to 14 application personnel and 3 supervisory personnel at a time.
   3. Minimum training requirements:
      a. Explain in detail the mixing, application, curing, and termination requirements.
      b. Provide hands-on demonstration of coating system mixing.
      c. Explain in detail the ambient condition requirements for temperature and humidity.
      d. Explain in detail the surface preparation requirements.
      e. Explain in detail the re-coat times, cure times, and related ambient condition requirements.
      f. Write a letter stating that training was satisfactorily completed by the personnel, listed by name and responsibility.
   4. Provide special training as specified in the Coating Detail Sheets.

C. Coating system inspection:
   1. CTR inspection is in addition to the CSA's inspection as specified in this Section.
   2. Be on-site to oversee:
      a. Coating application at least once a week.
      b. End of surface preparation.
      c. During coating application.
      d. Post-cure inspection.
   3. Routinely inspect and verify in writing that application personnel have successfully performed surface preparation, filler/surfacer application, coating system application, and Quality Control Inspection in accordance with this Section and to warrantable quality.
   4. Perform the following activities to confirm conformance with the specifications:
      a. Inspect ambient conditions during coating system installation at Hold Points for conformance with the specified requirements.

b. Inspect each coated surface type and coating system applied to verify the following:
    1) Cleanliness.
    2) Surface pH for concrete substrates.
    3) Confirm surface preparation of substrates where coating system will terminate or will be applied for conformance to the specified application criteria.
c. Verify surface profile of substrates by completing the following:
    1) Inspect preparation and application of coating detail treatment at terminations, transitions, metal embedments in concrete, and joints and cracks in substrates.
    2) Inspect application of filler/surfacer materials for concrete and masonry substrates.
    3) Verify proper mixing of coating materials.
    4) Inspect application of primers and finish coats, including wet and dry film thickness.
    5) Inspect coating systems for proper cure times and conditions.
d. Review adhesion testing of cured coating systems.
e. Review coating system continuity testing.
f. Inspect and record representative-localized repairs.
g. Conduct final review of completed coating system installation.
h. Prepare and submit site visit reports after each site visit to document that the coating work is in accordance with the CSM's Recommendations.

D. Final report:
    1. Prepare a final report, after coating work ends, summarizing each day's test data, observations, drawings, and photographs:
        a. Include substrate conditions, ambient conditions, and application procedures observed during the CTR's site visits.
        b. Include a statement that completed work was performed in accordance with the requirements of the CSM's recommendations.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Coating materials shall be formulated for environments encountered in water and wastewater treatment processes.

B. Coating materials that come in contact with water distributed as potable water shall be certified in accordance with NSF 61.

2.02 MATERIALS

A. General:
    1. Product requirements: As specified in Section 01 61 00 - Common Product Requirements.

2.03 COATING SYSTEMS IDENTIFICATION

A. Naming conventions: Coating Systems Identifications contain the elements defined in Table 1.

Table 1. Coating System Identification Elements						
First Element	**-**	**Second Element**	**-**	**Third Element**	**-**	**Fourth Element (optional)**
3 or 4 alpha characters		1-3 alpha characters		1 number		3 or 4 alpha characters
Coating Type		Substrate		System Number		Additional Substrate or Special Condition
Example: EPX	-	C	-	6	-	BSC

1. First element identifies the coating type using the following abbreviations:
   a. ACR: Acrylic.
   b. CTE: Coal tar epoxy.
   c. ELA: Elastomeric acrylic.
   d. EPU: Epoxy-polyurethane.
   e. EPX: Epoxy.
   f. POL: Polyurethane.
   g. SIL: Silicone.
   h. SILX: Siloxane or silane.
   i. VE: Vinyl ester.
2. Second element identifies the substrate using the following abbreviations:
   a. C: Concrete or masonry.
   b. F: Concrete flooring.
   c. FRP: Fiber-reinforced plastic.
   d. GM: Galvanized metal.
   e. M: Metal.
   f. PVC: Polyvinyl chloride, chlorinated polyvinyl chloride.
3. Third element identifies the sequential system number.
   a. For example, EPX-C-2 is the second standard epoxy coating system for concrete substrates.
4. Fourth element is optional and identifies the additional substrate or special condition with the following abbreviations:
   a. PWS: Potable water service applications (NSF-61 approved).
   b. BSC: Biogenic sulfide corrosion-resistant applications in wastewater.
   c. BG: Below grade or buried.
   d. OZ: Organic zinc primer, epoxy polyurethane system.
   e. SC: Secondary containment.

2.04 PRODUCTS FOR COATING SYSTEMS

A. Products: As specified in Attachment A - Coating Detail Sheets.

B. Cleaning solvents:
   1. Requirements for solvent wash, solvent wipe, or cleaner used, including, but not limited to, those used for surface preparation in accordance with SSPC-SP 1:
      a. Emulsifying type.

b. Containing no phosphates.
c. Biodegradable.
d. Does not damage zinc.
e. Compatible with the specified primer.
f. Complying with applicable air-quality control board requirements.

2. Use clean white cloths and clean fluids in solvent cleaning.

PART 3 EXECUTION

3.01 GENERAL PROTECTION REQUIREMENTS

A. Protect adjacent coated surfaces from coatings and damage associated with coating work. Repair damage resulting from inadequate or unsuitable protection.

B. Use drop cloths and other coverings to protect adjacent surfaces not to be coated against spatter and droppings.

C. Mask off surfaces of items not to be coated or remove items from area.

D. Furnish and deploy sufficient drop cloths, shields, and protective equipment to prevent spray or droppings from fouling surfaces not being coated and, in particular, surfaces within storage and preparation areas.

E. Place coating waste, cloths, and material that may pose a fire hazard in closed metal containers and remove daily from site.

F. Remove electrical plates, surface hardware, fittings, and fasteners before coating application:
1. Carefully store, clean, and replace items after completing coating in each area.
2. Do not use solvent or degreasers to clean hardware that may remove permanent lacquer finishes.

G. Erect and maintain protective enclosures in accordance with SSPC-Guide 6.

H. Protect the following surfaces from abrasive blasting by masking or by other means:
1. Threaded portions of valve and gate stems, grease fittings, and identification plates.
2. Machined surfaces for sliding contact.
3. Surfaces to be assembled against gaskets.
4. Surfaces of shafting where sprockets will be fit.
5. Surfaces of shafting where bearings will be fit.
6. Machined bronze surfaces, including slide gates.
7. Cadmium-plated items, except cadmium-plated, zinc-plated, or sherardized fasteners used to assemble equipment requiring abrasive blasting.
8. Galvanized items, unless scheduled to be coated.

I. Protect installed equipment, mechanical drives, and adjacent coated equipment from abrasive blasting to prevent damage caused by spent abrasive blast media, dust, or dirt entering such equipment.

J. Schedule cleaning and coating to keep dust and spray from the cleaning process from falling on wet, newly coated surfaces:
    1. Whenever possible, coordinate with other trades and complete surface preparation and coating work before installing hardware, hardware accessories, nameplates, data tags, electrical fixtures, and similar uncoated items that will be in contact with coated surfaces. Mask machined surfaces, sprinkler heads, and other small items that will not be coated.
    2. After completing coating, reinstall removed items.
    3. Disconnect and move equipment adjacent to walls to clean and coat equipment and walls. Replace and reconnect equipment after coating.

3.02 GENERAL SURFACE PREPARATION REQUIREMENTS

A. Prepare surfaces in accordance with CSM's instructions unless more stringent requirements are specified in this Section.

B. Coating detail sheets in Attachment A - Coating Detail Sheets include additional surface preparation requirements.

C. Follow more stringent requirement if information conflicts.

D. Where required by the City's Representative, a NACE International certified coatings inspector, provided by the Owner, will inspect and approve surfaces to be coated before applying a coating:
    1. CSA shall coordinate coating inspections:
        a. Identify coating inspection Hold Points during the pre-installation conference.
        b. Provide at least 2 days' notice before inspection.
    2. Correct surface defects identified by the inspector at no additional cost to the Owner.

3.03 MECHANICAL AND ELECTRICAL EQUIPMENT PREPARATION

A. Identify equipment, ducting, piping, and conduit as specified in Section 46_05_10 - Common Work Results for Mechanical Equipment, Section 40_05_00.03 - Pipe Identification, and Section 26_05_53 - Identification for Electrical Systems.

B. Remove grilles, covers, and access panels for mechanical and electrical system and coat separately.

C. Prepare and finish coat equipment primed by the manufacturer using specified intermediate and topcoats, as applicable, and color selected by the Owner.

D. Prepare, prime, and coat both insulated and bare pipes, conduits, boxes, insulated and bare ducts, hangers, brackets, collars, and supports, except where items are covered with material not requiring coating, or with a prefinished coating.

E. Replace identification markings on mechanical or electrical equipment when coated over or spattered.

F. Prepare and coat interior surfaces of air ducts and convector and baseboard heating cabinets visible through grilles and louvers with 1 coat of flat black paint to limit of sight line.

G. Prepare and coat dampers exposed immediately behind louvers, grilles, and convector and baseboard heating cabinets to match face panels.

H. Prepare and coat exposed conduit and appurtenances occurring in finished areas with color and texture to match adjacent surfaces.

I. Prepare and coat sides' front, back, and edges of plywood backboards for electrical equipment before installing backboards and mounting equipment on them.

J. Color code equipment, piping, conduit, and exposed ductwork and apply color banding and identification, such as flow arrows, naming, and numbering, in accordance with the Contract Documents.

3.04 CLEANING OF NEW AND PREVIOUSLY COATED OR NEW SURFACES

A. Utilize cleaning agent to remove soluble salts, such as chlorides, from concrete and metal surfaces:
   1. Cleaning agent: Biodegradable non-flammable and containing no VOC.
   2. Manufacturers: The following or equal:
      a. CHLOR*RID International, Inc.:
         1) Complete soluble salt removal with steam or warm water cleaning.
   3. Steam clean and degrease surfaces to be coated to remove oils and grease.
   4. Clean surfaces with decontamination agent in conjunction with abrasive blast cleaning, steam cleaning, high-pressure washing, or hand washing, as approved by the CTR and the Engineer.
   5. Test cleaned surfaces to ensure removal of soluble salts. Carry out additional cleaning as needed.
   6. Complete final surface preparation before applying new coating system in strict accordance with CSM's printed instructions.

3.05 BLAST CLEANING

A. Surface preparation requirements:
   1. Do not reuse spent blast abrasive.
   2. Ensure that filter compressed air used for blast cleaning is free of condensed water and oil:
      a. Clean moisture traps at least once every 4 hours or more frequently, as required, to prevent moisture from entering the abrasive blasting equipment air supply.
      b. Check blast air for moisture and oil after each cleaning in accordance with ASTM D4285.
   3. Install oil separators just downstream of compressor discharge valves and at the discharge point of blast pot discharges. Check separators on the same frequency as the moisture traps.
   4. Keep regulators, gauges, filters, and separators on compressor air lines to blasting nozzles operational at all times.

5. Install an air dryer or desiccant filter drying unit to dry the compressed air before blast pot connections. Use and maintain the dryer throughout surface preparation work.
6. Use a venturi-type, or other high velocity-type, abrasive blast nozzles supplied with at least 100 pounds per square inch gauge air pressure at the nozzle and enough volume to obtain appropriate blast cleaning production rates and surface cleanliness.
7. Provide airborne particulate evacuation and filtering that meets OSHA safety standards. Maintain optimal visibility both to clean and provide the specified surface profile and to allow inspection of the substrate during surface preparation work.
8. If prepared and cleaned metallic substrates become contaminated between final surface preparation work and coating system application, or if the prepared substrate darkens or changes color, re-clean by water blasting, or abrasive blast cleaning as appropriate until the specified degree of cleanliness is restored.

B. Water jetting or water blasting:
1. Use water jetting or water blasting for recoating or relining where an adequate surface profile exists.
2. Perform water jetting or water blasting in accordance with SSPC-SP 13 and SSPC-WJ-1, WJ-2, WJ-3, WJ-4.

3.06 PREPARATION REQUIREMENTS FOR CONCRETE SURFACES

A. Cure for at least 28 days before coating.

B. Remove degraded concrete using abrasive blast cleaning or high or ultra-high-pressure water jetting, chipping, or other abrading tools until achieving a sound, clean substrate. Remove bruised or cracked concrete.

C. Prepare substrate cracks and areas requiring resurfacing; perform detail treatment, including, but not limited to, terminating edges in accordance with the CSM's recommendations, and as indicated on the Drawings.
1. Prepare concrete surfaces in accordance with SSPC-SP 13.

D. Prepare concrete surfaces in accordance with SSPC-SP 13:
1. Inspect concrete surfaces to select appropriate surface preparation method to provide a suitable substrate for the specified coating system.
2. Use blast cleaning or other means to expose the complete perimeter of air voids or bug holes. Do not leave shelled over, hidden air voids beneath the exposed concrete surface.
3. Repair concrete defects and physical damage.
4. Clean concrete surfaces of dust, mortar, formwork, fins, loose concrete particles, form release materials, oil, and grease.
5. Fill voids to provide surface as specified in Section 03_35_29 - Concrete Finishes.

E. Provide clean substrate visually free of calcium sulfate, loose, coarse, or fine aggregate, laitance, loose hydrated cement paste, and otherwise harmful substances:
   1. Confirm concrete surface minimum pH of 9.0 with surface pH testing.
   2. If after surface preparation the surface pH remains below 9.0, perform additional water blasting, cleaning, or abrasive blast cleaning until additional pH testing indicates an acceptable pH level.

F. Prepare concrete surface for coating in accordance with SSPC-SP 13:
   1. Provide ICRI 310.2 minimum No. 3 concrete surface profile (CSP) or as specified on Coating Detail Sheets.
   2. Evaluate profile of the prepared concrete using ICRI 310.2 surface profile replicas.

G. Blast clean cementitious repair mortars or grouts to the same profile and degree of cleanliness requirements required for concrete substrates.

H. Blast clean polymer-based surfacers or waterborne modified cementitious surfaces only if they have exceeded the CSM's recommended recoat time.

I. Vacuum concrete surfaces before coating application, leaving a dust free, sound concrete substrate:
   1. Thoroughly clean concrete surfaces to be coated to remove loose dirt and spent abrasive.
   2. Remove debris produced by blast cleaning from the structures to be coated, and legally dispose of it off-site.

J. Test moisture content of concrete to be coated:
   1. Conduct ASTM D4263 plastic sheet test at least once for every 500 square feet of surface area to be coated:
      a. Any moisture on plastic sheet after test period constitutes a non-acceptable test, and the concrete must be dried further.
   2. Conduct ASTM F1869 test at least once for every 1,000 square feet of concrete floor surface area to be coated.
   3. Conduct ASTM F2170 one relative humidity moisture test at least once for each 500 square feet of non-floor concrete surface area where the opposite side is exposed to soil or water:
      a. Waterproof surfaces exposed to soil or water where specified.
   4. Comply with specified minimum moisture content and CSM's written recommendations for moisture vapor transmission rates or relative humidity values.

K. Masonry surfaces:
   1. Cure for at least 28 days before coating.
   2. Prepare masonry surfaces to remove chalk, laitance, loose dirt, dried mortar splatter, dust, peeling, or loose existing coatings, or otherwise deleterious substances to leave a clean, sound substrate.
   3. Wash and scrub masonry surfaces with clear water. Do not use muriatic acid.
   4. Seal or fill masonry surfaces with a sealer or block filler compatible with the specified primer after cleaning.

5. Confirm that masonry surfaces are dry before coating application:
    a. If using pressure washing or low-pressure water blast cleaning for preparation, allow the masonry to dry for at least 5 days under dry weather conditions or until the minimum ambient temperature is 70 degrees Fahrenheit before coating.

3.07 GENERAL PREPARATION REQUIREMENTS FOR METALLIC SURFACES

A. Remove rust, scale, and welding slag and spatter:
    1. Remove and grind smooth excessive weld material and weld spatter on metal surfaces before blast cleaning in accordance with NACE SP0178, Appendix C, Level C.
    2. Grind sharp edges on metal substrate to approximately 1/16-inch radius before abrasive blast cleaning.

B. Prepare metallic surfaces in accordance with applicable portions of surface preparation specifications of the SSPC specified for each coating system:
    1. Remove grease and oil in accordance with SSPC-SP 1.
    2. Use solvent as recommended by the CSM.
    3. Measure profile depth of the surface to be coated in accordance with Method C of ASTM D4417. Select blast particle size and gradation to produce the specified surface profile.
    4. Constantly monitor and maintain ambient environmental conditions to ensure cleanliness and that no “rust back” occurs before coating material application.

C. Prepare metallic surfaces by blast cleaning in accordance with SSPC-VIS 1 (ASTM D2200). Prepare abrasive blast representative areas for the City’s Representative to inspect on the first day of cleaning.

D. Unless otherwise specified, the requirements for blast cleaning steel, ductile iron, and stainless-steel substrates are as follows:
    1. Ferrous metal surfaces not to be submerged: Abrasive blast in accordance with SSPC-SP 10 unless blasting may damage adjacent surfaces, is prohibited, or is specified otherwise. Where abrasive blasting is not possible, clean surfaces to bare metal with power tools in accordance with SSPC-SP 11.
    2. Ferrous metal surfaces to be submerged: Abrasive blast in accordance with SSPC-SP 5, unless specified otherwise, to clean and provide roughened surface profile with a depth between 2 and 4 mils.
    3. Remove traces of grit, dust, dirt, rust scale, friable material, loose corrosion products, or embedded abrasive from substrate before coating application.
    4. When abrasive blasted surfaces rust or discolor before coating, abrasive blast clean surfaces again.

E. Field preparation of shop-primed surfaces:
    1. Smooth welds and prominences with power tools before applying field-applied coatings.
    2. Clean and dry shop-primed ferrous metal surfaces and fabricated assemblies before applying field coats.

3. Prepare shop epoxy primed surfaces with light abrasive blasting or abrading and then vacuum before applying finish coats:
    a. Follow CSM instructions for surface preparation when the primer recoat limit has been exceeded.
4. Non-immersion service: Clean in accordance with SSPC-SP 2 (Hand Tool Cleaning) or SSPC-SP 3 (Power Tool Cleaning) and uniformly roughen.
5. Immersion, BSC, and SC service: Remove shop primer in accordance with SSPC-SP 5 (Near-White Blast Cleaning).

F. Damaged shop primer or rust bleeding:
1. Ferrous metals: Clean in accordance with SSPC-SP 1 (Solvent Cleaning) and spot blast in accordance with SSPC-SP 10 (Near-White Metal Blast Cleaning) to achieve a uniform surface profile between 2.0 and 2.5 mils before recoating.
2. Reject galvanized steel with rust bleeding.

G. Damaged coating: Repair by abrasive blast cleaning surfaces as specified for the coating system; feather to a smooth transition before touching up.

3.08 PREPARATION REQUIREMENTS BY SURFACE TYPE

A. Galvanized steel and non-ferrous metal surfaces:
1. Degrease or solvent clean (SSPC-SP 1) to remove oily residue.
2. Abrasive blast clean in accordance with SSPC-SP 16:
    a. If abrasive blast cannot be performed, abrade in accordance with SSPC-SP 3 (Power Tool Cleaning).
3. Apply metal pretreatment within 24 hours before coating galvanized surfaces that cannot be thoroughly abraded, such as bolts, nuts, or preformed channels.
4. Test surface for contaminants using copper sulfate solution.

B. Stainless-steel surfaces:
1. Abrasive blast clean in accordance with SSPC-SP 16 to leave a clean, uniform appearance with surface profile between 1.5 and 2.5 mils.

C. Ductile iron pipe and fittings to be lined or coated: Abrasive blast clean in accordance with NAPF 500-03.

D. Sherardized, aluminum, copper, and bronze surfaces:
1. Abrasive blast clean in accordance with SSPC-SP 16.
2. Prepare in accordance with CSM’s instructions.

E. Cadmium-plated, zinc-plated, or sherardized fasteners:
1. Abrasive blast in the same manner as uncoated metal when assembling equipment designated for abrasive blasting.

F. PVC and FRP surfaces:
1. Lightly sand surfaces to be coated:
    a. Sand to remove gloss and establish uniform surface profile.
2. Vacuum to remove loose dust, dirt, and other materials.
3. Solvent clean with clean white rags and allow solvent to evaporate completely before applying coating materials.

3.09 APPLICATION REQUIREMENTS

A. Apply coatings in accordance with manufacturer's instructions.

B. Empty aboveground piping to be coated of contents when applying coatings.

C. Mechanical equipment shop primed by the manufacturer:
   1. Pumps and valves: Shop coat with manufacturer's highest quality coating system meeting the project specifications:
      a. Provide CTR shop coating reports.
   2. Non-immersed equipment: Touch up shop primer, and coat in the field with specified coating system after installation:
      a. If project requires equipment removal and reinstallation, complete touch-up coating after final installation.
   3. Immersed equipment not shop coated: Remove shop primer before surface preparation and field apply coating.

D. Verify surface preparation immediately before applying coating in accordance with SSPC-SP COM and the SSPC visual standard for the specified surface preparation method.

E. Allow surfaces to dry, except where coating manufacturer requires surface wetting before coating.

F. Wash coat and prime sherardized, aluminum, copper, and bronze surfaces, or prime with manufacturer's recommended special primer.

G. Do not apply coatings to a surface until it has been prepared as specified.

H. Use equipment designed to apply materials specified:
   1. Use compressors with moisture traps and filters that remove water and oils from the air:
      a. Perform a paper blotter test at the Engineer's request to verify air is sufficiently free of oil and moisture. Do not allow the amount of oil and moisture to exceed CSM-recommended amount.
   2. Equip spray equipment with properly sized mechanical agitators, pressure gauges, pressure regulators, and spray nozzles.

I. Where 2 or more coats are required, tint prime coat intermediate coats as necessary to distinguish each coating and to help indicate coverage:
   1. Do not use color additives with chromium, lead or lead compounds that hydrogen sulfide, other corrosive gases, might destroy or alter. Apply the specified number of coats.

J. Apply coating by brush, roller, trowel, or spray unless a specific application method is required by coating manufacturer's instructions or these Specifications:
   1. Apply primer or first coat by brush to power tool cleaned ferrous surfaces.
   2. Brush or spray-apply coats for blast-cleaned ferrous surfaces and subsequent coats for non-blast cleaned ferrous surfaces.
   3. After prime coat dries, mark, repair, and retest pinholes and holidays before intermediate or topcoats are applied.

K. Spray application:
   1. With a brush, stripe coat edges, welds, corners, nuts, bolts, and difficult-to-reach areas, as necessary, before spray application to ensure specified coating thickness along edges.
   2. When using spray application, apply each coat to thickness no greater than recommended in coating manufacturer's instructions.
   3. Use airless spray method unless air spray method is required by CSM's instruction or these Specifications.
   4. Conduct spray coating under controlled conditions. Protect adjacent construction and property from coating mist, fumes, or overspray.

L. Lightly sand and thoroughly clean surfaces to receive high-gloss finishes unless CSM instructs otherwise.

M. Remove dust on coatings between coats.

N. Shop and field coats:
   1. Prime coat: Shop-apply or field-apply prime coats as specified. Use shop-applied primer compatible with the specified field coating system and apply at the minimum dry film thickness recommended by the finish coat CSM:
      a. Provide datasheets identifying the shop primer to on-site coating application personnel.
      b. Perform adhesion tests on the shop primer.
      c. Remove and recoat damaged, deteriorated, and poorly applied shop coatings.
      d. If shop primer coat meets this Section's requirements, spot prime exposed metal of shop-primed surfaces before spray applying primer over the entire surface.
   2. Field coats: Apply field coats with 1 or more prime coats and finish coats to build up coating to dry film thickness specified for the coating system:
      a. Do not apply finish coats until other work in the area is complete and previous coats are inspected.
   3. Adhesion confirmation: Perform adhesion tests after proper coating cure in accordance with ASTM D3359. Demonstrate that:
      a. Prime coat adheres to the substrate.
      b. Coatings adhere to the prime and intermediate coats:
         1) Coating 5 mils or more DFT: Achieve adhesion test result of 5A on immersed surfaces and 4A or better on other surfaces.
         2) Coating less than 5 mils DFT: Achieve adhesion test results of 5B on immersed surfaces and 4B or better on other surfaces.

O. Brush, roll, trowel, or spray and back roll coats for concrete and masonry.

P. Plural component coating application:
   1. Premix contents of component drums if required by the CSM each day.
   2. Before starting application:
      a. Verify gauges are working properly.
      b. Complete ratio checks.
      c. Sample the mix on plastic sheeting to ensure set time is appropriate and complete.
      d. Label and retain spray samples. Submit to Engineer when requested.

Q. Drying and recoating:
   1. Provide fans, heating devices, or other means to prevent condensate or dew on substrate surface or between coats and during curing after applying the last coat.
   2. Allow each coat to cure or dry thoroughly, in accordance with if required in CSM's printed instructions, before recoating.
   3. Use CSM's printed instructions and the requirements specified in this Section to determine minimum required drying time:
      a. Do not allow excessive drying time or exposure, which may impair bond between coats.
      b. Recoat coatings within time limits recommended by CSM.
      c. If time limits are exceeded, abrasive blast clean and de-gloss clean before applying another coat.
   4. If limitations on time between abrasive blasting and coating are not met before attaching components to surfaces that cannot be abrasive blasted, coat components before attachment.
   5. Ensure primer and intermediate coats of coating are unscarred and completely integral when applying each succeeding coat.
   6. Touch up suction spots between coats and apply additional coats where required to produce finished surface of solid, even color, free of defects.
   7. Leave no holidays. Repair holidays in accordance with the requirements on pertinent Coating Detail Sheets or as recommended by the CSM.
   8. Sand and feather into a smooth transition and recoat scratched, contaminated, or otherwise damaged coating surfaces so repairs are invisible to the naked eye.

R. Workmanship:
   1. Ensure that coated surfaces are free from runs, drips, ridges, waves, laps, and brush marks. Coats shall be applied to produce a smooth, even film of uniform thickness completely coating corners and crevices.
   2. Coat surfaces without drops, overspray, dry spray, excessive runs, ridges, waves, holidays, laps, or brush marks.
   3. Remove splatter and droppings after coating work is completed.
   4. Evenly apply each coat of material and sharply cut to a line created with masking tape or other suitable materials.
   5. Avoid over spraying or spattering paint on surfaces not to be coated. Protect glass, hardware, floors, roofs, vehicles, and other adjacent areas and installations by taping, drop cloths, or other suitable measures.
   6. When coating complex steel shapes, stripe coat welds, edges of structural steel shapes, metal cut-outs, pits in steel surfaces, or rough surfaces with the primer before overall coating system application:
      a. Brush apply stripe coat to ensure proper coverage.
      b. Do not stripe coat with spray or roller.
   7. Ensure that finish coat, including repairs, has a uniform color and gloss.

S. Coating properties, mixing, and thinning:
   1. Thin prime coat and apply as recommended by the CSM. Thinned coating must comply with prevailing air pollution control regulations.
   2. If maximum recoat time is exceeded, prepare surface with solvent washing, light abrasive blasting, or other procedures in accordance with CSM's instructions.

3. Allow adequate drying time between coats as instructed by the CSM, adjusted as necessary for the site conditions.
4. Ensure that coatings, when applied, provide a satisfactory film and a smooth even surface. Lightly sand glossy undercoats to provide a surface suitable for proper application and adhesion of subsequent coats. Thoroughly stir and strain coating materials during application and maintain uniform consistency.
5. Mix coatings with 2 or more components in accordance with CSM's instructions.
6. Where necessary to suit conditions of the surface, temperature, weather, and method of application, thin the coating in accordance with CSM's recommendations:
    a. Ensure that volatile organic content (VOC) of the thinned coating complies with prevailing air pollution control regulations.
    b. Thin coatings to only what is necessary to obtain proper application characteristics.
    c. Use a thinner recommended by the CSM.

T. Film thickness and continuity:
1. Apply coating to the specified thicknesses:
    a. Apply additional coats when necessary to achieve specified thicknesses, especially at edges and corners.
2. Verify WFT of the coating system first coat and after applying each subsequent coat.
3. Do not allow the minimum thickness at any point to deviate more than 25 percent from the required average.
4. Do not allow the surface area covered per gallon of coating for various types of surfaces to exceed those recommended by the CSM:
    a. Provide coating coverage worksheets listing the maximum and minimum coverage for each unit volume of coating for concrete surfaces.
5. Apply additional coats to achieve the specified dry film thickness if brush or roller application methods cannot achieve the specified film thicknesses per coat.

U. Protecting coated surfaces:
1. Do not handle, work on, or otherwise disturb coated items until the coating is completely dry and hard.
2. After installation, recoat shop-coated surfaces with specified coating system as necessary to match surrounding surfaces, and to coordinate with the specified color identification requirements.

V. Special requirements:
1. Before erection, 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 inaccessible after assembly. Apply final coat after erection.
2. Coat structural slip-critical connections and high strength bolts and nuts after erection.
3. Areas damaged during erection:
    a. Prepare surface for spot repairs as specified for the coating system.
    b. Recoat with prime coat before applying subsequent coats.
    c. Touch up surfaces after installation.
    d. Clean and dry surfaces to be coated at time of application.

4. Coat underside of equipment bases and supports not galvanized with at least 2 coats of primer specified before setting the equipment in place.
5. Coat aluminum in contact with concrete.

3.10 APPLICATION REQUIREMENTS FOR CONCRETE COATING SYSTEMS

A. Apply filler/surfacer as recommended by CSM to fill bug holes and air voids in concrete or block texture in CMU, leaving a uniformly filled surface that does not produce blowholes or outgassing causing the coating system to pinhole:
   1. Allow filler/surfacers to cure sufficiently before applying prime coat as required by the CSM. Use the CSM-recommended drying time between coats.

B. Apply surfacer or filler and let dry before coating application:
   1. Use the drying time between filler/surfacer and coating system specified by the CSM for the site conditions:
      a. Let concrete substrate dry before applying filler/surfacers or coating system materials.
   2. If the maximum recoat time is exceeded, prepare surfaces by solvent washing, light abrasive blasting, and other procedures in accordance with CSM's instructions.
   3. Apply a complete parge coat of the specified filler/surfacer material over the entire substrate before applying the coating system:
      a. Scrub filler/surfacer into the substrate to completely fill open air voids and bug holes.
      b. Completely cover the substrate, unless otherwise specified, above such filled voids by 1/8 inch of thickness.
      c. Provide relatively flat, uniformly even surface before coating application.
   4. Secondary containment: Place surfacer or filler 1/16-inch thick above concrete plane to create a monolithic surface free of pinholes:
      a. Floor surfaces: Broadcast with aggregate to create a non-slip surface texture.
      b. Remove excess aggregates and apply base coat to encapsulate embedded non-slip aggregate.

C. Concrete substrate temperatures:
   1. Apply filler/surfacers and the coating system when temperatures are falling, typically late afternoon or evening:
      a. Do not coat concrete with rising concrete substrate surface temperatures or substrates in direct sunlight, to minimize outgassing from the substrate and formation of pinholes, and/or blistering.
   2. Should bubbles, pinholes, or other discontinuities form in the applied coating system material, they shall be repaired.
      a. Should discontinuities develop in the filler/surfacer material or in the first coat of the coating material, repair them before the next coat.
      b. When discontinuities occur, open the air void behind or beneath the discontinuities and completely fill with specified coating material. Then, abrade the coated area around the discontinuities repair reapply coating over that area.

D. Perform application detail work in accordance with these Specifications, the CSM's current written recommendations, and Drawings, whichever is stricter.

E. Concrete coating systems application requirements:
   1. Concrete coating minimum dry film thickness excludes parge coat, block filler, and sealer.

3.11 COATING SYSTEM SCHEDULE

A. As indicated on Attachment A.

3.12 SURFACES NOT REQUIRING COATING

A. Stainless steel piping, valves, pipe supports, instrument sunshades.

B. Sliding surfaces on expansion joints, motor and pump shafts, machined surfaces at bearings and seals, grease fittings, etc.

C. Galvanized structural steel framing, galvanized roof decking, galvanized pipe supports.

D. Copper and brass pipe, fittings, valves, etc.

E. Bronze valves, bearings, bushings, and fasteners.

F. Corrosion resistant special alloys: Inconel, Alloy 20, Hastelloy, etc.

G. Exterior concrete.

H. Plastic surfaces except coat PVC, CPVC, and other plastic piping system exposed to sunlight.

I. Buried piping that is encased in concrete or cement mortar.

3.13 QUALITY CONTROL

A. Owner-provided inspection or inspection by others does not limit the Contractor's or CSA's responsibilities for quality workmanship or quality control as specified or as required by the CSM's instructions. Owner inspection is in addition to any inspection required of the Contractor.

B. Owner may perform, or contract with an inspection agency to perform, quality control inspection and testing of the coating work covered by this Section. These inspections may include the following:
   1. Inspect materials upon receipt to ensure that the CSM supplied them.
   2. Verify that specified storage conditions for the coating system materials, solvents, and abrasives are provided.
   3. Inspect and record findings for substrate cleanliness.
   4. Inspect and record pH of concrete and metal substrates.
   5. Inspect and record substrate profile (anchor pattern).
   6. Measure and record ambient air and substrate temperature.
   7. Measure and record relative humidity.
   8. Check for substrate moisture in concrete.

9. Verify that mixing of coating system materials is in accordance with CSM's instructions.
10. Inspect, confirm, and record that coating system materials' "pot life" is not exceeded during installation. Inspect to verify that recoat limitations for coating materials are not exceeded.
11. Perform adhesion testing.
12. Measure and record the coating system's thickness.
13. Verify proper curing of the coating system in accordance with the CSM's instructions.
14. Holiday or continuity testing in accordance with NACE SP0188 for coatings that will be immersed or exposed to aggressively corrosive conditions.

C. Perform holiday testing in accordance with NACE SP0188 to identify holidays or pinholes needing repair for coating over 100 percent of surfaces:
   1. Coated steel that will be immersed or exposed to aggressively corrosive conditions.
   2. Coated concrete.
   3. Perform holiday tests after proper application and coating system cure.

3.14 CORRECTIVE MEASURES

A. Repair pinholes or holidays identified by Holiday Testing as follows:
   1. Remove the coating system with a grinder or other suitable power tool.
   2. Remove coating system at pinholes and holidays at least 2 inches diameter around the defect back to expose substrate.
   3. Concrete voids: Chip back to expose entire cavity in all directions:
      a. Completely fill void with approved filler/surfacer material using a putty knife or other suitable tool and strike off. Cure in accordance with CSM's recommendations.
   4. Aggressively abrade or sand the intact coating system surface at least 3 inches beyond the removal area in all directions to produce a uniform 6-to 8-mil profile in the intact coating system.
   5. Vacuum the prepared area to remove dust, dirt, etc., leaving clean, sound surfaces.
   6. Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area.
   7. Apply the coating system with enough coats to achieve the specified finish coat thickness over the defect and coating removal area. Feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline.
   8. Follow curing time between coats as specified by CSM for the site conditions. Solvent wash and abrasive blast in accordance with CSM's instructions if the maximum recoat time is exceeded.
   9. Apply coating at specified dry film thickness.

3.15 CLEANUP

A. Remove surplus materials, protective coverings, and accumulated rubbish after completing coating. Thoroughly clean surfaces and repair overspray or other coating-related damage.

3.16 FINAL INSPECTION

A. Conduct final inspection of coating system work to determine whether it meets specifications requirements.

B. Conduct subsequent final inspection with the Engineer to ensure Work is in accordance with Contract Documents requirements.

C. Mark any rework required:
   1. Re-clean and repair, as specified, at no additional cost to the Owner.

END OF SECTION

ATTACHMENT A - SCHEDULE OF SURFACES TO BE COATED

ATTACHMENT A
Schedule of Surfaces to be Coated

A. The following schedule is incomplete. Coat unlisted surfaces with same coating system as similar listed surfaces. Contact Engineer for clarification.

EPU-M-1	Metals, exterior, non-immersed
EPX-M-2	Metals, interior, non-immersed
EPX-M-2-PWS	Metals: immersed and in contact with water being treated for domestic use (potable water).
EPX-M-3	Metals, immersed
VE-M-1	Immersion or non-immersion (primary or secondary containment) very corrosive. Indoors or exterior.

Notes:

1: Non-immersed ferrous metal surfaces include:

a. Doors, doorframes, ventilators, louvers, grilles, exposed sheet metal, and flashing.
b. Pipe, valves, pipe hangers, supports and saddles, conduit, cable tray hangers, and supports.
c. Motors and motor accessory equipment.
d. Drive gear, drive housing, coupling housings, and miscellaneous gear drive equipment.
e. Valve and gate operators and stands.
f. Structural steel.
g. Crane and hoist rails.
h. Exterior of tanks and other containment vessels.
i. Mechanical equipment supports, drive units, and accessories.
j. Bare electrical equipment: boxes, exposed conduit, and accessories.
k. Pumps not submerged.
l. Other miscellaneous metals.

2: Immersed ferrous metal surfaces include:

a. Interior surfaces of ferrous metal tanks.
b. Field priming of ferrous metal surfaces with defective shop-prime coat; including non-submerged service.
c. Bell rings, underside of manhole covers and frames.
d. Sump pumps, including underside of base plates and submerged suction and discharge piping.
e. Exterior of submerged piping and valves other than stainless steel or PVC piping.
f. Submerged pipe supports and hangers.
g. Stem guides.
h. Other submerged iron and steel metal unless specified otherwise.

ATTACHMENT B - COATING DETAIL SHEETS

Attachment B			
Coating Detail Sheet			
Coating System	EPU-M-1		
Coating Material	Two coats epoxy with polyurethane finish coat		
Substrate	Metal		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	Carboguard 890	Carboguard 890	Carbothane 134 VOC
International Paint	Devran 224V	Devran 224V	Devthane 379H
PPG	Amerlock 2VOC	Amerlock 2VOC	Amershield VOC
Sherwin Williams	Macropoxy 646 100	Macropoxy 646 100	Hi Solids Polyurethane 250
Tnemec	Series 69	Series 69	Series 1095
Service Condition	Interior or Exterior, subject to direct sunlight. Non-immersion.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Ferrous Metal	Bare surfaces: SSPC-SP10, Near-White Blast Cleaning. Shop primed surfaces: SSPC-SP2, Hand Tool Cleaning or SSPC-SP3, Power Tool Cleaning. Damaged primer or rust: SSPC-SP10, Near White Blast Cleaning and spot prime.		
Nonferrous Metal	SSPC-SP16, Brush Blast Cleaning.		
Galvanized Metal	SSPC-SP16, Brush Blast Cleaning. Test for surface contaminants.		
Surface Profile			
Ferrous Metal	2.5 to 3.0 mils		
Nonferrous Metal	1.5 to 2.0 mils		
Galvanized Metal	1.5 to 2.0 mils		
System Thickness (Dry Film)			
Total	10 to 13 mils		
Primer	4 to 5 mils		
Intermediate Coat	4 to 5 mils		
Finish Coat	2 to 3 mils		
Application			
Special CTR Training	Not required.		

Attachment B			
Coating Detail Sheet			
Coating System	EPX-M-2		
Coating Material	Epoxy		
Substrate	Metal		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	Carboguard 890	Carboguard 890	Carboguard 890
International Paint	Bar-Rust 236	Bar-Rust 236	Bar-Rust 236
PPG	Amerlock 2/400 Series	Amerlock 2/400 Series	Amerlock 2/400 Series
Sherwin Williams	TankClad HS	TankClad HS	TankClad HS
Tnemec	Series 69	Series 69	Series 69
Service Condition	Immersed, non-immersed, moderately corrosive environment.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Ferrous Metal	Bare surfaces: SSPC-SP5, White Metal Blast Cleaning. Shop primed surfaces: SSPC-SP7, Brush-Off Blast Cleaning. Damaged primer or rust: SSPC-SP5, White Metal Blast Cleaning and spot prime.		
Nonferrous Metal	SSPC-SP16, Brush-Off Blast Cleaning.		
Galvanized Metal	SSPC-SP16, Brush-Off Blast Cleaning.		
Surface Profile			
Ferrous Metal	2 to 4 mils		
Nonferrous Metal	1.0 to 1.5 mils		
Galvanized Metal	1.0 to 1.5 mils		
System Thickness (Dry Film)			
Total	12 to 16 mils		
Primer	4 to 6 mils		
Intermediate Coat	4 to 6 mils		
Finish Coat	4 to 6 mils		
Application			
Special CTR Training	Not required.		

Attachment B			
Coating Detail Sheet			
Coating System	EPX-M-2-PWS		
Coating Material	Ultra-high Solids Epoxy		
Substrate	Metal		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	Plasite 4500	None Applied	Plasite 4500
International Paint	No product specified	No product specified	No product specified
PPG	No product specified	No product specified	No product specified
Sherwin Williams	Sher-Plate	None Applied	Sher-Plate
Tnemec	Series 22	None Applied	Series 22
Service Condition	Immersed, moderately corrosive environment in contact with Potable Water.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Ferrous Metal	Bare surfaces: SSPC-SP5, White Metal Blast Cleaning. Shop primed surfaces: SSPC-SP7, Brush-Off Blast Cleaning. Damaged primer or rust: SSPC-SP5, White Metal Blast Cleaning and spot prime.		
Surface Profile			
Ferrous Metal	2.0 to 2.5 mils		
Primed surfaces	1.0 to 1.5 mils on the intact primer.		
System Thickness (Dry Film)			
Total	16 to 25 mils		
Application			
Special CTR Training	Required.		

Attachment B			
Coating Detail Sheet			
Coating System	EPX-M-3		
Coating Material	Epoxy		
Substrate	Metal		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	Carboguard 891VOC	Carboguard 891VOC	Carboguard 891VOC
International Paint	Bar-Rust 236	Bar-Rust 236	Bar-Rust 236
PPG	Amercoat 240	Amercoat 240	Amercoat 240
Sherwin Williams	Tank Clad HS	Tank Clad HS	Tank Clad HS
Tnemec	Series 104	Series 104	Series 104
Service Condition	Immersed; non-immersed, corrosive environment. Not for Biogenic Sulfide Corrosion areas in wastewater.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Ferrous Metal	Bare surfaces: SSPC-SP5, White Metal Blast Cleaning. Shop primed surfaces: SSPC-SP7, Brush-Off Blast Cleaning. Damaged primer or rust: SSPC-SP5, White Metal Blast Cleaning and spot prime.		
Nonferrous Metal	SSPC-SP16, Brush-Off Blast Cleaning.		
Galvanized Metal	SSPC-SP16, Brush-Off Blast Cleaning.		
Surface Profile			
Ferrous Metal	2.5 to 3.0 mils		
Nonferrous Metal	1.5 to 2.0 mils		
Galvanized Metal	1.5 to 2.0 mils		
System Thickness (Dry Film)			
Total	16 to 20 mils		
Primer	4 to 8 mils		
Intermediate Coat	4 to 8 mils		
Finish Coat	4 to 8 mils		
Application			
Special CTR Training	Not required.		

Attachment B			
Coating Detail Sheet			
Coating System	VE-M-1		
Coating Material	Vinyl Ester		
Substrate	Metal		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
International Paint			Ceilcote Flakeline 232.
PPG			Nova Rez 370
Sherwin Williams			CorCote VEN
Tnemec			Series 120-5001
Service Condition	Immersion or non-immersion (primary or secondary containment) very corrosive - indoors or exterior.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Ferrous Metal	Bare surfaces: SSPC-SP5, White Metal Blast Cleaning. Shop primed surfaces: SSPC-SP7, Brush-Off Blast Cleaning. Damaged primer or rust: SSPC-SP5, White Metal Blast Cleaning and spot prime.		
Surface Profile			
Ferrous Metal	4.0 mils		
System Thickness (Dry Film)			
Total	60 to 65 mils		
Application			
Special CTR Training	Required.		

SECTION 26_05_00

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Requirements for electrical:
      a. Basic design and performance criteria.
      b. Prescriptive requirements for common components.
      c. Installation.

B. Contract Drawings:
   1. Schematic diagrams:
      a. Controls are shown as de-energized.
      b. Add relays, where required, to provide necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
      c. Mount devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted.
   2. Plan drawings:
      a. Electrical drawings show desired locations, arrangements, and components of the electrical Work in a diagrammatic manner.
      b. Locations and sizes of equipment are approximate only.
   3. Installation details:
      a. Contract Drawings include typical installation details the Contractor is to use to complete the electrical Work. For cases where a typical detail does not apply, develop installation details that may be necessary for completing the Work, and submit these details for review by the Engineer.
      b. Not all typical installation details are referenced within the drawing set. Apply and use typical details where appropriate.

C. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. Abbreviations:
   1. FAT: Factory acceptance test that is also referred to as source test.
   2. ICSC: Instrumentation and controls subcontractor.
   3. PCIS: Process control and instrumentation system.

B. Standards:
    1. American National Standards Institute (ANSI).
    2. National Electrical Manufacturers Association (NEMA):
        a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
    3. National Fire Protection Association (NFPA):
        a. 70 - National Electrical Code (NEC).
    4. Underwriters Laboratories, Inc. (UL).

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning:
    1. LCP: Local control panel: Operator interface panel that may contain pilot type control devices, operator interface devices, control relays, etc., and does not contain a PLC or RIO.
    2. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
    3. Space: Portion of a switchgear, motor control center, panelboard, switchboard, or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment:
        a. Furnish hardware to accommodate installation of future circuit breakers, instruments, relays, and controls.
        b. Wire relay and circuit breaker control power and network connections to the compartment and provide terminations.
        c. Space for future devices shall include:
            1) All necessary bus.
            2) Device supports and mounting equipment.
            3) Device connections to bus work.
            4) Wire troughs or raceway space.
    4. Spare: Portion of a switchgear, motor control center, panelboard, switchboard, or control panel that physically contains a device with no load connections to be made.
    5. Unequipped space: Portion of a switchgear, motor control center, panelboard, switchboard, or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.
    6. Vendor control panel (VCP): Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.

1.04 DELEGATED DESIGN

A. Requirements for Delegated Design are specified in the technical sections.

1.05 SUBMITTALS (NOT USED)

1.06 QUALITY ASSURANCE

A. General:
    1. Furnish equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Shipping precautions:
   1. After completion of shop assembly and successful factory testing, pack equipment in protective crates, and enclose in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture.
   2. Place dehumidifiers, when required, inside the polyethylene coverings.
   3. Skid-mount the equipment for final transport.
   4. Provide lifting rings for moving without removing protective covering.
   5. Display boxed weight on shipping tags together with instructions for unloading, transporting, storing, and handling at the job site.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.09 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Loop drawings:
      a. Provide electrical information required in the preparation of loop drawings, including, but not limited to:
         1) Conduit numbers and associated signal(s) contained within each conduit.
         2) Wire numbers.
         3) Equipment terminal numbers.
         4) Junction boxes and signal(s) contained within each junction box.
         5) Equipment power sources, and associated circuit numbers.
         6) As-built drawings detailing wiring.

B. Meetings:
   1. As specified in Section 01 31 19 - Project Meetings.

C. Sequencing and scheduling:
   1. Equipment anchoring: Project construction schedule must include an event for obtaining the anchor layout drawings from equipment manufacturers in adequate time for templates to be constructed and anchors to be cast-in-place.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide field wiring and terminations.

B. Equipment mounting and anchoring:
   1. Design equipment anchorage, supports, and connections for dead load, running loads, loads during start-up, seismic load specified in technical

sections and as indicated on the Drawings, and other loads as required for proper operation of equipment.

a. For equipment with an operating weight of 400 pounds or greater and equipment that is supported higher than 4 feet above the floor, provide calculations for:
    1) Operating weight and location of the centroid of mass for the equipment.
    2) Forces and overturning moments.
    3) Shear and tension forces in equipment anchorages, supports, and connections.
    4) Design of equipment anchorage, supports, and connections based on calculated shear and tension forces.

2. Anchorage of equipment to concrete or masonry:
    a. Perform calculations and determine number, size, type, strength, and location of anchor bolts or other connections.
    b. Unless otherwise indicated on the Drawings, select and provide anchors from the types specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
    c. Provide bolt sleeves around cast-in anchor bolts for 400 pounds or greater equipment.
        1) Adjust bolts to final location and secure the sleeve.
3. Anchorage of equipment to metal supports:
    a. Perform calculations and determine number, size, type, strength, and location of bolts used to connect equipment to metal supports.

2.03 MANUFACTURERS (NOT USED)

2.04 MATERIALS

A. Enclosures:
    1. Provide enclosures for electrical, instrumentation, and control equipment, regardless of Supplier or Subcontractor furnishing the equipment, that meet the requirements of NEMA Standard 250:
        a. Provide metallic enclosures unless specifically indicated otherwise.

B. Stainless steel:
    1. Where stainless steel is indicated or used for any portion of the electrical Work, provide a non-magnetic, corrosion-resistant alloy, ANSI Type 316, satin finish.
    2. Provide exposed screws of the same alloys.
    3. Use stainless steel hardware, when chemically compatible, in all chemical areas or areas requiring NEMA Type 4X construction.
    4. Do not use stainless steel in any area containing chlorine, gas or solution, chlorine products or ferric chloride.

C. Plant area electrical Work requirements:
   1. Provide electrical materials in accordance with the following table, unless otherwise specifically indicated on the Drawings:
      a. Conduit installation requirements: As specified in Section 26_05_33 - Conduits.

Table 1. Electrical Material Requirements				
Plant Area	**Environment: W = Wet D = Damp C = Clean/dry X = Corrosive H = Hazardous**	**NEMA Enclosure Type**	**Exposed Conduit Type (as specified in Section 26_05_33 - Conduits)**	**Support Materials**
Outdoor Areas	W	3R	PCS	SST
Beltz 8 Process Room	D	12	GRC	GAVL STL
Beltz 8 Electrical Room	C	12	GRC	GAVL STL

PART 3 EXECUTION

3.01 EXAMINATION

A. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment:
   1. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before starting any Work.
   2. Determine information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
   3. Provide and document interface with, modifications to, upgrades, or replacement of existing circuits, power systems, controls, and equipment.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Demolition:
   1. As specified in technical sections and as indicated on the Drawings.
   2. Disconnect utilities:
      a. Disconnect electrical equipment.
   3. Remove and dispose of conduit, wire, electrical equipment, controls, etc., associated with the items and/or areas to be demolished as indicated on the Drawings unless otherwise indicated.
   4. Salvage electrical equipment as where indicated on the Drawings.
   5. For each piece of equipment to be removed, remove ancillary components (e.g., instruments, solenoid valves, disconnect switches, etc.).
   6. Conduit:
      a. Where conduit removal, other than associated with equipment to be removed, is indicated on the Drawings:
         1) Remove exposed conduit to the point of encasement or burial.

2) Cut conduit flush and plug or cap encased or buried conduit.
b. Where conduits are to remain in place and removal is not indicated on the Drawings:
1) Cap conduit open ends.
2) Re-label empty conduits as spare.
7. Remove wire back to the source for conduits to be removed or abandoned in place.
8. Provide new nameplates for modified electrical distribution equipment, motor control centers etc., to identify equipment and circuits that are no longer used as spares.
9. Provide new typewritten schedules for modified panelboards.

B. Equipment:
1. Where the Drawings do not show dimensions for locating equipment, install equipment in the approximate locations indicated on the Drawings.

C. Provide NEC required working space in front of electrical equipment as if it could be worked on energized.

D. Circuits of different service voltage:
1. Voltage and service levels:
a. Low voltage:
1) Power and controls: 120 V to 480 V.
2) Instrumentation: Less than 50 VDC.
2. Install different service voltage circuits in separate raceways as well as underground manholes and hand holes.
3. Install different service voltage circuits in separate junction boxes and pullboxes or provide physical dividers where boxes can be divided.

E. Conductors shall not pass through equipment they are not terminating in unless indicated on the Drawings or approved by the Engineer.

3.04 FIELD QUALITY CONTROL

A. Workmanship:
1. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:
a. Neatly coil and label spare wiring lengths.
b. Shorten, re-terminate, and re-label excessively used, as well as spare, wire and cable lengths, as directed by the Engineer.

B. Inspection activities conducted during construction do not satisfy the inspection or testing requirements specified in Section 26_08_50 - Field Electrical Acceptance Tests.

C. Provide onsite assistance for troubleshooting and correcting electrical issues discovered during installation and testing for the Project.

3.05 OWNER TRAINING (NOT USED)

3.06 ADJUSTING (NOT USED)

3.07 CLEANING

A. General:
   1. Clean and vacuum enclosures to remove metal filings, surplus insulation and any visible dirt, dust, or other matter before energization of the equipment or system start-up:
      a. Use of compressors or air blowers for cleaning is not acceptable.
   2. Clean luminaries in the areas affected by the construction.

END OF SECTION

SECTION 26_05_09

LOW VOLTAGE MOTORS UP TO 500 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Low voltage motors up to 500 horsepower (hp).

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. Standards:
   1. American Bearing Manufacturers Association (ABMA):
      a. 9 - Load Ratings and Fatigue Life for Ball Bearings.
      b. 11 - Load Ratings and Fatigue Life for Roller Bearings.
   2. ASTM International (ASTM):
      a. B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.
   3. Institute of Electrical and Electronic Engineers (IEEE):
      a. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
   4. National Electrical Manufacturers Association (NEMA):
      a. MG 1 - Motors and Generators.
   5. Underwriters Laboratories Inc. (UL):
      a. 674 - Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Submit completed motor data sheets for each motor supplied:
   1. As specified in Attachment A - Motor Data Sheet.
   2. Manufacturer’s or other data sheets are not acceptable.

C. Product data:
   1. Descriptive bulletins.
   2. Machine tag and loop number as indicated on the Drawings and in the specification section number of the driven machine.

3. Complete electrical data.
4. Manufacturer's storage recommendations.
5. Torque, current, and power factor versus speed curves:
    a. At 100 percent rated voltage for full voltage started and VFD-driven motors.
6. Accessories data:
    a. Power factor correction capacitors:
        1) Size in KVAR for motors not connected to variable frequency drives.
    b. Motor winding heaters:
        1) Voltage.
        2) Watts.
    c. Winding temperature detectors:
        1) Type.
        2) Rating.
    d. Moisture detectors.
7. Mechanical data:
    a. Bearing design and bearing life calculations.
    b. Resonant frequencies for VFD-driven motors 50 hp or greater.

D. Shop Drawings:
1. Motor weight.
2. Frame size.
3. Conduit box(es), size(s), and location(s).
4. Outline drawings with dimensions.
5. Installation details for the project seismic criteria.

E. Calculations:
1. Where Site conditions specified in technical sections and as indicated on the Drawings exceed manufacturer's ratings, provide derating calculations for each motor.

F. Quality Control Submittals:
1. Manufacturer's representative qualifications.
2. Manufacturer's Certificate of Source Testing as specified in Section 01 91 00 - Commissioning.
    a. With test reference standard identified.

G. Certification:
1. When motors are driven by variable speed drive systems, submit certification that selected motor:
    a. Is capable of satisfactory performance under the intended load.
    b. Meets the requirements of the latest edition of NEMA MG 1 Part 31.

1.05 QUALITY ASSURANCE (NOT USED)

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store motors in accordance with the manufacturer's recommendations.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawing.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL

A. Furnish and install electric motors and accessories as specified in this Section and the Sections specifying driven equipment to provide a complete and operable installation.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide equipment and components that are fully rated for the site elevation and operating environment where the equipment will be installed as specified in technical sections and as indicated on the Drawings.

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Baldor.
   2. General Electric.
   3. Reliance.
   4. Toshiba.
   5. US Motors.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

A. 3-phase induction motors - general:
   1. Voltage:
      a. Motors 1/2 hp and larger shall be rated 460 V, 3-phase unless otherwise indicated on the Drawings.
      b. Dual voltage motors rated 230/460 V; 3-phase are acceptable provided all leads are brought to the conduit box.
   2. Motors driving identical machines shall be identical.
   3. Motors greater than 1 hp and up to 500 hp shall meet the NEMA Premium Efficiency percent listed in NEMA MG 1.
   4. Horsepower as indicated on the Drawings:
      a. Horsepower ratings indicated on the Drawings are based on vendor’s estimates. Provide motors sized for the load of the actual equipment furnished without operating in the service factor.
   5. Service factor:
      a. 1.15 service factor on sine wave power.

b. 1.0 when driven by VFD.

6. Torque:
   a. Provide motors that develop sufficient torque for acceleration to full speed at voltage 10 percent less than motor nameplate rating.
   b. When started using reduced voltage starters:
      1) Provide motors that develop sufficient torque for acceleration to full speed.
   c. NEMA Design B except where driven load characteristics require other than normal starting torque:
      1) In no case shall starting torque or breakdown torque be less than the values specified in NEMA MG 1.
7. Enclosures:
   a. As specified in the individual equipment Specifications or in this Section.
   b. Totally enclosed fan cooled:
      1) Cast iron conduit box.
      2) Tapped drain holes with Type 304 stainless steel plugs for frames 286 and smaller, and automatic breather and drain devices for frames 324 and larger.
   c. Explosion proof:
      1) Tapped drain holes with corrosion resistant plugs for frames 286 and smaller and automatic breather and drain devices for frames 324 and larger.
   d. Lifting devices: Motors weighing 265 pounds (120 kilograms) or more shall have suitable lifting devices for installation and removal.
8. Manufactured with cast iron frames in accordance with NEMA MG 1 or manufacturer's standard material for the specified rating.
9. Nameplates:
   a. Provide motors with a permanent, stainless steel nameplate indelibly stamped or engraved with:
      1) NEMA standard motor data:
         a) Indicate compliance with NEMA MG 1 Part 31 for inverter duty motors.
      2) AFBMA bearing numbers and lubrication instructions.
10. Hardware:
    a. Type 304 stainless steel.
11. Conduit boxes:
    a. Cast iron or stamped steel.
    b. Split from top to bottom.
    c. Provide gaskets at the following interfaces:
       1) Frames and conduit boxes.
       2) Conduit boxes and box covers.
    d. Rotatable through 360 degrees in 90-degree increments:
       1) Where available based on the size of the conduit box.
    e. Exceeding the dimensions defined in NEMA MG 1.
    f. Provide grounding lugs inside conduit boxes for motor frame grounding.
12. Motor bearings:
    a. Antifriction.
    b. Regreasable and initially filled with grease for horizontal motors and vertical motors in accordance with the manufacturer's standard design.
    c. Bearings and lubrication suitable for ambient temperature and temperature rise.

d. Suitable for intended application and have a rate for ABMA 9 or 11, L-10 rating life of 60,000 hours or more.
e. Fit bearings with easily accessible grease supply, flush, drain, and relief fittings using extension tubes where necessary.
f. Where specified in the equipment Specifications, provide split-sleeve type hydrodynamic radial bearings. Provide a bearing isolator to protect bearings from contaminants.

13. Insulation systems:
    a. Motors installed in ambient temperatures 40 degrees Celsius or less:
        1) Provide Class F insulation.
        2) Design temperature rise consistent with Class B insulation.
        3) Rated to operate at an ambient temperature of 40 degrees Celsius at the altitude where the motor will be installed.
    b. Motors installed in ambient temperatures between 40 degrees Celsius and 50 degrees Celsius:
        1) Provide Class F insulation.
        2) Design temperature rise consistent with Class B insulation.
        3) Rated to operate at an ambient temperature of 50 degrees Celsius at the altitude where the motor will be installed.
14. Motor leads:
    a. Insulated leads with non-wicking, non-hydroscopic material. Class F insulation.
15. Noise:
    a. Maximum operating noise level in accordance with NEMA MG 1.

B. Submersible motors:
1. Enclosures:
    a. Totally enclosed non-ventilated (TENV) watertight casing.
    b. Inner and outer shaft seals separated by an oil chamber.
2. Cooling:
    a. Suitable for continuous operation in totally, partially, or nonsubmerged condition without overheating.
    b. Convection cooling by the surrounding environment or pump cooling by circulating a portion of the pumped media through a cooling water jacket as recommended by the manufacturer based on hp and application.
3. Electrical cables:
    a. Wire unit without splices. Coordinate with Contractor to ensure cables of adequate length.
    b. Epoxy encapsulated cable entry into terminal box.
4. Insulation:
    a. Sealed moisture resistant windings.
    b. Class H.
5. Motor protection:
    a. Provide temperature detection in motor windings.
    b. Provide moisture detection in motor housing.
    c. Other detection and protection functions specified in the in the driven equipment Section.

C. Vertical motors:
   1. Enclosures:
      a. Totally enclosed fan cooled (TEFC) for motors 200 hp and less installed outdoors.
      b. Weather protected Type I (WPI) where installed indoors.
   2. Thrust bearings:
      a. Selected for combined rotor and driven equipment loads.
      b. Coordinate with driven equipment supplier for maximum vertical thrust of driven equipment.
   3. Anti-reverse ratchet.

D. Motors driven by variable frequency drives:
   1. Compatible with the variable frequency drives specified.
   2. Inverter duty rated and labeled.
   3. Meet the requirements of NEMA MG 1 Part 31.
   4. Winding insulation meets the requirements of NEMA MG 1 Part 31.4.4.2.
   5. Capable of running continuously at 1/10th of full speed, with no harmful effects or overheating.
   6. Shaft grounding ring:
      a. Provide a manufacturer-installed shaft grounding ring for each VFD-driven motor.
      b. Aluminum frame and internal components.
      c. Conductive microfiber brushes.
      d. Maintenance free design.
      e. Colloidal silver compound installed on shaft under the shaft grounding ring.
      f. High frequency ground strap.
      g. Grounding ring:
         1) Installed inside motor housing on drive end (DE).
         2) Installed on exterior of motor housing on drive end with written permission from the Engineer.
      h. Refer to the following table for specific requirements based upon the driven motor:

Motor Size	**<100 hp**
Voltage	<600 VAC
AEGIS® Ring	SGR
Bearing Insulation	No
Colloidal Sliver	Recommended
HF Grounding Straps	Required
Notes: DE - drive end. HF - AEGIS® High Frequency Grounding Strap. NDE - non-drive end. PRO - AEGIS® PRO Series Shaft Grounding Rings. SGR - AEGIS® Shaft Grounding Ring Series.	

      i. AEGIS® bearing protection ring, as manufactured by Electro Static Technology, or equal.

7. Insulated bearings:
    a. Provide motor manufacturer's standard insulated sleeve or ceramic bearings.

E. Single-phase motors:
1. Capacitor start type rated for operation at 115 volts, 60 hertz, unless otherwise specified or as indicated on the Drawings.
2. Totally enclosed fan cooled (TEFC) motors manufactured in accordance with NEMA MG 1.
3. Ball bearings: Sealed.
4. 1/2 hp or less fan motors:
    a. Split-phase or shaded pole type when standard for the equipment.
    b. Open type when suitably protected from moisture, dripping water, and lint accumulation.
5. Wound rotor or commutator type single-phase motors only when their specific characteristics are necessary for application and their use is acceptable to the Engineer.
6. Integral overload protection.

F. Immersible motors:
1. Meet all general requirements for 3-phase induction motors, except as modified in this Section.
2. Inverter duty as indicated on the Drawings or in the driven equipment Specifications.
3. Enclosure:
    a. Cast iron.
    b. Designed and constructed to meet or exceed IP67.
    c. Epoxy paint finish:
        1) Withstands salt spray and corrosion tests in accordance with ASTM B117.
    d. Furnished with lifting plates or lugs.
    e. Vertical or horizontal mounting as required by the application.
4. Conduit box:
    a. Cast iron.
    b. Bolted and sealed cover.
    c. Rotatable in 90-degree increments.
    d. Watertight gland or potable hub for power cable entry.
5. Power cable:
    a. Type SOOW or W cable, non-shielded.
    b. Length as required for the installation.
6. Cooling blower:
    a. As required by the motor manufacturer.
    b. Washdown duty rated.
    c. Constant speed.
7. Humidity moisture detector.

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

A. Winding temperature detectors:
   1. Provide factory installed winding temperature detector with leads terminating in the conduit box:
      a. Where required by the driven equipment Specification or as indicated on the Drawings.
      b. RTD type, 2 per phase, 100-ohm platinum.
   2. Temperature switches with normally closed contacts as indicated on the Drawings.

2.09 MIXES (NOT USED)

2.10 FABRICATION (NOT USED)

2.11 FINISHES (NOT USED)

2.12 SOURCE QUALITY CONTROL

A. Source Testing:
   1. Motors less than 250 hp:
      a. Perform manufacturer's standard production tests, including, but not limited to:
         1) No load current.
         2) High potential test.
         3) Winding resistance.
      b. Furnish copies of standard test reports on prototype or identical units.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Install motors in accordance with the manufacturer's instructions.

B. Install shaft grounding ring on VFD-driven motors in accordance with the manufacturer's instructions.

3.04 FIELD QUALITY CONTROL

A. Field electrical acceptance testing:
   1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

B. Before start-up, perform insulation resistance test on each motor furnished or installed on this project:
   1. Windings energized to 1,000 volts DC for 1 minute.
   2. Resistance measured at the end of the test, recorded, and submitted to the Engineer for review.

3. Inform the Engineer of any unusual or unacceptable test results.
4. This test is in addition to the acceptance tests in Section 26_08_50 - Field Electrical Acceptance Tests.

END OF SECTION

ATTACHMENT A - MOTOR DATA SHEET

MOTOR DATA SHEET

MOTOR/ EQUIPMENT TAG _____ MOTOR NUMBER _____

SPECIFICATION NUMBER OF DRIVEN MACHINE _____

MOTOR NAMEPLATE DATA

MANUFACTURER _____ MODEL/SERIES _____ MODEL NO. _____

FRAME _____ ENCLOSURE _____ NEMA DESIGN _____

HP _____ SERVICE FACTOR _____ RPM _____

INSULATION CLASS _____ VOLTS _____ FULL LOAD AMPS _____

AMBIENT TEMP _____ PHASE _____ NO LOAD AMPS _____

DESIGN TEMP _____ HERTZ _____ LOCK ROTOR AMPS _____

INRUSH CODE LETTER _____

	100% LOAD	75% LOAD	50% LOAD
GUARANTEED MINIMUM EFFICIENCIES:			
GUARANTEED MINIMUM POWER FACTOR:			

MAXIMUM SIZE OF POWER FACTOR CORRECTION CAPACITOR: _____ KVAR

ACCESSORIES

MOTOR WINDING HEATER _____ VOLTS _____ WATTS

WINDING THERMAL PROTECTION:

WINDING TEMP SWITCHES (YES/NO) _____

RTD:

TYPE _____ QUANTITY PER PHASE _____ # OF WIRES _____

NOMINAL RESISTANCE _____ NOMINAL TEMP _____ COEFFICIENT _____

RECOMMENDED ALARM _____ DEGREES CELSIUS RECOMMENDED TRIP _____ DEGREES CELSIUS

SPECIAL APPLICATIONS

INVERTER DUTY* (YES/NO) _____ PART WINDING (YES/NO) _____ WYE - DELTA (YES/NO) _____

2 SPEED, 1 WINDING (YES/NO) _____ 2 SPEED, 2 WINDING (YES/NO) _____

AREA CLASSIFICATION:

CLASS _____ DIVISION _____ GROUP _____ TEMP CODE _____

* Conforms to NEMA MG 1 Part 31.

SECTION 26_05_18

600-VOLT OR LESS WIRES AND CABLES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. 600-volt class or less wire and cable.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. Abbreviations:
   1. AWG: American wire gauge.
   2. BCCS: Bare copper-covered steel.
   3. CPE: Chlorinated polyethylene.
   4. FHDPE: Foam high-density polyethylene.
   5. FPE: Foam polyethylene.
   6. OD: Outside diameter.
   7. PVC: Polyvinyl chloride.
   8. XHHW: Cross-linked high heat water resistant insulated wire.

B. Standards:
   1. ASTM International (ASTM):
      a. B3 - Standard Specification for Soft or Annealed Copper Wire.
      b. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   2. CSA International (CSA).
   3. National Electrical Manufacturers Association/Insulated Cable Engineers Association (NEMA/ICEA):
      a. NEMA WC 57/ICEA S-73-532 - Standard for Control, Thermocouple Extension, and Instrumentation Cables.
      b. NEMA WC 70/ICEA S-95-658-1999 - Standard for Power Cables Rated 2,000 Volts or Less for the Distribution of Electrical Energy.
   4. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code (NEC).
      b. 262 - Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
   5. Underwriters Laboratories Inc. (UL):
      a. 44 - Standard for Thermoset-Insulated Wires and Cables.

b. 1666 - Standard for Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Product data:
   1. Manufacturer of wire and cable.
   2. Insulation:
      a. Type.
      b. Voltage class.
   3. AWG size.
   4. Conductor material.
   5. Pulling compounds.

C. Shop Drawings:
   1. Show splice locations:
      a. For each proposed splice location provide written justification describing why the splice is necessary.

D. Test reports:
   1. Submit test reports for meg-ohm tests.

E. Calculations:
   1. Submit cable pulling calculations to the Engineer for review and comment for cables that will be installed using mechanical pulling equipment. Show that the maximum cable tension and sidewall pressure will not exceed manufacturer recommended values:
      a. Provide a table showing the manufacturer's recommended maximum cable tension and sidewall pressure for each cable type and size included in the calculations.
      b. Submit the calculations to the Engineer a minimum of 2 weeks before conduit installation.

F. Cable lengths:
   1. Submit installed cable lengths using a conduit measuring tape for 3-phase circuits.

1.05 QUALITY ASSURANCE

A. Wires and cables shall be UL listed and labeled.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. General Site and Project conditions:
   1. As specified in technical sections and as indicated on the Drawings.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL

A. Color-coding:
   1. Color-coding shall be consistent throughout the facility.
   2. The following color code shall be followed for 240/120-volt and 208/120-volt systems:
      a. Phase A: Black.
      b. Phase B: Red.
      c. Phase C: Blue.
      d. Single phase system: Black for 1 hot leg, red for the other.
      e. Neutral: White.
      f. High phase or wild leg: Orange.
      g. Equipment ground: Green.
   3. The following color code shall be followed for 480/277-volt systems:
      a. Phase A: Brown.
      b. Phase B: Orange.
      c. Phase C: Yellow.
      d. Neutral: Gray.
      e. Equipment ground: Green.
   4. The following color code shall be followed for 120 VAC control wiring:
      a. Power: Red.
      b. Neutral: White.
   5. The following color code shall be followed for general purpose DC control circuits:
      a. Grounded conductors: White with blue stripe.
      b. Ungrounded conductors: Blue.
   6. Switch legs shall be violet. 3-way switch runners shall be pink.
   7. Wires in intrinsically safe circuits shall be light blue.
   8. Wire colors shall be implemented in the following methods:
      a. Wires manufactured of the desired color.
      b. Continuously spiral wrap the first 6 inches of the wire from the termination point with colored tape:
         1) Colored tape shall be wrapped to overlap half of the width of the tape.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Furnish and install the complete wire and cable system.

2.03 MANUFACTURERS

A. One of the following, or equal:
   1. 600-volt class wire and cable:
      a. Okonite Co.
      b. Prysmian General Cable.
      c. Service Wire.
      d. Southwire Co.
   2. 600-volt VFD cable:
      a. Prysmian General Cable.
      b. Service Wire.
      c. Southwire Co.
   3. Instrumentation class wire and cable:
      a. Alpha Wire Co.
      b. Belden CDT.
      c. Okonite Co.
      d. Prysmian General Cable.
      e. Rockbestos Surprenant Cable Corp.

2.04 MATERIALS

A. Conductors:
   1. Copper in accordance with ASTM B3.

2.05 MANUFACTURED UNITS

A. General:
   1. Provide new wires and cables manufactured within 1 year of the date of delivery to the Site.
   2. Permanently mark each wire and cable with the following at 24-inch intervals:
      a. AWG size.
      b. Voltage rating.
      c. Insulation type.
      d. UL symbol.
      e. Month and year of manufacture.
      f. Manufacturer’s name.
   3. Identify and mark wire and cable as specified in Section 26_05_53 - Identification for Electrical Systems:
      a. Use integral color insulation for #2 AWG and smaller wire.
      b. Wrap colored tape around cable larger than #2 AWG.

B. 600-volt class wire and cable:
   1. Provide AWG or kcmil sizes as indicated on the Drawings or in the Conduit Schedules:
      a. When not indicated on the Drawings, size wire as follows:
         1) In accordance with the NEC:
            a) Use 75-degree Celsius ampacity ratings.
            b) Ampacity rating after derating factors, equal to or greater than rating of the overcurrent device.
         2) Provide #12 AWG minimum for power conductors.
         3) Provide #14 AWG minimum for control conductors.

2. Provide Class B stranding in accordance with ASTM B8:
    a. Provide Class C stranding where extra flexibility is required.
3. Insulation:
    a. XHHW-2.
    b. 90-degree Celsius rating.

C. 600-volt VFD cables:
1. Conductor:
    a. Provide Class B stranding in accordance with ASTM B3 and ASTM B8.
    b. Copper conductor.
2. Insulation:
    a. Cross-linked Polyethylene, XLPE.
    b. 90-degree Celsius rating.
    c. UL 44 type RHH/RHW-2 or XHHW-2.
    d. 2,000 volts.
3. Ground:
    a. Provide Class B compressed stranded bare copper in accordance with ASTM B3 and ASTM B8.
    b. 3 symmetrically placed bare copper conductors in direct contact with shield.
    c. Equivalent ground size 50 percent of the phase conductor size.
4. Filler:
    a. Cable sizes 8 and 6 use polypropylene filler.
    b. Other cable sizes use paper filler.
5. Metallic shield:
    a. Overall 5 mil bare copper tape shield with 50 percent overlap.
6. Outer jacket:
    a. UL 1277 Type PVC.
7. Cable tray rated, UL Type TC-ER.

D. Instrumentation class cable:
1. Type TC.
2. Suitable for use in wet locations.
3. Voltage rating: 600 volts.
4. Temperature rating:
    a. 90-degree Celsius rating in dry locations.
    b. 75-degree Celsius rating in wet locations.
5. Conductors:
    a. Insulation:
        1) Flame-retardant PVC, 15 mils nominal thickness, with nylon jacket 4 mils nominal thickness.
    b. #16 AWG stranded and tinned.
    c. Color code: ICEA Method 1:
        1) Pair: Black and white.
        2) Triad: Black, white and red.
        3) Multiple pairs or triads:
            a) Color-coded and numbered.
6. Drain wire:
    a. #18 AWG.
    b. Stranded, tinned.

7. Jacket:
    a. Flame retardant, moisture and sunlight resistant PVC.
    b. Ripcord laid longitudinally under jacket to facilitate removal.
8. Shielding:
    a. Individual pair/triad:
        1) Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
    b. Multiple pair or triad shielding:
        1) Group shield: Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
        2) Completely isolate group shields from each other.
        3) Cable shield: 2.35-mil double-faced aluminum and synthetic polymer backed tape overlapped to provide 100 percent coverage.
    c. Shielding to be in contact with the drain wire.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

A. Wire ties:
    1. One of the following, or equal:
        a. Panduit, cable ties.
        b. T&B, “Ty-Rap” cable ties.

B. Wire markers:
    1. As specified in Section 26_05_53 - Identification for Electrical Systems.

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Assembly and testing of cable shall comply with the applicable requirements of NEMA WC 70/ICEA S-95-658-1999.

B. Test Type XHHW-2 in accordance with the requirements of UL 44.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Install conductors only after the conduit installation is complete, and enclosures have been vacuumed clean, and the affected conduits have been swabbed clean and dry:
    1. Install wires only in approved raceways.

2. Do not install wire:
    a. In incomplete conduit runs.
    b. Until after the concrete work and plastering is completed.

B. Properly coat wires and cables with pulling compound before pulling into conduits:
    1. For #4 AWG and larger, use an approved wire-pulling lubricant while cable is being installed in conduit:
        a. Ideal Products.
        b. Polywater Products.
        c. 3M Products.
        d. Greenlee Products.
        e. Or equal, as recommended by cable manufacturer.
        f. Do not use oil, grease, or similar substances.

C. Cable pulling:
    1. Prevent mechanical damage to conductors during installation.
    2. For cables #1 AWG and smaller, install cables by hand.
    3. For cables larger than #1 AWG, power pulling winches may be used if they have cable tension monitoring equipment.
    4. Provide documentation that maximum cable pulling tension was no more than 75 percent of the maximum recommended level as published by the cable manufacturer. If exceeded, the Engineer may, at his discretion, require replacement of the cable.
    5. Ensure cable pulling crews have calculations and cable pulling limitations while pulling cable.
    6. Make splices or add a junction box or pull box where required to prevent cable pulling tension or sidewall pressure from exceeding 75 percent of the manufacturer's recommendation for the specified cable size:
        a. Make splices in manholes or pull boxes only.
        b. Leave sufficient slack to make proper connections.

D. Use smooth-rolling sheaves and rollers when pulling cable into cable tray to keep pulling tension and bending radius within the manufacturer's recommendations.

E. Install and terminate wire in accordance with the manufacturer's recommendations.

F. Neatly arrange and lace conductors in switchboards, panelboards, pull boxes, and terminal cabinets by means of wire ties:
    1. Do not lace wires in gutter or panel channel.
    2. Install wire ties with a flush cutting wire tie installation tool:
        a. Use a tool with an adjustable tension setting.
    3. Do not leave sharp edges on wire ties.

G. Terminate stranded conductors on equipment box lugs such that conductor strands are confined within the lug:
    1. Use ring type lugs if box lugs are not available on the equipment.

H. Lighting circuits:
    1. Each circuit shall have a dedicated neutral.

I. Splices:
   1. Provide continuous circuits from origin to termination whenever possible:
      a. Obtain the Engineer's approval prior to making any splices.
   2. Lighting and receptacle circuit conductors may be spliced without prior approval from the Engineer.
   3. Where splices are necessary because of extremely long wire or cable lengths that exceed standard manufactured lengths:
      a. Splice box NEMA rating requirements as specified in Section 26_05_00 - Common Work Results for Electrical.
      b. Make splices in labeled junction boxes for power conductors.
      c. Make splices for control and instrument conductors in terminal boxes:
         1) Provide terminal boards with setscrew pressure connectors, with spade or ring lug connectors.
   4. Power and control conductors routed in common raceways may be spliced in common junction boxes.
   5. Clearly label junction and terminal boxes containing splices with the word "SPLICE LOCATED WITHIN."
   6. Leave sufficient slack at junction boxes and termination boxes to make proper splices and connections. Do not pull splices into conduits.
   7. Install splices with compression type butt splices and insulate using a heat-shrink sleeve.
   8. Splices in below grade pull boxes, in any box subject to flooding, and in wet areas shall be made waterproof using:
      a. A heat-shrink insulating system listed for submersible applications.
      b. Or an epoxy resin splicing kit.

J. Apply wire markers to wires at each end after being installed in the conduit and before meg-ohm testing and termination.

K. Instrumentation class cable:
   1. Install instrumentation class cables in separate raceway systems from power cables:
      a. Install instrument cable in metallic conduit within non-dedicated manholes or pull boxes.
      b. Install cable without splices between instruments or between field devices and instrument enclosures or panels.
   2. Do not make intermediate terminations, except in designated terminal boxes as indicated on the Drawings.
   3. Shield grounding requirements as specified in Section 26_05_26 - Grounding and Bonding.

L. Signal cable:
   1. Separate and isolate electrical signal cables from sources of electrical noise and power cables by a minimum of 12 inches.

M. Wiring allowances:
   1. Equipment locations may vary slightly from the Drawings. Include an allowance for necessary conductors and terminations for motorized equipment, electrical outlets, fixtures, communication outlets, instruments, and devices within 10 linear feet of locations indicated on the Drawings.

2. Locations for pull boxes, manholes, and duct banks may vary slightly from the Drawings. Include an allowance for necessary conductors and related materials to provide conductors to pull boxes, manholes and duct banks within 20-linear feet of locations indicated on the Drawings.

3.04 FIELD QUALITY CONTROL

A. Field electrical acceptance testing:
   1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

END OF SECTION

SECTION 26_05_21

LOW VOLTAGE WIRE CONNECTIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Wire connecting devices.
   2. Terminations.
   3. Splices.
   4. Power distribution blocks.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.

B. CSA International (CSA):
   1. C22.2 - No. 197-M1983 (R2208) - PVC Insulating Tape.

C. Underwriters Laboratories, Inc. (UL):
   1. 486A-B - Standard of Safety for Wire Connectors.
   2. 510 - Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
   3. 1953 - Outline of Investigation for Power Distribution Blocks.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Product data:
   1. Catalog cutsheets.
   2. Installation instructions.

1.05 QUALITY ASSURANCE

A. Materials shall be UL listed.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide a complete system of wiring connectors, terminators, fittings, etc., for a complete wiring system suitable for the cables and conductors used.

2.03 MANUFACTURERS

A. Manufacturers for each type of technology are specified with the equipment in this Section.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

A. Control connections:
   1. Use insulated ring type wire terminators for connections to screw terminals:
      a. With chamfered/funneled terminal barrel entry.
      b. Deep internal serrations.
      c. Long barrel design to reduce electrical resistance and increased insulator-barrel surface area to ensure that the insulator remains in contact with the barrel.
      d. Electroplated-tin copper conductor.
      e. Manufacturers: The following or equal:
         1) ABB, Sta-Kon.
   2. For process equipment connections, work from manufacturer’s drawings.

B. Joints, splices, taps, connections, and terminations:
   1. 600-volt conductors:
      a. Use solderless connectors.
      b. Copper pigtail adaptors:
         1) For use on select applications as approved by the Engineer.
         2) 600 volt, 90 degrees Celsius rated.
         3) UL 486A/B listed.

4) Manufacturers: The following or equal:
a) Burndy APY series.
b) ILSCO CPM series.

c. Use only plated copper alloy connectors or lugs:
1) Aluminum connectors or lugs are not acceptable for copper conductors.

d. Under those specific conditions where aluminum conductors have been allowed or are specified then the connectors for aluminum conductors shall be specifically designed for that purpose.

e. For wire Number 10 AWG and smaller, use compression splice caps, with insulating caps:
1) Manufacturers: The following or equal:
a) Buchanan, 2006S or 2011S, with 2007 or 2014 insulating caps.

f. For wire Number 8 AWG and larger, use heavy duty copper compression connectors:
1) Manufacturers: One of the following or equal:
a) ABB.
b) Burndy.

g. Heat-shrink tubing:
1) Suitable for indoors, outdoors, overhead, direct burial or submerged applications.
2) Minimum shrink ratio: 4 to 1.
3) Continuous operating temperature: -55 degrees Celsius to 110 degrees Celsius.
4) Internally applied adhesive sealant.
5) Cross-linked polyolefin:
a) Manufacturers: One of the following or equal:
(1) 3M, ITCSN.
(2) ABB, Shrink-Kon.

2. Instrumentation class cable splices:
a. Suitable for indoor, outdoors, weather exposed, direct buried, or submersed applications.
b. Utilizing an epoxy, polyurethane, and re-enterable compounds.
c. For use with shielded or unshielded plastic- and rubber-jacketed, signal, control, and power cables rated up to 1 kilovolt.
d. Two-part mold body with tongue and groove seams and built-in spacer webbing.
e. Manufacturers: The following or equal:
1) 3M, Scotchcast 72-N.

C. Insulating tape:
1. General purpose insulating tape:
a. Minimum 7 mil vinyl tape.
b. Suitable for application in an ambient of -18 degrees Celsius (0 degrees Fahrenheit).
c. Operating range up to 105 degrees Celsius (220 degrees Fahrenheit).
d. Flame retardant, hot- and cold-weather resistant, UV resistant.
e. For use as a primary insulation for wire cable splices up to 600 VAC.
f. Meeting and complying with:
1) ASTM D3005 Type I.
2) UL 510.

3) CSA C22.2.
g. Manufacturers: The following or equal:
1) 3M, Scotch Number Super 33+.
2. General purpose color-coding tape:
a. Minimum 7 mil vinyl tape.
b. Suitable for application on PVC and polyethylene jacketed cables.
c. For use indoors and outdoors in weather protected enclosures.
d. Available with the following colors:
1) Red.
2) Yellow.
3) Blue.
4) Brown.
5) Gray.
6) White.
7) Green.
8) Orange.
9) Violet.
e. For use as phase identification, marking, insulating, and harnessing.
f. Meeting and complying with:
1) UL 510.
2) CSA C22.2.
g. Manufacturers: The following or equal:
1) 3M, Scotch Number 35.

D. Power distribution blocks:
1. UL 1953 listed.
2. Short circuit rating: Not less than the system maximum available fault current at the point of application.
3. Provide fuses or circuit breakers in enclosure as required to meet the fault current requirements.
4. Voltage rating: 600 VAC.
5. IP 20 finger safe enclosure.
6. Tin-plated aluminum or copper terminals suitable for copper conductors.
7. Manufacturers: One of the following or equal:
a. Eaton CHDB series.
b. Rockwell Automation 1492 PD series.
c. Schneider Electric LB series.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Load connections:
1. Connect loads to the circuits as indicated. Color-code branch circuits as specified in Section 26_05_18 - 600-Volt or Less Wires and Cables.

B. Zero to 600-volt systems:
   1. Make connections with the proper tool and die as specified by the device manufacturer.
   2. Use only tooling and dies manufactured by the device manufacturer.
   3. Insulate connections and splices with Scotch 33+ tape and Scotchfill, or pre-molded plastic covers, or heat shrink tubing and caps.
   4. Number power and control wires before termination.

C. Motor connections (600 volts and below):
   1. Terminate leads and wires with compression type ring lugs.
   2. Terminations on motor leads, including leads that are connected together to accommodate the motor voltage, and the machine wires entering the motor terminal box from the power source, shall have ring type compression lugs.
   3. Cover bolted connectors with a heat shrinkable, cross-linked polyolefin material formed as a single opening boot:
      a. In damp and wet locations, use a complete kit containing mastic that shall seal out moisture and contamination.
      b. Shrink cap with low heat as recommended by the manufacturer.
   4. Wire markers shall be readable after boot installation.
   5. Manufacturers: The following or equal:
      a. Raychem, MCK.

D. Power distribution terminal blocks:
   1. Connect fuses or circuit breakers on the line side of power distribution terminal blocks as required to meet short circuit requirements.

END OF SECTION

SECTION 26_05_26

GROUNDING AND BONDING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Grounding materials and requirements.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.

C. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).

D. Underwriters Laboratories, Inc. (UL):
   1. 467 - Ground and Bonding Equipment.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Product data:
   1. Catalog cutsheets.

1.05 QUALITY ASSURANCE

A. Grounding components and materials shall be UL listed and labeled.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Ground equipment and raceway systems so that the completed installation is in accordance with applicable code requirements.

B. Provide a complete electrical grounding system as indicated on the Drawings and as specified including but not limited to:
   1. Grounding electrodes.
   2. Bonding jumpers.
   3. Ground connections.

2.03 MANUFACTURERS

A. Compression connectors: One of the following or equal:
   1. ABB.
   2. Burndy.
   3. Erico.
   4. Harger.
   5. Panduit.

2.04 MATERIALS

A. Compression connectors:
   1. Manufactured of high copper alloy specifically for the particular grounding application.
   2. Suitable for direct burial in earth and concrete.
   3. Identifying compression die number inscription to be impressed on compression fitting.

B. Main bonding jumpers and bonding jumpers:
   1. Minimum size in accordance with the NEC.

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors:
   1. Size grounding conductors and bonding jumpers in accordance with NFPA 70, Article 250.

B. Provide a grounding electrode system in accordance with NFPA 70, Article 250 and as indicated on the Drawings:
   1. All grounding electrode conductors terminate on a main ground bar located adjacent to the service entrance equipment.

C. Provide a separate grounding conductor for each motor and connect at motor terminal box. Do not use bolts securing motor box to frame or cover for grounding connectors:
   1. When grounding motors driven by variable frequency drives (VFD) comply with the requirements of the VFD manufacturer.

D. Provide a grounding type bushing with lug for connection of grounding conductor for conduits that originate from each motor control center section, switchboard, or panelboard:
   1. Individually bond these raceways to the ground bus in the equipment.

E. Provide grounding type bushings with lugs for connection of grounding conductor at both ends of metallic conduit runs. Bond ground bushings to the grounding system.

F. Provide a green insulated wire-grounding jumper from the ground screw to a box grounding screw and, for grounding type devices, to equipment grounding conductor.

G. Interconnect the secondary panelboard neutral bus to the ground bus in the secondary panelboard compartment, only at service entrance point or after a transformer.

H. Duct bank ground system:
   1. Provide a bare copper grounding conductor the entire length of each duct bank, embedded in the concrete of the duct bank as indicated on the Drawings and specified in the Specifications.
   2. Bond duct bank ground conductors together where duct banks join, merge, intersect, or split.

I. Ground connections:
   1. Connections to the ground grid system, the duct bank grounding system, equipment, ground rods, etc., shall be made using compression type grounding connectors as indicated on the Drawings, UL listed, and labeled for the application.
   2. Make ground connections in accordance with the manufacturer's instructions.
   3. Do not conceal or cover any ground connections until the Engineer or authorized representative has established and provided written confirmation that every grounding connection is as indicated on the Drawings and specified in the Specifications.

J. Shield grounding:
   1. Analog signal cables shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
   2. For communication and data line signal cable shields and drain wires should be grounded at both ends of the cable run.
   3. Insulate the shielding and exposed drain wire for each signal cable with heat-shrink tubing.
   4. Terminate the signal cable shield on a dedicated grounding terminal block.

3.04 FIELD QUALITY CONTROL

A. Field electrical acceptance testing:
   1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

B. Ground system resistance (electrode to ground) of the completed installation, as determined by tests, shall be:
   1. 5 ohms or less for industrial systems.
   2. 1 ohm or less for electrical buildings.

C. Measure grounding electrode system resistance to ground in accordance with IEEE 81.

3.05 ADJUSTING

A. Under the direction of the Engineer, add additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurement meets the specified resistance requirements:
   1. Use of salts, water, or compounds to attain the specified ground resistance is not acceptable.

END OF SECTION

SECTION 26_05_29

HANGERS AND SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Mounting and supporting electrical equipment and components.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   2. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Anchor: Elements (including hardware) connecting hangers and supports to the structure.
   2. Hardware: Nuts, bolts, straps, clamps, threaded rod, etc.
   3. Supports: Preformed channel or other structural member on which the electrical equipment or raceway is mounted.

1.04 DELEGATED DESIGN

A. As specified in Section 01_35_73 - Delegated Design Procedures.

B. Anchoring and bracing.

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Product data:
   1. Supports:
      a. Materials.
      b. Geometry.

c. Manufacturer.
2. Hardware:
   a. Materials.
   b. Manufacturer.

C. Shop Drawings:
1. Dimensioned and scalable Shop Drawings of hangers and supports for distribution systems and equipment.
2. Complete details for:
   a. Member sizes and arrangement in hangers and support assemblies.
   b. Connections between members in hangers and support assemblies.
   c. Anchoring hangers and supports to structures.
   d. Bracing for hangers and supports and anchoring of bracing to structures.
3. Include data on connections, attachment hardware and construction to demonstrate that hangers and supports will satisfy the design loading, bracing, and anchoring criteria.

D. Delegated Design Submittals:
1. Hangers and supports - General:
   a. Locations and conditions:
      1) Hangers and supports inside structures.
      2) Hangers and supports that resist cable pulling/rigging loads.
   b. Required Submittals: Details with supporting calculations for:
      1) Support member arrangement, sizes, and connections.
      2) Bracing to resist cable pulling/rigging loads.
      3) Connections of hangers, supports, and bracing to the structure.
      4) Connections between supports and the equipment or raceway(s) thereon.
2. Hangers and supports - Exterior and seismic conditions:
   a. Locations and conditions:
      1) Hangers and supports at structures designated as Seismic Design Category (SDC) C, D, E, or F as specified in technical sections and as indicated on the Drawings.
      2) Hangers and supports for outdoor installations.
   b. Required Submittals:
      1) Interior: Bracing to resist seismic design loads specified in technical sections and as indicated on the Drawings.
      2) Exterior: Bracing to resist seismic, wind, and other environmental loads specified in technical sections and as indicated on the Drawings.
3. Hangers and supports anchored to concrete and masonry:
   a. Locations and conditions:
      1) Post-installed mechanical anchors in tension.
      2) Post-installed adhesive-bonded all-thread rods in tension.
   b. Required Submittals:
      1) Calculations demonstrating that anchors have a demand/capacity ratio (D/C) not greater than the following when anchor capacity is adjusted for moisture conditions, anchor spacing and edge distances, and sustained loading conditions present at the location of installation.
         a) Post-installed mechanical anchors maximum: 85 percent.
         b) Post-installed adhesive-bonded anchors maximum: 75 percent.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.10 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL

A. Mount raceways, cabinets, boxes, fixtures, instruments, and devices on Contractor-fabricated supports unless otherwise indicated on the Drawings.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Hangers and supports individually and as a system shall resist weights and code-required forces without deflections and deformations that would damage the supporting elements, the raceway or equipment supported, or the surrounding construction:
   1. Provide the necessary sway bracing to keep support structures from swaying due to lateral forces, including wire and cable pulling forces.
   2. Lateral deflection at top of slab mounted supports shall not exceed support height divided by 240, unless otherwise approved by the Engineer.

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Preformed channel:
      a. Eaton B-line.
      b. Power-Strut.
      c. Robroy.
      d. Tyco.
      e. Unistrut.

2.04 MATERIALS

A. Hot dip galvanized steel:
   1. Supports:
      a. In accordance with ASTM A123 or A153.
      b. Minimum zinc coating thickness of 2.5 mils.
      c. Nominal dimensions: 1-5/8 inch by 1-5/8 inch.
   2. Hardware:
      a. Electro-galvanized.

b. In accordance with ASTM A153.

B. Stainless steel:
   1. Supports:
      a. In accordance with ASTM A240.
      b. ANSI Type 316 material.
      c. Nominal dimensions: 1-5/8 inch by 1-5/8 inch.
   2. Hardware:
      a. ANSI Type 316 material.

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

A. Fabricated metal supports: As specified in Section 05_50_00 - Metal Fabrications.

2.08 ACCESSORIES

A. Anchors:
   1. As specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Paint and finish structures as specified in Section 09_96_01 - High-Performance Coatings.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

A. Use materials appropriate for the area as specified in Section 26_05_00 - Common Work Results for Electrical.

B. General:
   1. Refer to the Drawings for details. Equipment, cabinets, boxes, instruments, and devices in damp or wet locations on minimum of 7/8-inch preformed mounting channel.
   2. Mount channel vertically along the length of the device so that water or moisture may run freely behind the device.

C. Corrosion protection:
   1. Isolate dissimilar metals, except where required for electrical continuity:
      a. Use neoprene washers, 9-mil polyethylene tape, or gaskets for isolation.

D. Anchoring methods:
   1. Solid concrete:
      a. Anchor bolts, anchor rods or post-installed anchors as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
   2. Metal surfaces: Machine screws or bolts.
   3. Hollow masonry units:
      a. Post installed anchors as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
   4. Wood and metal studs:
      a. When supporting devices on metal or wood stud construction, bridge studs with preformed channel, and mount the devices to the channel.

E. Recoat or seal drilled holes, cut or scratched surfaces or with products recommended by the manufacturer.

F. Group raceway and position on racks to minimize crossovers.

END OF SECTION

SECTION 26_05_33

CONDUITS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Metallic conduits.
   2. Nonmetallic conduits.
   3. Conduit bodies.
   4. Conduit fittings and accessories.
   5. Conduit installation.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. Abbreviations:
   1. GRC: Galvanized rigid steel conduit.
   2. PCS: Polyvinyl chloride (PVC) coated rigid steel conduit.
   3. PVC: Polyvinyl chloride rigid nonmetallic conduit.
   4. SLT: Sealtight-liquidtight flexible conduit.

B. Standards:
   1. American National Standards Institute (ANSI):
      a. C80.1 - Electrical Rigid Steel Conduit.
   2. National Electrical Manufacturers Association (NEMA):
      a. RN-1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Steel Conduit.
   3. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code (NEC).
   4. Underwriters Laboratories (UL), Inc.:
      a. 1 - Standard for Safety Flexible Metal Conduit.
      b. 6 - Standard for Safety Electrical Rigid Metal Conduit - Steel.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning:
   1. Conduit bodies: A separate portion of a conduit system that provides access through a removable cover to the interior of the system at a junction of two or more conduit sections. Includes, but not limited to, shapes C, E, LB, T, X, etc.

2. Conduit fitting: An accessory that primarily serves a mechanical purpose. Includes, but not limited to, bushings, locknuts, hubs, couplings, reducers, etc.

1.04 DELEGATED DESIGN

A. As specified in Section 01_35_73 - Delegated Design Procedures and Section 26_05_29 - Hangers and Supports.

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Product data:
   1. Furnish complete manufacturer's catalog sheets for every type and size of conduit, fitting, conduit body, and accessories to be used on the Project.
   2. Furnish complete manufacturer's recommended special tools to be used for installation, if required.
   3. Certified test results for PVC-coated metallic conduit showing the adhesive bond is stronger than the tensile strength of the PVC.

C. Shop Drawings:
   1. Furnish conduit routing plans for conduits before the installation of any conduits embedded within concrete.
   2. Detail the intended routing of each conduit, conduit material and include supporting methods.
   3. Number conduits in accordance with the Contract Documents:
      a. Provide conduit labels as specified in Section 26_05_53 - Identification for Electrical Systems.

D. Delegated Design Submittals:
   1. As specified in Section 26_05_29 - Hangers and Supports.

E. Certifications:
   1. Furnish PVC-coated conduit manufacturer's valid, unexpired certification for each installer.

F. Record documents:
   1. Incorporate changes in conduit routing on electrical plan drawings.
   2. Dimension underground and concealed conduits from building lines.
   3. Furnish hard copy drawings.

1.06 QUALITY ASSURANCE

A. Conduits, conduit bodies, and fittings shall be UL listed and labeled.

B. Every installer of PVC-coated metallic conduit shall be certified by the manufacturer for installation of the conduit, and be able to present a valid, unexpired installer certification card prior to installation beginning.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Do not expose non-metallic conduit to direct sunlight.

B. Do not store conduit in direct contact with the ground.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.09 ADMINISTRATIVE REQUIREMENTS

A. Sequencing:
   1. Before performing any trenching locate existing underground utilities:
      a. As specified in Section 33_05_01 - Subsurface Utility Engineering.
      b. Review of existing civil record drawings for recorded underground utilities:
         1) Determine underground utility horizontal and vertical location by at least one of the following methods:
            a) Soft excavation.
            b) Local utility location service, CALL BEFORE YOU DIG, or equal.

1.10 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide conduits, conduit bodies, fittings, junction boxes, and necessary components, whether or not indicated on the Drawings, as required, to install a complete electrical raceway system.

B. Provide location and protection of existing underground utilities, underground conduit trenching, conduit and backfill necessary for the complete installation of underground conduits.

2.03 MANUFACTURERS

A. Galvanized rigid steel conduit:
   1. One of the following or equal:
      a. Allied Tube and Conduit.
      b. Western Tube and Conduit.
      c. Wheatland Tube Co.

B. PVC-coated rigid steel conduit:
   1. One of the following or equal:
      a. Allied.
      b. Calbond.

c. NEC, Inc. BlackGuard.
d. Ocal, Inc.
e. Robroy Ind.

C. Sealtight-liquidtight flexible conduit:
1. One of the following or equal:
a. AFC Cable Systems.
b. Anaconda.
c. Electri-Flex Co.
d. Southwire.

D. Rigid nonmetallic PVC conduit:
1. One of the following or equal:
a. Cantex.
b. Carlon.
c. Triangle Conduit and Cable.

E. Conduit bodies:
1. One of the following or equal:
a. Appleton.
b. Calbond.
c. Carlon.
d. Crouse-Hinds.
e. O-Z/Gedney.
f. Ocal, Inc.
g. Robroy Ind.

F. Joint compound:
1. As recommended by the conduit manufacturer.

G. Galvanized rigid steel conduit expansion fittings:
1. One of the following or equal:
a. Appleton.
b. Crouse-Hinds.
c. O-Z/Gedney.

H. PVC-coated rigid steel conduit expansion fittings:
1. One of the following or equal:
a. NEC, Inc. BlackGuard.
b. Ocal, Inc.
c. Robroy Ind.

I. Conduit sleeve:
1. One of the following or equal:
a. Appleton.
b. Crouse-Hinds.
c. O-Z/Gedney.

J. Conduit through wall and floor seals:
    1. The following or equal:
        a. O-Z/Gedney:
            1) Type “WSK.”
            2) Type “CSM.”

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

A. GRC:
    1. NPT standard conduit threads with a 3/4-inch taper per foot:
        a. Running conduit threads are not acceptable.
    2. Hot dip galvanized inside and out:
        a. Ensures complete coverage and heats the zinc and steel to a temperature that ensures the zinc alloys with the steel over the entire surface.
        b. Electro-galvanizing is not acceptable.
    3. Manufactured in accordance with:
        a. UL 6.
        b. ANSI C80.1.

B. PCS:
    1. Steel conduit, before PVC coating, shall be new, unused, hot dip galvanized material, in accordance with to the requirements for Type GRC.
    2. Coated conduit NEMA Standard RN-1:
        a. Galvanized coating may not be disturbed or reduced in thickness during the cleaning and preparatory process.
    3. Factory-bonded PVC jacket:
        a. Exterior galvanized surfaces shall be coated with primer before PVC coating to ensure a bond between the zinc substrate and the PVC coating.
        b. Nominal thickness of the exterior PVC coating shall be 0.040 inch, except where part configuration or application of the piece dictates otherwise.
        c. PVC coating on conduits and associated fittings shall have no sags, blisters, lumps, or other surface defects and shall be free of holes and holidays.
        d. PVC adhesive bond on conduits and fittings shall be greater than the tensile strength of the PVC plastic coating:
            1) Confirm bond with certified test results.
    4. Urethane coating shall be uniformly and consistently applied to the interior of conduits and fittings:
        a. Nominal thickness of 0.002 inch.
        b. Conduits having areas with thin or no coating are not acceptable.
        c. Threads shall be coated with urethane.
    5. PVC exterior and urethane interior coatings applied to the conduits shall afford sufficient flexibility to permit field bending without cracking or flaking at temperature above 30 degrees Fahrenheit (1 degree Celsius).

6. PCS conduit bodies and fittings:
    a. Malleable iron.
    b. Conduit body, before PVC coating, shall be new, unused material and shall be in accordance with appropriate UL standards.
    c. PVC coating on the outside of conduit bodies shall be 0.040-inch thick and have a series of ribs to protect the coating from tool damage during installation.
    d. 0.002-inch interior urethane coating.
    e. Utilize PVC coating as an integral part of the gasket design.
    f. Stainless steel cover screw heads shall be encapsulated with plastic to ensure corrosion protection.
    g. PVC sleeve extending 1 conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening:
        1) Inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.
        2) Sleeve shall provide a vapor- and moisture resistant seal at every connection.
        3) Fittings shall be Form 8 and supplied with plastic encapsulated stainless steel cover screws. Fittings shall be UL Type 4X. Fittings shall be from the same manufacturer as the conduit in order to maintain system continuity and warranty.

C. SLT:
1. Temperature rated for use in the ambient temperature at the installed location but not less than the following:
    a. General purpose:
        1) Temperature range: -20 degrees Celsius to +80 degrees Celsius.
    b. Oil-resistant:
        1) Temperature range: -20 degrees Celsius to +60 degrees Celsius.
2. Sunlight-resistant, weatherproof, and watertight.
3. Manufactured from single strip steel, hot dip galvanized on all 4 sides before conduit fabrication.
4. Strip steel spiral wound resulting in an interior that is smooth and clean for easy wire pulling.
5. Overall PVC jacket.
6. With integral copper ground wire, built in the core, in conduit trade sizes 1/2 inch through 1-1/4 inch.

D. PVC:
1. Extruded from virgin PVC compound:
    a. Schedule 40 unless otherwise specified.
    b. Schedule 80 extra-heavy wall where specified.
2. Rated for 90 degrees Celsius conductors or cable.
3. Rated for use in direct sunlight.

E. Conduit bodies:
1. Material consistent with conduit type:
    a. Malleable iron bodies and covers when used with Type GRC.
    b. PVC bodies and covers when used with Type PVC.
    c. PVC-coated malleable iron bodies and covers when used with Type PCS.

2. Conduit bodies to be in accordance with to Form 8, Mark 9, or Mogul design:
    a. Mogul design in accordance with NEC requirements for bending space for large conductors for conduit trade sizes of 1 inch and larger with conductors #4 AWG and larger, or where required for wire-bending space.
3. Gasketed covers attached to bodies with stainless steel screws secured to threaded holes in conduit body.

2.08 ACCESSORIES

A. Connectors and fittings:
    1. Manufactured with compatible materials to the corresponding conduit.

B. Insulated throat metallic bushings:
    1. Construction:
        a. Malleable iron or zinc-plated steel when used with steel conduit.
        b. Positive metallic conduit end stop.
        c. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
        d. Use fully insulated bushings on nonmetallic conduit system made of high-impact 150 degrees Celsius rated non-combustible thermosetting phenolic.

C. Insulated grounding bushings:
    1. Construction:
        a. Malleable iron or steel, zinc-plated, with a positive metallic end stop.
        b. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
        c. Tin-plated copper grounding saddle for use with copper or aluminum conductors.

D. Electrical unions (Erickson Couplings):
    1. Construction:
        a. Malleable iron for use with steel conduit.
        b. PVC-coated malleable iron for use with PCS conduit.
        c. Concrete tight, 3-piece construction.
        d. Rated for Class I, Division 1, Group D in hazardous areas.

E. SLT fittings:
    1. Construction:
        a. Malleable iron.
        b. Furnished with locknut and sealing ring.
        c. Liquidtight, raintight, oiltight.
        d. Insulated throat.
        e. Furnish as straight, 45-degree elbows, and 90-degree elbows.
        f. Designed to prevent sleeving:
            1) Verify complete bonding of the raceway jacket to the plastic gasket seal.
        g. Equipped with grounding device to provide ground continuity irrespective of raceway core construction. Grounding device, if inserted into raceway and directly in contact with conductors, shall have rolled-over edges for sizes under 5 inches.

h. Where terminated into a threadless opening using a threaded hub fitting, a suitable moisture-resistant/oil-resistant synthetic rubber gasket shall be provided between the outside of the box or enclosure and the fitting shoulder. Gasket shall be adequately protected by and permanently bonded to a metallic retainer.

2. Corrosion-resistant and outdoor SLT fittings:
   a. Construction:
      1) PVC-coated liquidtight fittings with a bonded 0.040-inch-thick PVC coating on the metal connector to form a seal around the SLT conduit.
      2) Insulated throat and an integral sealing ring.

F. Hubs for threaded attachment of steel conduit to sheet metal enclosures:
   1. Construction:
      a. Insulated throat.
      b. PVC-coated when used in corrosive areas.
      c. Bonding locknut.
      d. Recessed neoprene O-ring to ensure watertight and dusttight connector.
      e. 1/2-inch through 1-1/4-inch steel zinc electroplated.
      f. 1-1/2-inch through 6-inch malleable iron zinc plated.
   2. Usage:
      a. Conduits in damp, wet, outdoor, and corrosive areas shall use threaded hubs for connections to sheet metal enclosures.

G. PVC fittings:
   1. Materials:
      a. Devices shall be made of PVC, using the same materials as used for Type PVC conduit.
      b. Metal hardware shall be stainless steel.

H. Through wall and floor seals:
   1. Materials:
      a. Body: Casting of malleable or ductile iron with a hot dip galvanized finish.
      b. Grommet: Neoprene.
      c. Pressure rings: PVC-coated steel.
      d. Disc material: PVC-coated steel.

I. Expansion/deflection couplings:
   1. Use to compensate for movement in any directions between 2 conduit ends where they connect.
   2. Shall allow movement of 3/4 inch from the normal in all directions.
   3. Shall allow angular movement for a deflection of 30 degrees from normal in any direction.
   4. Constructed to maintain electrical continuity of the conduit system.
   5. Materials:
      a. End couplings: Bronze or galvanized ductile iron.
      b. Sleeve: Neoprene.
      c. Bands: Stainless steel.
      d. Bonding jumper: Tinned copper braid.

J. Expansion couplings:
    1. Shall allow for expansion and contraction of conduit:
        a. Permitting 8-inch movement, 4 inches in either direction.
    2. Constructed to maintain electrical continuity of the conduit system.
    3. Materials:
        a. Head: Malleable or ductile iron.
        b. Sleeve: Steel.
        c. Insulating bushing: Phenolic.
        d. Finish: Hot dip galvanized.
        e. PVC-coated steel when used with Type PCS.

K. Conduit markers:
    1. As specified in Section 26_05_53 - Identification for Electrical Systems.

PART 3 EXECUTION

3.01 EXAMINATION

A. Before installing any conduit or locating any device box:
    1. Examine the complete set of Drawings and Specifications, and applicable Shop Drawings.

B. Verify all dimensions and space requirements and make any minor adjustments to the conduit system as required to avoid conflicts with the building structure, other equipment, or the work of other trades.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. General:
    1. Conduit routing:
        a. Electrical drawings are diagrammatic in nature:
            1) Install conduit runs as specified with schematic representation indicated on the Drawings and as specified.
            2) Modify conduit runs to suit field conditions, as accepted by the Engineer:
                a) Make changes in conduit locations that are consistent with the design intent but are dimensionally different, or routing to bypass obstructions.
                b) Make changes in conduit routing due to the relocation of equipment.
                c) Install conduits and equipment in such a manner as to avoid obstructions and to preserve headroom and keep openings and passageways clear.
            3) Where the Drawings do not indicate the exact mounting and/or supporting method to be used, use materials and methods similar to the mounting details indicated on the Drawings.

4) Electrical drawings do not indicate all required junction boxes and pull boxes:
    a) Provide junction boxes and pull boxes to facilitate wire pulling as required:
        (1) To meet cable manufacturer's pulling tension requirements.
        (2) To limit total conduit bends between pull locations.
    b) Install junction boxes and pull boxes at locations acceptable to the Engineer.

b. Contractor is responsible for any deviations in general location, conduit size, routing, or changes to the conduit schedule without the express written approval or direction by the Engineer:
    1) Engineer is the sole source in determining whether the change is constituted as a deviation.
    2) Perform any changes resulting in additional conduits, or extra work from such deviations.
    3) Incorporate any deviations on the Record Documents.

c. Owner reserves the right to deduct the amount of applicable reimbursement, equivalent to the cost of the engineering effort required to show those unauthorized changes on record Drawings.

2. Use only tools recommended by the conduit manufacturer for assembling the conduit system.
3. Provide adequate clearances from high-temperature surfaces for conduit runs. Provide minimum clearances as follows:
    a. Clearance of 6 inches from surfaces 113 degrees Fahrenheit to 149 degrees Fahrenheit.
    b. Clearance of 12 inches from surfaces greater than 149 degrees Fahrenheit.
    c. Keep conduits at least 6 inches from the coverings on hot water and steam pipes, 18 inches from the coverings on flues and breechings, and 12 inches from fuel lines and gas lines.
    d. Where it is necessary to route conduits close to high-temperature surfaces, provide a high-reflectance thermal barrier between the conduit and the surface.
4. Support conduit runs on water-bearing walls a minimum of 7/8-inch away from wall on an accepted preformed channel:
    a. Do not run conduits within water-bearing walls unless otherwise indicated on the Drawings.
5. Do not install 1-inch or larger conduits in or through structural members unless approved by the Engineer.
6. Run conduits exposed to view parallel with or at right angles to structural members, walls, or lines of the building:
    a. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends.
    b. Make changes in direction with long radius bends or with conduit bodies.
7. Install conduits with total conduit bends between pull locations less than or equal to 270 degrees.
8. Route exposed conduits to preserve headroom, access space and workspace, and to prevent tripping hazards and clearance problems:
    a. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and do not block or interfere with ingress or egress, including equipment-removal hatches.

b. Route conduits to avoid drains or other gravity lines. Where conflicts occur, relocate the conduit as required.

9. When installing conduits through existing slabs or walls, make provisions for locating any possible conflicting items where the conduit is to penetrate. Use tone signal or X-ray methods to make certain that no penetrations will be made into the existing conduits, piping, cables, post-tensioning cables, etc.
10. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture.
11. Install conduits through wall and floor seals where indicated on the Drawings.
12. For existing and new 2-inch and larger conduit runs, snake conduits with a conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of the conduit:
    a. Remove and replace conduits through which mandrel will not pass.
13. Provide sleeves and openings required for the passage of electrical raceways or cables even when these openings or sleeves are not specifically indicated on the Drawings.
14. Install complete conduit systems before conductors are installed.
15. Provide metallic conduits terminating in transformer, motor control center, or other equipment conduit windows with grounding bushings and ground with a minimum No. 6 AWG ground wire.
16. Underground conduits:
    a. Install underground conduits, including conduit runs below slabs-on-grade in concrete-reinforced duct bank construction:
        1) As specified in Section 26_05_44 - Duct Banks.
    b. Make underground conduit size transitions at handholes and manholes.
    c. Install spare conduits in underground duct banks towards top center of runs to allow for ease of installation of future cables as conduits enter underground manholes and handholes.
    d. Seal around conduit penetrations of below grade walls with a mechanical seal.
17. Underground conduit trenching:
    a. Perform trenching as specified in Section 31_23_35 - Trenching.
    b. Trench must be uniformly graded with the bottom, rock free and covered with select material.
    c. Damage occurring to existing ducts, conduits, cables, and other utilities during underground conduit installation shall be remediated to the satisfaction of the Owner.
    d. Whenever possible, use the walls of the trench as forms for concrete encasement:
        1) Forms are required where the soil is not self-supporting.

B. Equipment grounding conductors:
    1. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material:
        a. Multi-conductor power and control cables shall include an integral green insulated grounding conductor.
        b. Provide a separate grounding conductor in each individual raceway for parallel feeders.
    2. Conductors shall be the same type and insulation as the circuit conductors:
        a. Use 600-volt insulation for the equipment grounding conductors for medium voltage systems.

3. Minimum size in accordance with the NEC.

C. Conduit usage:
   1. Exposed conduits:
      a. Rigid conduit:
         1) Install the rigid conduit type for each location as specified in Section 26_05_00 - Common Work Results for Electrical.
         2) Minimum size: 3/4-inch.
      b. Flexible conduit:
         1) Use flexible conduit for final connections between rigid conduit and motors, vibrating equipment, instruments, control equipment, or where required for equipment servicing:
            a) Use Type SLT with rigid metallic conduit.
         2) Minimum size: 3/4-inch:
            a) 1/2 when required for connection to instruments.
         3) Maximum length:
            a) Fixed equipment:

Conduit Trade Size	Flexible Conduit Length (inch)
3/4	18
1	18
1-1/4	18
1-1/2	18
2	36
2-1/2	36
3	36
3-1/2	38
4	40

            b) Removable instruments or hinged equipment:
               (1) As required to allow complete removal or full movement without disconnecting or stressing the conduit.
   2. Concrete-encased and embedded conduits:
      a. Straight runs and bends less than 45 degrees:
         1) Type PVC Schedule 40.
      b. Bends with total deflection greater than 45 degrees:
         1) PCS.
      c. Entering and exiting duct bank, underground or embedded conduit runs a minimum 12 inches above and below grade, finished floor, or entering equipment:
         1) PCS.
      d. Minimum size:
         1) 2-inch in duct banks.
         2) 1-inch for in-slab conduits.
         3) Provide conduit fittings to enlarge the conduit from the exposed size in the conduit schedule as required.

3. Direct-buried and sand-bedded duct bank conduits:
    a. Type PCS.
    b. Minimum size: 1-inch.
4. PVC-coated rigid metallic conduit:
    a. Use specifically manufactured or machined threading dies to manufacturer's specifications to accommodate the PVC jacket.
    b. Repair damage to PVC coatings with manufacturer supplied touchup compound or PVC Coating Repair Kit for PVC Coated Raceway Systems.
5. GRC:
    a. Conduit shall be cut square and reamed before threading.

D. Conduit joints and bends:
1. General:
    a. Where conduit is underground, under slabs on grade, or exposed to the weather, make joints liquidtight.
    b. Keep bends and offsets in conduit runs to an absolute minimum.
    c. Bends shall be symmetrical.
    d. The following conduit systems shall use large radius sweep elbows:
        1) Underground conduits.
        2) Conduits containing shielded cables.
        3) Conduits containing fiber optic cables.
    e. Provide large-radius factory-made bends for 1-1/4-inch trade size or larger.
    f. Make field bends with a radius of not less than the requirements found in the NEC:
        1) Minimum bending radius of the cable must be less than the radius of the conduit bend.
        2) Make field bends with power bending equipment or manual benders specifically intended for the purpose:
            a) Make bends so that the conduit is not damaged, and the internal diameter is not effectively reduced.
            b) For the serving utilities, make bends to meet their requirements.
        3) For PCS conduit, field bends are permitted on conduits 1 inch and smaller. Manufactured elbows shall be used on conduits larger than 1 inch.
    g. Replace deformed, flattened, or kinked conduit.
2. Threaded conduit:
    a. Cut threads on rigid metallic conduit with a standard conduit-cutting die that provides a 3/4-inch per foot taper and to a length such that bare metal exposed by the threading operation is completely covered by the couplings or fittings used. In addition, cut the lengths of the thread such that joints become secure and wrench-tight just preceding the point where the conduit ends would butt together in couplings or where conduit ends would butt into the ends or shoulders of other fittings.
    b. Thoroughly ream conduit after threads have been cut to remove burrs.
    c. Use bushings or conduit fittings at conduit terminations.
    d. On exposed conduits, repair scratches and other defects with galvanizing repair stick, Enterprise Galvanizing "Galvabar™," or CRC "Zinc It".
    e. Coat conduit threads with an approved electrically conductive sealant and corrosion inhibitor that is not harmful to the conductor insulation:
        1) Apply to the male threads and tighten joints securely.
        2) Clean excess sealant from exposed threads after assembly.

f. Securely tighten threaded connections.
g. Any exposed threaded surfaces must be cleaned and coated with a galvanizing solution so that exposed surfaces have a galvanized protective coating.

3. PVC:
   a. Use approved solvent-weld cement specifically manufactured for the purpose. Spray-type cement is not allowed.
   b. Apply heat for bends so that conduit does not distort or discolor. Use a spring mandrel as required to ensure full inside diameter at bends:
      1) Utilize a heater specifically for PVC conduit as recommended by the conduit manufacturer.

E. Conduit sealing and drainage:
   1. Other than required for hazardous and classified areas:
      a. Provide sealing and drainage in vertical drops of long (in excess of 20 feet), exterior, above-grade conduit runs at the points at which the conduit enters buildings, switchgear, control panels, lighting panelboards, and other similar enclosures.
      b. Provide seal fittings with drains in vertical drops directly above grade for exterior and above-grade conduit runs that are extended below grade.
      c. Provide conduit seals with drains in areas of high humidity and rapidly changing temperatures:
         1) Where portions of an interior raceway pass through walls, ceilings, or floors that separate adjacent areas having widely different temperatures.
      d. Provide conduit seals similar to O-Z/Gedney (Type CSM) on conduits between corrosive and non-corrosive areas.
      e. Seal one end only of underground conduits at highest point with O-Z/Gedney sealing (non-hazardous) filling, or equal.
   2. Install seals with drains at any location along conduit runs where moisture may condense or accumulate. This requirement includes, but is not limited to, the following locations: Control panels, junction boxes, pull boxes, or low points of the conduit.

F. Hangers and supports:
   1. General:
      a. Provide appropriate hangers, supports, fasteners, and seismic restraints to suit applications:
         1) As specified in Section 26_05_29 - Hangers and Supports.
         2) Provide support materials consistent with the type of conduit being installed as specified in Section 26_05_00 - Common Work Results for Electrical.
      b. Support conduit at the intervals required by the NEC.
      c. Perforated strap and plumbers' tape are not acceptable for conduit supports.
   2. Conduit on concrete or masonry:
      a. Use 1-hole malleable iron straps with metallic or plastic expansion anchors and screws or support from preset inserts.
      b. Use preset inserts in concrete when possible.
      c. Use pipe spacers (clamp backs) in wet locations.

3. Suspended conduit:
    a. Use malleable-iron factory-made split-hinged pipe rings with threaded suspension rods sized for the weight to be carried (minimum 3/8-inch diameter), Kindorf, or equal.
    b. For grouped conduits, construct racks with threaded rods and tiered angle iron or preformed channel cross members. Clamp each conduit individually to a cross member. Where rods are more than 2 feet long, provide rigid sway bracing.
4. Supports at structural steel members:
    a. Use beam clamps.
    b. Drilling or welding may be used only as specified or with approval of the Engineer.
5. PVC-coated rigid metal systems:
    a. Provide right-angle beam clamps and “U” bolts specially formed and sized to snugly fit the outside diameter of the coated conduit. Provide “U” bolts with PVC-encapsulated nuts that cover the exposed portions of the threads.
    b. Securely fasten exposed conduits with Type 316 stainless steel clamps or straps.

G. Expansion or expansion/deflection fittings:
1. General:
    a. Align expansion coupling with the conduit run to prevent binding.
    b. Follow manufacturer’s instructions to set the piston opening.
    c. Install expansion fittings across concrete expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction.
    d. Furnish fittings of the same material as the conduit system.
2. For metallic conduit, provide expansion or expansion/deflection couplings, as appropriate, where:
    a. Install expansion fittings a minimum of every 200 feet in straight conduit runs.

H. Empty conduits:
1. Provide a pull tape in each empty conduit more than 10 feet in length.
2. Provide 1 empty 3/4-inch conduit for each 4 spare unused circuits or spaces of each flush-mounted branch circuit panelboard. Terminate empty 3/4-inch conduits in individual junction boxes that are accessible to enable extension of future branch circuits.
3. Seal ends of conduits with approved, manufactured conduit seals, caps, or plugs immediately after installation:
    a. Keep ends sealed until immediately before pulling conductors.

I. Maintain minimum spacing between parallel conduit and piping runs in accordance with the following when the runs are greater than 30 feet:
1. Between instrumentation and telecommunication: 1 inch.
2. Between instrumentation and 125 V, 48 V and 24 VDC: 2 inches.
3. Between instrumentation and 600 V and less AC power or control: 6 inches.
4. Between instrumentation and greater than 600 VAC power: 12 inches.
5. Between telecommunication and 125 V, 48 V and 24 VDC: 2 inches.
6. Between telecommunication and less AC power or control: 6 inches.

7. Between telecommunication and greater than 600 VAC power: 12 inches.
8. Between 125 V, 48 V and 24 VDC and 600 V and less AC power or control: 2 inches.
9. Between 125 V, 48 V and 24 VDC and greater than 600 VAC power: 2 inches.
10. Between 600 V and less AC and greater than 500 VAC: 2 inches.
11. Between process, gas, air and water pipes: 6 inches.

J. Miscellaneous:
1. Seal roof penetrations for raceways and other items that penetrate the roof in accordance with roofing manufacturer's instructions and as indicated on the Drawings.
2. Provide electrical unions at all points of union between ends of rigid conduit systems that cannot otherwise be coupled:
   a. Running threads and threadless couplings are not allowed.
3. Replace any conduits installed that the Engineer determines do not meet the requirements of this Specification.
4. Provide conduit housekeeping curb around embedded or below-grade conduits exiting or entering the slab, in accordance with the Typical Details.

END OF SECTION

SECTION 26_05_34

BOXES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Device boxes.
   2. Raceway system boxes.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

B. ASTM International (ASTM):
   1. A47 - Standard Specification for Ferritic Malleable Iron Castings.

C. Joint Industry Conference (JIC).

D. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

E. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).

F. Underwriters Laboratories, Inc. (UL).

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning:
   1. Arcing parts: Circuit breakers, motor controllers, switches, fuses, or any device intended to interrupt current during its operation.
   2. Raceway system boxes: Boxes that are used for wire and cable pull boxes, conduit junction boxes, or terminal boxes.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Product data:
   1. Manufacturer.
   2. Materials.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
      d. Weight.
      e. NEMA rating.
   4. Conduit entry locations.
   5. Catalog cutsheets.
   6. Installation instructions.

C. Shop Drawings:
   1. Include identification and sizes of pull boxes.

1.06 QUALITY ASSURANCE

A. Regulatory requirements:
   1. Outlet boxes shall comply with applicable standards of:
      a. JIC.
      b. NEC.
      c. NEMA.
      d. UL.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.10 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide outlet boxes for wiring devices, junction, and pull boxes for use in the raceway systems, etc.

B. Provide boxes as indicated on the Drawings and as needed to complete the raceway installation.

C. Size pull boxes in accordance with NEC requirements and to provide sufficient room for any future conduits, components, and cables as indicated on the Drawings.

D. Provide materials and construction suitable for environmental conditions at the location of the box as specified in Section 26_05_00 - Common Work Results for Electrical.

E. For boxes not indicated:
   1. Provide outlet boxes to match the exposed conduit system. Provide junction boxes and pull boxes as specified in Section 26_05_00 - Common Work Results for Electrical.

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Plastic coated boxes:
      a. OCAL.
      b. Rob Roy.
   2. Cast device boxes:
      a. Appleton.
      b. Crouse - Hinds.
      c. O-Z/Gedney.
   3. Formed steel enclosures:
      a. Hoffman.
      b. Rittal.
      c. Stahlin.
   4. Stainless steel enclosures:
      a. Hoffman.
      b. Rittal.
      c. Stahlin.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

A. Cast device boxes:
   1. Construction:
      a. With internal green ground screw.
      b. Furnished with a suitable gasketed cover.
      c. With integral cast mounting lugs when surface mounted.
      d. Conduit sizes range from 3/4 inch to 1 inch.
      e. Tapered threaded hubs with integral bushing.
   2. Aluminum (copper free) boxes:
      a. High strength copper free 4/10 of 1 percent maximum alloy for use with aluminum rigid conduit.
   3. Malleable iron boxes:
      a. In accordance with ASTM A47 Grade 32510.

B. Plastic coated cast device boxes:
   1. Construction:
      a. With internal green ground screw.
      b. Furnished with a suitable gasketed cover.
      c. With integral cast mounting lugs when surface mounted.
      d. Conduit sizes range from 3/4 inch to 1 inch.
      e. Double coated with a nominal 0.002-inch (2 mil) urethane on both the interior and exterior before application of PVC coating.
      f. With a minimum 0.040-inch (40 mil) PVC coating bonded to exterior.
      g. With pressure sealing sleeve to protect the connection with conduit.

C. Formed steel enclosures:
   1. Steel:
      a. NEMA Type 12.
      b. Fabricated from 14-gauge steel, minimum.
      c. Seams continuously welded ground smooth.
      d. Door:
         1) Rolled lip around 3 sides.
         2) Attached to enclosure by means of a continuous stainless-steel hinge and pin.
      e. Neoprene door gasket to provide a watertight, dusttight, oiltight seal:
         1) Attached with an adhesive.
         2) Retained by a retaining strip.
      f. Fabricate external removable hardware for clamping the door to the enclosure body from zinc-plated heavy gauge steel:
         1) With a hasp and staple for padlocking.
      g. Provide large enclosures with door and body stiffeners for extra rigidity.
      h. No holes or knockouts.
      i. Finish:
         1) ANSI 61 gray electrostatically applied polyester powder inside and out over cleaned and primed surfaces.
         2) White electrostatically applied polyester powder mounting plate.
      j. Heavy gauge steel external mounting brackets when surface mounted.
   2. Stainless steel:
      a. NEMA Type 4X.
      b. Fabricated from 14-gauge Type 316 stainless steel.
      c. Seams continuously welded.
      d. Door:
         1) Rolled lip around 3 sides.
         2) Attached to enclosure by means of a continuous stainless-steel hinge and pin.
      e. Neoprene door gasket to provide a watertight seal:
         1) Attached with an adhesive.
         2) Retained by a retaining strip.
      f. Fabricate external removable hardware for clamping the door to the enclosure body from heavy gauge stainless steel:
         1) With a hasp and staple for padlocking.
      g. Provide large enclosures with door and body stiffeners for extra rigidity.
      h. No holes or knockouts.
      i. Finish:
         1) Brushed.

j. Stainless steel external mounting brackets when surface mounted.

D. Cast iron junction boxes:
1. NEMA Type 4.
2. Recessed cover boxes.
3. Suitable for use outdoors where subject to rain, dripping, or splashing water.
4. Designed for flush mounting in walls or floors:
a. Can be surface mounted using mounting lugs.
5. Construction:
a. Cast iron.
b. Covers:
1) Checkered plate covers suitable for foot traffic.
2) When used in areas subject to vehicular traffic, design to support an AASHTO Standard Specifications for Highway Bridges, H-20 vehicle loading.
c. Hot dip galvanized.
d. Neoprene gasket.
e. Stainless steel screw covers.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

A. Fasteners:
1. Electroplated or stainless steel in boxes with wiring devices.
2. Screws, nuts, bolts, and other threaded fasteners:
a. Stainless steel.

B. Provide breather and drain fittings where appropriate.

C. Internal panels:
1. Provide internal panels where required for mounting of terminal strips or other equipment.
2. With plated steel shoulder studs.
3. Steel with white polyester powder finish.

D. Floor stand kit when shown:
1. Fabricated from 12-gauge steel.
2. Bottom plate 11-gauge.
3. Heights:
a. 18 inches.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. General:
   1. Provide outlet box materials to match the exposed conduit system:
      a. GRC - Cast ferrous boxes.
      b. PCS - PVC coated cast ferrous boxes.
   2. Solid type gang boxes:
      a. For more than 2 wiring devices.
      b. For barriered outlets.
   3. Support wall mounted NEMA Type 4 or NEMA Type 4X boxes to maintain a minimum of 7/8-inch free air space between the back of the enclosure and the wall:
      a. Use machined spacers to maintain air space; built-up washers are not acceptable.
      b. Use stainless steel or nylon materials for spacers.
   4. Use cast boxes when box must support other devices.
   5. Boxes serving luminaires or wiring devices:
      a. Use as pull boxes wherever possible.
   6. In terminal boxes, furnish terminals as indicated on the Drawings with a minimum of 50 percent spare terminals:
      a. Furnish wireways for discrete and analog/DC wiring.
      b. Separate analog wiring from 120 V discrete or power wiring.
   7. For fire-rated construction, provide materials and installation for use in accordance with the listing requirements of the classified construction.

B. Pull boxes and junction boxes:
   1. Provide junction box materials and NEMA ratings as specified in Section 26_05_00 - Common Work Results for Electrical.
   2. Install pull boxes such that access to them is not restricted.
   3. Fire rated construction: Use materials and methods to comply with the listing requirements for the classified construction.

END OF SECTION

SECTION 26_05_44

DUCT BANKS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Electrical underground duct banks.
   2. Duct bank installation requirements.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. Underwriters Laboratories, Inc. (UL).

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Product data:
   1. PVC conduit spacers.
   2. Detectable underground marking tape.
   3. Pull line.

C. Shop Drawings:
   1. Submit Site plan drawings of duct banks, including underground profiles indicating underground utilities.
   2. Submit cross section of each duct bank with dimensions.
   3. For duct bank routings crossing under building footers or foundations alternative to designed routings indicated on the Drawings:
      a. Submit Shop Drawings detailing the new building footer crossing locations and plan drawings labeling equipment to be installed on top of the new routing for approval by the Project structural Engineer.

1.05 QUALITY ASSURANCE (NOT USED)

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.08 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Duct bank sections indicated on the Drawings are an initial arrangement and may need to be modified due to existing Site conditions, existing underground utilities, and infrastructure:
   1. Reorganize duct bank section with approval of the Engineer.
   2. Make changes required to accommodate duct bank configuration and routing changes due to field conditions:
      a. Where changes in a duct bank configuration extend to a manhole or handhole, coordinate manhole/handhole blockouts and size with the new configuration.

B. Provide location and protection of existing underground utilities, duct bank, trenching, forming, rebar, spacers, conduit, concrete, backfill, and compaction necessary for the complete installation of the duct banks.

C. Provide reinforced concrete duct banks for conduits installed below grade, on the Site, below structures, or in contact with the earth, unless otherwise indicated on the Drawings.

2.03 MANUFACTURERS

A. Conduit spacers:
   1. One of the following or equal:
      a. Cantex.
      b. Osburn Associates, Inc.

B. Detectable underground marking tape:
   1. One of the following or equal:
      a. Blackburn Manufacturing Co.
      b. Panduit.

C. Pull line:
   1. One of the following or equal:
      a. Arnco.
      b. Greenlee.
      c. Osburn Associates, Inc.

D. Duct seal:
    1. The following or equal:
        a. O-Z/Gedney type DUX.

2.04 MATERIALS

A. Provide conduit as specified in Section 26_05_33 - Conduits.

B. Provide reinforcing steel as specified in Section 03_30_01 - Concrete Work:
    1. Provide minimum Number 4 reinforcing steel.

C. Concrete:
    1. Mix requirements as specified in Section 03_30_01 - Concrete Work.
    2. Provide a red-oxide conduit encasement coloring agent as specified in Section 03_30_01 - Concrete Work.

2.05 MANUFACTURED UNITS

A. Conduit spacers:
    1. Recommended by the conduit manufacturer or specified above.
    2. Saddle type.
    3. Non-metallic, non-corrosive, non-conductive.
    4. Interlocking type:
        a. Vertical interlocking.
        b. Horizontal interlocking.
    5. Suitable for concrete encasement.
    6. Molded-in rebar holder.
    7. Accommodates 2-inch through 6-inch conduit sizes.
    8. Relieves the conduit from both horizontal and vertical stresses.

B. Pull line:
    1. Minimum 1/4-inch wide, flat design.
    2. Polyester.
    3. Minimum pulling strength 1,200 pounds.
    4. Sequential footage markings.

C. Detectable marking tape:
    1. Locatable by a cable or metal detector from above the undisturbed grade.
    2. Aluminum core laminated between polyethylene film.
    3. 6-inch-wide red tape imprinted with black lettering stating “CAUTION - BURIED ELECTRIC LINE BELOW”, or equivalent.

D. Duct seal:
    1. Non-hardening sealing compound.
    2. Flexible, can be applied by hand.
    3. UL Listed for use with installed conductors.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Duct banks:
   1. Encased in concrete at least 24 inches below finish grade, unless otherwise indicated on the Drawings.
   2. Damage minimization:
      a. Conduit should not be left exposed in an open trench longer than is necessary.
      b. Protect underground duct banks against damage during pouring of concrete or backfilling.
   3. Plastic conduit fittings to be joined should be exposed to the same temperature conditions for a reasonable length of time before assembly.
   4. Provide No. 4/0 American Wire Gauge bare copper ground wire the entire length of duct bank and bond to the grounding system at each end of the duct bank:
      a. Where duct bank terminates at structures with a grounding electrode, bond duct bank ground wire to the grounding electrode.
      b. Where duct bank terminates at electrical equipment, bond duct bank ground wire to the equipment ground bus.
      c. Where duct bank terminates at structure without either a grounding electrode or electrical equipment, provide ground rod adjacent to structure and bond duct bank ground wire to ground rod.
   5. Install underground ducts to be self-draining:
      a. Slope duct banks away from buildings to manholes, handholes, or pullboxes.
      b. Slope duct banks uniformly from manholes, handholes, or pullboxes to manholes, handholes, or pullboxes or both ways from high points between manholes, handholes, or pullboxes.
      c. Slope a minimum of 1/4 inch per 10 feet.
   6. Where new duct banks join to existing manholes, handholes, or pullboxes, make the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions, as indicated on the Drawings.
   7. Install pull line in spare conduits:
      a. Provide adequate pull line at both ends of conduits to facilitate conductor pulling.
      b. Cap above ground spare conduit risers at each end with screw-on conduit caps.

B. Trenching:
   1. Perform as specified in Section 31_23_35 - Trenching.
   2. Trench must be uniformly graded with the bottom rock free and covered with select material.
   3. Whenever possible, use the walls of the trench as forms for concrete encasement:
      a. Forms are required where the soil is not self-supporting.

4. Damage occurring to existing ducts, conduits, cables, and other utilities during duct bank installation shall be remediated to the satisfaction of the Owner.

C. Duct spacing:
   1. Separate conduits with manufactured plastic spacers using a minimum space between the outside surfaces of adjacent conduits of 2 inches, unless otherwise indicated on the Drawings.
   2. Install spacers to maintain uniform spacing of duct assembly a minimum of 4 inches above the bottom of the trench during concrete pour. Install spacers on 8-foot maximum intervals:
      a. Due to some distortion of conduit from heat, and other means, it may be necessary to install extra spacers within the duct bank:
         1) Install the intermediate set of spacers within normal required spacing to maintain the proper horizontal clearance:
            a) Clearance is required to allow the proper amount of concrete to infiltrate vertically among the duct to ensure proper protection.
   3. Spacers shall not be located at the center of a bend:
      a. Locate spacer in the tangent, free of the coupling on fabricated bends.
      b. Locate spacers midway between the tangent and the center bend on trench formed sweeps.

D. Terminating:
   1. Use bell ends in duct at entrances into cable vaults.
   2. Make conduit entrances into cable vaults tangential to walls of cable vault.
   3. Form trapezoidal transitions between duct bank and cable vaults as needed in order to ensure adequate cable bending radius for the duct bank-to-vault transition.
   4. Install duct seal in all conduits, including spare conduits, at both ends. Form by hand to conduit and around cables to develop moisture barrier.
   5. New manhole or handhole applications, provide a single opening or “window” per duct bank, sized to accommodate the duct bank envelope.

E. Concrete:
   1. Install concrete as specified in Section 03_30_01 - Concrete Work.
   2. Provide tie wires as specified in Section 03_30_01 - Concrete Work to prevent displacement of the conduits during pouring of concrete:
      a. Tie wire shall not act as a substitute for spacers.
   3. Install minimum 3-inch cover around conduit and rebar.
   4. Consolidation of encasement concrete around duct banks shall be by hand puddling. Mechanical vibrators are acceptable for use outside of the rebar cage.
   5. Conduit is subject to temperature rise. As concrete cures, allow the free end to expand by pouring the concrete from the center of the run or from one tie in point.

F. Marking tape:
   1. Install a detectable marking tape 12 inches above the duct bank the entire length of the duct bank.

G. Restore surfaces to their original condition as specified in Section 32_01_15 - Pavement Restoration and Rehabilitation unless otherwise specified.

3.04 FIELD QUALITY CONTROL (NOT USED)

3.05 ADJUSTING (NOT USED)

3.06 CLEANING

A. Clean conduits of dirt and debris by use of an appropriately sized steel mandrel no less than 1/2 inch smaller than the inside diameter of the conduit.

3.07 PROTECTION

A. Provide shoring and pumping to protect the excavation and safety of workers.

B. Protect excavations with barricades as required by applicable safety regulations.

END OF SECTION

SECTION 26_05_53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Identification of electrical equipment, devices and components.
   2. Material, manufacturing and installation requirements for identification devices.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

B. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).

C. Occupational Safety and Health Administration (OSHA).

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Product data:
   1. Nameplates:
      a. Color.
      b. Size:
         1) Outside dimensions.
         2) Lettering.
      c. Material.
      d. Mounting means.
   2. Nameplate schedule:
      a. Show exact wording for each nameplate.
      b. Include nameplate and letter sizes.
   3. Wire numbers:
      a. Manufacturer’s catalog data for wire labels and label printer.

C. Record documents:
    1. Update the conduit schedule to reflect the exact quantity of wire numbers, including spares and destination points for all wires.

1.05 QUALITY ASSURANCE (NOT USED)

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL

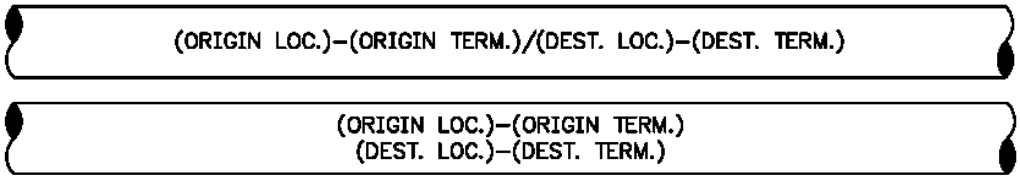
A. Nameplates:
    1. Provide for control panel operator devices (e.g., pushbuttons, selector switches, pilot lights, etc.):
        a. Same material and same color and appearance as the device nameplates to achieve an aesthetically consistent and coordinated system.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Nameplates:
    1. Provide for each piece of electrical equipment, device, control panel, and control panel components.
    2. Identical style, color, and material throughout the facility.
    3. Device nameplates information:
        a. Equipment tag number as indicated on the Drawings.

B. Wire numbers:
    1. Coordinate the wire numbering system with vendors of equipment so that every field wire has a unique number associated with it for the entire system:
        a. Correspond to the wire numbers on the control drawings or the panel and circuit numbers for receptacles and lighting.
        b. Correspond to the terminal block number to which they are attached in the control panel.
        c. Internal panel wires on a common terminal shall have the same wire number.
        d. Multi-conductor cables shall be assigned a cable number that shall be attached to the cable at intermediate pull boxes and stub-up locations beneath freestanding equipment. Multi-conductor and instrumentation cables shall be identified at pull points as described above:
            1) Label armored multi-conductor cable using the conduit number as indicated on the Drawings, following the requirements for conduit markers specified in Section 26_05_33 - Conduits.

2. Provide the following wiring numbering schemes throughout the Project for field wires between process control module (PCM), vendor control panels (VCP), motor control centers (MCC), field starters, field instruments, etc.



OR:

Where:

ORIGIN LOC. = Designation for originating panel or device

ORIGIN TERM. = Terminal designation at originating panel or device

DEST. LOC. = Designation for destination panel or device

DEST. TERM. = Terminal designation at destination panel or device or PLC

3. I/O address at destination panel:
   a. Identify equipment and field instruments as the origin.
   b. PCMs are always identified as the destination.
   c. Location is the panel designation for VCP, LCP, or PCM. For connections to MCCs, location is the specific starter tag and loop number. Location is the tag and loop number for motor starters, field instruments and equipment. Any hyphen in the panel designation or tag and loop number shall be omitted.
   d. Terminal designation is the actual number on the terminal block where the conductor terminates at field devices and vendor control panels. For multi-conductor cables, all terminal numbers shall be shown, separated by commas.
   e. Terminal designations at motor leads shall be the motor manufacturer's standard terminal designation (e.g., T1, T2, T3, etc.).
   f. Terminal designations at PCMs where the field conductor connects to field terminal blocks for a PLC input or output shall be the PLC address (Note: The following PLC I/O numbering scheme is typical for Allen-Bradley. The numbering scheme should be modified to match that of the actual PLC manufacturer used for the Project):

      Discrete Point: W:X:Y/Z.

      Analog Point: W:X:Y.Z.

      Where:

      W = I for input, O for output.

      X = PLC number (1, 2, 3…).

      Y = Slot number (01, 02, 03…).

      Z = Terminal number (00, 01, 02…) for a discrete point or a word number for an analog point (1, 2, 3…).

   g. Terminal designations at PCMs where the conductor does not connect to a PLC I/O point shall be the terminal number with a "C" prefix

(e.g., C0010). For common power after a fuse or neutrals after a switch, the subsequent points shall have and capital letter suffix starting with “A” (e.g., C0010A).

4. **Case 1**: Vendor control panel (VCP) to process control module (PCM):

   Field wire number/label: A-B/C-D:

   A = Vendor control panel number without hyphen (VCP#).

   B = Terminal number within VCP (manufacturer’s or vendor’s standard terminal number).

   C = Process control module number without hyphen (PCM#).

   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a “C” prefix if not connected directly to a PLC I/O point (C0010).

   Examples:

   VCP#-10/PCM#-I: 1:01/01.

   VCP#-10/PCM#-O: 1:10/07.

   VCP#-10/PCM#-C0100.

5. **Case 2**: Field instrument to process control module (PCM):

   Field wire number/label: E-F/C-D:

   C = Process control module number without hyphen (PCM#).

   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a “C” prefix if not connected directly to a PLC I/O point (C0010).

   E = Field mounted instrument tag and loop numbers without hyphen (EDV#).

   F = Manufacturer’s standard terminal number within instrument. Use both terminal numbers for analog points separated by a comma.

   Examples:

   TIT#-2,3/PCM#-I: 1:01.1.

   TSH#-1/PCM#-I: 2:01/00.

6. **Case 3**: Motor control center (MCC) to process control module (PCM):

   Field wire number/label: G-B/C-D:

   B = Terminal number within Motor Control Center (manufacturer’s or vendor’s standard terminal number).

   C = Process control module without hyphen (PCM#).

   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a “C” prefix if not connected directly to a PLC I/O point (C0010).

   G = Actual starter designation in the motor control center without hyphen (MMS#).

Examples:

MMS#-10/PCM#-I: 1:01/01.

MMS#-10/PCM#-O: 1:10/07.

MMS#-10/PCM#-C0100.

7. **Case 4**: Motor control center (MCC) to vendor control panel (VCP):

   Field wire number/label: G-B/A-B:

   A = Vendor control panel number without hyphen (VCP#).

   B = Terminal number within motor control center or vendor control panel (manufacturer's or vendors standard terminal number).

   G = Actual starter designation in the motor control center without hyphen (MMS#).

   Example:

   MMS#-X2/VCP#-10.

8. **Case 5**: Motor leads to a motor control center (MCC):

   Field wire number/label: H-I/G-B:

   B = Terminal number within motor control center (manufacturer's standard terminal number).

   G = Actual starter designation in the motor control center without hyphen (MMS#).

   H = Equipment tag and loop number without hyphen (PMP#).

   I = Motor manufacturer's standard motor lead identification (e.g., T1, T2, T3, etc.).

   Example:

   PMP-#-T3/MMS#-T3.

2.03 MANUFACTURERS

A. Nameplates and signs:
   1. One of the following or equal:
      a. Brady.
      b. Seton.

B. Conductor and cable markers:
   1. Heat-shrinkable tubing:
      a. One of the following or equal:
         1) Brady.
         2) Kroy.
         3) Panduit.
         4) Raychem.

C. Conduit and raceway markers:
   1. Non-metallic: One of the following or equal:
      a. Almetek: Mini Tags.
      b. Lapp Group: Maxi System.

2.04 MATERIALS

A. Nameplates:
   1. Colors:
      a. Warning: White-center, red face.
      b. Other: Black-center, white face.
   2. Laminated plastic engraving stock:
      a. 3/32-inch thick material.
      b. 2-ply.
   3. With chamfered edges.
   4. Lettering:
      a. Block style engraved characters of adequate size to be read easily from a distance of 6 feet.
      b. Minimum letter height: 1/8 inch.

B. Signs:
   1. Automatic equipment and high voltage signs:
      a. Suitable for exterior use.
      b. In accordance with OSHA regulations.

C. Conductor and cable markers:
   1. Lettering:
      a. Machine printed black characters on white tubing.
      b. Minimum letter height: 10-point type or larger.

D. Conduit and raceway markers:
   1. Non-metallic:
      a. UV resistant holder and letters.
      b. Black letters on yellow background.
      c. Minimum letter height: 1/4 inch.
      d. Adhesive labels are not acceptable.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Nameplates:
   1. Attach to equipment with rivets, bolts, or sheet metal screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment.

2. Provide for each disconnecting means with the following:
    a. Equipment served, voltage, and fuse size as required.
    b. Identification of the circuit source that supplies the disconnecting means.
3. Aligned and level or plumb to within 1/64 inch over the entire length:
    a. Misaligned or crooked nameplates shall be remounted or provide new enclosures at the discretion of the Engineer.

B. Conductor and cable markers:
1. Apply before termination.
2. Heat-shrinkable tubing:
    a. Shrunk using a heat gun that produces low temperature heated air.
    b. Tight on the wire after it has been heated.
    c. Characters shall face the open panel and shall read from left to right or top to bottom.
    d. Marker shall start within 1/32 inch of the end of the stripped insulation point.

C. Conduit markers:
1. Furnish and install markers for every conduit in the electrical system that is identified in the conduit schedule or part of the process system:
    a. Markings shall match the conduit schedule.
2. Mark conduits at the following locations:
    a. Each end of conduits that are greater than 10 feet in length.
    b. The middle of conduits that are 10 feet or less in length.
    c. Where the conduit penetrates a wall, structure, manhole, or handhole.
        1) Marker shall be non-metallic with stainless steel hardware.
    d. Where the conduit emerges from the ground, slab, etc.
3. Mark conduits after the conduits have been fully painted.
4. Position conduit markers so that they are easily read from the floor.
5. Attach non-metallic conduit markers with nylon cable ties:
    a. Provide ultraviolet resistant cable ties for conduit markers exposed to direct sunlight.
6. Mark conduits before construction review by the Engineer for punch list purposes.
7. Label intrinsically safe conduits in accordance with the requirements of the NEC.

D. Signs and labeling:
1. Furnish and install permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
    a. Fasten warning signs with round head stainless steel screws or bolts.
    b. Locate and mount in a manner to be clearly legible to operations personnel.
2. Furnish and install permanent and conspicuous warning signs on equipment (front and back), doorways to equipment rooms, pull boxes, manholes, etc., where the voltage exceeds 600 volts.
3. Furnish and install warning signs on equipment that has more than one source of power:
    a. Warning signs to identify every panel and circuit number of the disconnecting means of external power sources.

4. Place warning signs on equipment that has 120 VAC control voltage source used for interlocking:
    a. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.
5. Label MCCs, panelboards, and transfer switches with the available short circuit current, equipment label, and date of application in accordance with NEC.

3.04 FIELD QUALITY CONTROL

A. Replace any nameplates, signs, conductor markers, cable markers, or raceway labels that in the sole opinion of the Engineer do not meet the Engineer's aesthetic requirements.

END OF SECTION

SECTION 26_05_74

ELECTRICAL SYSTEM STUDIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Short-circuit fault analysis studies.
   2. Protective device coordination study.
   3. Arc-flash hazard study.

1.02 REFERENCES

A. American National Standards Institute (ANSI).

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. 1584 - IEEE Guide for Performing Arc-Flash Hazard Calculations.

C. National Fire Protection Association (NFPA):
   1. 70E - Standard for Electrical Safety in the Workplace.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Modified: Equipment with load additions or with loads being removed that affect fault current, include new overcurrent protective devices that require settings and device coordination, or require additional/removal/replacement of arc flash labels.

1.04 DELEGATED DESIGN

A. As specified in Section 01_35_73 - Delegated Design Procedures.

B. Signed and sealed electrical system study reports.

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Credentials of the individual(s) performing the study and the individual in responsible charge of the study.

C. General:
   1. Format and quantity:
      a. 6 bound copies of all final reports.
      b. 3 complete sets of electronic files on USB media, including the electrical system model(s), configuration files, custom libraries, and any other files

used to perform the studies and produce the reports. Also provide an electronic version of the bound reports in PDF format.

2. One-line diagrams:
    a. The following information shall be included at a minimum:
        1) Motor horsepower.
        2) Transformer data:
            a) kVA.
            b) Configuration.
        3) Cable data:
            a) Insulation.
            b) Size.
            c) Length.
    b. Fully legible at 11-inch by 17-inch size.

D. Initial short-circuit fault analysis:
    1. Based on the Contract Documents and electric utility information.
    2. Include a description of all operating scenarios.
    3. One-line diagrams.
    4. Indicate the estimated available short-circuit current at the line side terminals of each piece of equipment covered by the scope of the study.
        a. Measure conductor lengths from the Drawings. Use of arbitrary short conductor lengths is not allowed.
        b. Provide a list of assumptions used in the initial study.

E. Delegated Design final studies and reports:
    1. Include the following sections at a minimum:
        a. Copies of correspondence and data obtained from the electric utility company.
        b. Letter certifying the inspection and verification of existing equipment and incorporation of applicable RFI's and change orders.
        c. Short-circuit fault analysis:
            1) Modify the initial short-circuit fault analysis as follows:
                a) Utilize the actual equipment provided on the project.
                b) Utilize conductor lengths based on installation.
                c) Update one-line diagrams to show as-built conditions.
            2) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
            3) Normal system connections and those that result in maximum fault conditions.
            4) Tabulation of circuit breaker, fuse, and other protective device ratings compared to maximum calculated short-circuit duties.
            5) Fault current calculations for the cases run including a definition of terms and guide for interpretation of computer software printouts.
        d. Protective device coordination study shall include:
            1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
            2) List requirements used in the selection and setting criteria for any protective devices.
            3) Manufacturer's time-current curves for circuit breakers, fuses, motor circuit protectors, and other protective devices for new equipment.

4) TCCs graphically indicating the coordination proposed for the system on log-log graphs:
   a) All TCCs shall be in color.
5) Tabulation of relay, fuse, circuit breaker, and other protective devices in graphical form with a one-line diagram to display area coordination.
6) Where coordination could not be achieved, an explanation shall be included in the report to support the statement along with recommendations to improve coordination. Recommended equipment modifications or settings shall be in a tabulated form.
7) Protective device settings in a tabulated format.

e. Include in the arc-flash hazard study:
   1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
   2) Normal system connections and those that result in maximum arc-flash conditions.
   3) Arc-flash raw data, calculations, and assumptions.

f. Form and format of arc-flash labels.
   1) Label data:
      a) Identifying the content of each label.
      b) Identifying the location of each label.

F. Submit course outline for Owner Training.

1.06 QUALITY ASSURANCE

A. Qualifications of the entity responsible for electrical system studies:
   1. A minimum of 5 years of experience in power system analysis is required for the individual in responsible charge of the studies.
   2. Short-circuit fault analysis, protective device coordination, and arc-flash hazard studies shall be performed with the aid of a digital computer program:
      a. Point-to-point calculations are not acceptable.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. The individual performing the studies shall visit the site and collect necessary field data in order to perform and complete comprehensive electrical system studies.
   2. Obtain, for all equipment, the required data for preparation of the study, including, but not limited to:
      a. Transformer kilovolt-ampere (kVA), nameplate data, and impedances.
      b. Generator impedances, kilovolt-ampere (kVA), and voltage.
      c. Generator decrement curves.
      d. Bus withstand ratings.
      e. Cable and bus data.
      f. Protective device taps, time dials, instantaneous pickups, and time-delay settings.

g. As-built lengths for new wire and cable installations covered by the studies.
h. Grounding schemes (solidly grounded or resistive grounded).

3. Obtain the electric utility information on the minimum and maximum available fault current, minimum and maximum utility impedances, utility protective device settings including manufacturer and model number, interrupting ratings, X/R ratios, and model information one level above the point of connection:
   a. Utility tolerances and voltage variations.
   b. Coordinate with the utility for changes to their protective devices and settings to achieve a coordinated system between the utility and the Owner.
4. Obtain equipment layouts and configurations from the manufacturer's final Submittal requirements and Project layout drawings as required.
5. Bus and conductor data:
   a. Use impedances of the actual installed or specified conductors, unless otherwise indicated.
   b. Use cable and bus impedances calculated at 25 degrees Celsius, unless otherwise indicated.
   c. Use 600-volt cable reactance based on typical dimensions of actual installed or specified conductors, unless otherwise indicated.
   d. Use bus withstand values for all equipment having buses.

B. Use medium-voltage cable reactance based on typical dimensions of shielded cables with 133 percent insulation levels, unless otherwise indicated.

C. Certification:
1. Submit written certification signed by the professional engineer conducting the study, equipment supplier, and electrical subcontractor, stating that the data used in the study is correct and captures all RFIs, as-builts, and change orders affecting the study.

D. Meetings:
1. Electrical system study meetings:
   a. As specified in Section 01 31 19 - Project Meetings.
   b. The individual conducting the electrical system studies leads the meeting.
   c. Meet with the Owner and Engineer 3 times.
   d. First meeting:
      1) Discuss the scope of the studies.
      2) Confirm electrical system operating modes.
      3) Confirm assumptions to be used in the electrical system study with the Owner, including, but not limited to:
         a) Maximum protective device fault clearing time.
      4) Discuss the Owner's operational requirements for both normal operation and maintenance.
   e. Second meeting:
      1) Inform the Owner of the results of the study and impacts on normal operation and maintenance including:
         a) Protective device coordination problems and recommended solutions.

b) Explanation of the arc-flash hazard study results and its potential impact on operations.
c) Recommendations for reduction of arc-flash category levels including reduction of protective device settings or changes in operational practices.

f. Final meeting:
1) Prior to substantial completion.
2) Discuss changes to the studies based on the previous meeting.
3) Discuss with the Owner how changes to the electrical system may change the arc-flash hazard category.

E. Sequencing:
1. Below is an outline of the typical work sequence. Proposed changes to the work sequence may be reviewed and approved by the Engineer.
a. First system study meeting.
b. Submit the initial short-circuit fault analysis study before submittal of any electrical equipment.
1) Only the initial short-circuit results will be reviewed.
c. Site visit to gather data on the existing facility systems for all studies:
1) Make multiple trips as required to obtain data for the short-circuit fault analysis, protection device coordination, and arc flash hazard studies.
d. Submit the preliminary short-circuit fault analysis, protective device coordination, and arc-flash hazard studies after the approval of all electrical equipment.
e. Second system study meeting for preliminary results.
f. Update the model with changes to the electrical system made during start-up and commissioning.
g. Final system study meeting.
h. Submit the final electrical system studies.
i. Label equipment with approved arc-flash labels.
j. Owner Training.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. General study requirements:
1. Scope:
a. Short-circuit fault analysis, protective device coordination, and arc-flash hazard studies shall include all new and modified equipment in the power distribution system, including, but not limited to:
1) Utility equipment (utility transformer and primary protective device).
2) Available utility fault contribution current.
3) All electrical equipment including:
a) Dry-type transformers.
b) 240- and 208-volt panelboards.
4) Generators.

5) Motors.
6) Vendor control panels.
7) HVAC equipment.

b. Study scenarios:
1) Include all possible electrical system configurations, for example:
a) Operation on normal (utility) source.
b) Operation on generator source.
c) Main-breakers closed; tie-breaker open.
d) Either main-breaker open; tie-breaker closed.

2. Motors:
a. Each motor shall be individually modeled:
1) Grouping of motors for fault contribution current is not acceptable.
b. Motors with variable frequency drives (VFDs) may be assumed to have no contribution to fault current, unless VFDs are equipped with bypass contactors.
3. Use the equipment, bus, and device designations as indicated on the Drawings for all studies.

B. Short-circuit fault analysis study additional requirements:
1. Calculate 3-phase bolted fault, line-to-line fault, line-to-ground fault, double line-to-ground fault, short-circuit 1/2 cycle momentary symmetrical and asymmetrical RMS, 1-1/2 to 4 cycle interrupting symmetrical RMS, and 30-cycle steady-state short-circuit current values at each piece of equipment in the distribution system.
2. Evaluate bus bracing, short-circuit ratings, fuse interrupting capacity and circuit-breaker-adjusted interrupting capacities against the fault currents, and calculate X/R values:
a. Identify and document all devices and equipment as either inadequate or acceptable.
3. Calculate line-to-ground and double line-to-ground momentary short-circuit values at buses having ground-fault devices.
4. Provide calculation methods, assumptions, one-line diagrams, and source impedance data, including utility X/R ratios, typical values, recommendations, and areas of concern.

C. Protective device coordination study additional requirements:
1. Furnish protective device settings for functions indicated on the Drawings, including, but not limited to:
a. Current.
b. Machine protection functions:
1) Provide settings for motor and generator protective relays based on the manufacturer’s recommended protection requirements.
2. Provide log-log form time-current curves (TCCs) graphically indicating the coordination proposed for the system:
a. Include with each TCC a complete title and one-line diagram with legend identifying the specific portion of the system covered by the particular TCC:
1) Typical TCCs for identical portions of the system, such as motor circuits, are acceptable as allowed by the Engineer.
b. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics:
1) These details can be included on the TCC.

c. Include a detailed description of each protective device tap, time dial, pickup, instantaneous, and time delay settings:
    1) These details can be included on the TCC.

3. TCCs shall include all equipment in the power distribution system where required to demonstrate coordination. Include utility relay and fuse characteristics, medium-voltage equipment protective relay and fuse characteristics, low-voltage equipment circuit breaker trip device characteristics, transformer characteristics, motor and generator characteristics, and characteristics of other system load protective devices:
    a. Include devices down to the largest branch circuit and largest feeder circuit breaker in each motor control center, main breaker in branch panelboards, and fused disconnect switches.
    b. Provide ground fault TCCs with adjustable settings for ground fault protective devices.
    c. Include manufacturing tolerances and damage bands in plotted fuse and circuit breaker characteristics.
    d. On the TCCs, show transformer full load currents, transformer magnetizing inrush, ANSI transformer withstand parameters, and transformer damage curves.
    e. Cable damage curves.
    f. Terminate device characteristic curves at a point reflecting the maximum symmetrical or asymmetrical fault current to which the device is exposed based on the short-circuit fault analysis study.
    g. Coordinate time interval medium-voltage relay characteristics with upstream and downstream devices to avoid nuisance tripping.
4. Site generation: When site generation (including cogeneration, standby, and emergency generators) is part of the electrical system, include phase and ground coordination of the generator protective devices:
    a. Show the generator decrement curve and damage curve along with the operating characteristic of the protective devices.
5. Suggest modifications or additions to equipment rating or settings in a tabulated form.

D. Arc-flash hazard study additional requirements:
1. Include the calculated arc-flash boundary and incident energy (calories/square centimeter) at each piece of equipment in the distribution system:
    a. Perform study with 15 percent arcing fault variation in accordance with IEEE 1584.
    b. Perform arc-flash calculations at minimum and maximum fault contributions.
    c. Perform arc-flash calculations for both the line side and load side of the switchgear, switchboard, motor control center, and panelboard main breakers.
    d. Perform arc-flash calculations for short-circuit scenarios with all motors on for 3 to 5 cycles and with all motors off.
2. Provide executive summary of the study results:
    a. Provide summary based upon worst case results.
3. Provide a detailed written discussion and explanation of the tabulated outputs:
    a. Include all scenarios.

4. Provide alternative device settings to allow the Owner to select the desired functionality of the system:
    a. Minimize the arc-flash energy by selective trip and time settings for equipment maintenance purposes.
    b. Identify the arc-flash energy based upon the criteria of maintaining coordination and selectivity of the protective devices.

2.03 MANUFACTURERS

A. Electrical system study software: One of the following or equal:
    1. Operation Technology, Inc., ETAP.
    2. SKM Systems Analysis, Powertools.

2.04 EXISTING PRODUCTS (NOT USED)

2.05 MATERIALS (NOT USED)

2.06 MANUFACTURED UNITS (NOT USED)

2.07 EQUIPMENT (NOT USED)

2.08 COMPONENTS

A. Arc-flash hazard labels:
    1. Dimensions:
        a. Minimum 5 inches by 3.5 inches.
    2. Materials:
        a. Polyester with polyvinyl polymer over-laminate.
        b. Self-adhesive.
        c. Resistant to:
            1) UV.
            2) Chemicals and common cleaning solvents.
            3) Scuffing.
            4) Wide temperature changes.
    3. Contents:
        a. Short-circuit bus identification.
        b. Calculated incident energy (calories/square centimeter) range:
            1) Based on worst-case study results.
        c. Arc-flash protection boundary.
        d. Shock hazard boundary:
            1) Contractor may provide separate labels for indication of the shock hazard boundary.
        e. Fed from:
            1) Identify the tag number of the upstream equipment providing power.
    4. Color scheme:
        a. For locations above 40 calories/square centimeter:
            1) White label with red “DANGER” strip across the top.
            2) Black lettering.
        b. For locations below 40 calories/square centimeter:
            1) White label with orange “WARNING” strip across the top.
            2) Black lettering.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. After review and acceptance of the arc-flash hazard study by the Engineer, install arc-flash hazard labels:
   1. At all locations required by NFPA, ANSI, or IEEE standards.
   2. At a minimum, in the following locations:
      a. Front of each accessible auxiliary or conductor compartment.
      b. Each accessible rear or side vertical section.
      c. Each motor control center vertical section.
      d. Each panelboard covered by the study.
      e. Each control panel, individual starter or VFD, or other equipment covered by the scope of the study.

3.04 OWNER TRAINING

A. Including, but not limited to:
   1. Introduction and basics of NFPA 70E: 2 hours 2 sessions.
   2. Detailed review of the electrical system study: 2 hours 1 session.

3.05 FIELD QUALITY CONTROL

A. Individual performing the arc-flash hazard study shall direct the installation of the arc-flash hazard labels:
   1. Remove and replace any improperly applied labels.
   2. Repair the equipment finish damaged by removal of any label.
   3. Install labels level or plumb across the entire dimension of the label.

3.06 ADJUSTING

A. After review and acceptance of the draft arc-flash hazard study and protective device coordination study by the Engineer, adjust protective device settings in accordance with final study prior to equipment energization.
   1. Devices that require power for configuration may be set during energization, but before any subfed loads are energized.
   2. Ensure that settings for upstream equipment are set prior to energizing downstream devices. Provide documentation that protective devices are set in accordance with the study recommendation.

END OF SECTION

SECTION 26_08_50

FIELD ELECTRICAL ACCEPTANCE TESTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Responsibilities for testing the electrical installation.
   2. Adjusting and calibration.
   3. Acceptance tests.

B. Copyright information:
   1. Some portions of this Section are copyrighted by the InterNational Electrical Testing Association, Inc. (NETA). See NETA publication ATS for details.

1.02 REFERENCES

A. Project references:
   1. Specification sections for the electrical equipment being tested.
   2. Electrical equipment Shop Drawings.

B. Standards:
   1. American National Standards Institute (ANSI).
   2. ASTM International (ASTM).
   3. Institute of Electrical and Electronics Engineers (IEEE):
      a. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
      b. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
      c. C57.13 - IEEE Standard Requirements for Instrument Transformers.
      d. C57.13.1 - IEEE Guide for Field Testing of Relaying Current Transformers.
      e. C57.13.3 - IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases.
   4. Insulated Cable Engineer's Association (ICEA).
   5. InterNational Electrical Testing Association (NETA).
      a. ATS - Standard for Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.
   6. International Electrotechnical Commission (IEC).
   7. National Electrical Manufacturers Association (NEMA):
      a. MG1 - Motors and Generators.
   8. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code (NEC).
      b. 110 - Standard for Emergency and Standby Power Systems.
   9. National Institute of Standards and Technology (NIST).

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning:
   1. Testing laboratory: Organization performing the acceptance tests.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Copper Ethernet test form:
   1. Cable test reports:
      a. Submit 3 copies of test reports showing the results of all tests specified in this Section:
         1) Test type.
         2) Test location.
         3) Test date.
         4) Cable number.
         5) Cable length.
         6) Certification that the cable meets or exceeds the specified standard.
      b. Furnish hard copy and electronic copy for all traces.

C. Manufacturers' testing procedures:
   1. Submit manufacturers' recommended testing procedures and acceptable test results for review by the Engineer prior to beginning testing.

D. Test report:
   1. Include the following:
      a. Summary of Project.
      b. Description of equipment tested.
      c. Description of tests performed.
      d. Test results.
      e. Conclusions and recommendations.
      f. Completed test forms.
      g. List of test equipment used and calibration dates.
      h. LAN cable test reports.

E. Test data records:
   1. Include the following:
      a. Identification of the testing organization.
      b. Equipment identification.
      c. Nameplate data.
      d. Humidity, temperature, and/or other conditions that may affect the results of the tests and or calibrations.
      e. Dates of inspections, tests, maintenance and or calibrations.
      f. Indication of the inspections, tests, maintenance, and or calibrations to be performed and recorded.
      g. Expected results when calibrations are to be performed.

h. Indication of as-found and as-left results as applicable.
i. Indication of test results outside specified tolerances.

F. Testing laboratory qualifications:
1. Submit a complete resume and statement of qualifications from the proposed testing laboratory detailing their experiences in performing the tests specified:
a. This statement will be used to determine whether the laboratory is acceptable, and shall include:
1) Corporate history and references.
2) Resume of individual performing test.
3) Equipment list and test calibration data.

G. Division of responsibilities:
1. Submit a list identifying who is responsible for performing each portion of the testing.

1.06 QUALITY ASSURANCE

A. Testing laboratory qualifications:
1. May be qualified testing personnel from the electrical subcontractor's staff or an independent testing company.
2. NETA certification required.
3. Selection of the testing laboratory and testing personnel is subject to approval by the Engineer based on testing experience and certifications of the individuals and testing capabilities of the organization.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.09 ADMINISTRATIVE REQUIREMENTS

A. General requirements:
1. Testing of electrical equipment installed under this Contract in accordance with the manufacturer's requirements and as specified in this Section.
2. Conduct tests in the presence of the Engineer or the Engineer's representative:
a. Engineer will witness visual, mechanical, and electrical tests, and inspections.
3. Testing and inspections shall verify that the equipment is operational within the tolerances required and expected by the manufacturer, and these Specifications.

B. Responsibilities:
1. Contractor responsibilities:
a. Ensure that resources are made available for testing and that testing requirements are met.
2. Electrical subcontractor responsibilities:
a. Perform routine tests during installation.
b. Demonstrate operation of electrical equipment.

c. Commission the electrical installation.
d. Provide the necessary services during testing, and provide these services to the testing laboratory, Contractor, and other subcontractors, including, but not limited to:
1) Providing electrical power as required.
2) Operating of electrical equipment in conjunction with testing of other equipment.
3) Activating and shutting down electrical circuits.
4) Making and recording electrical measurements.
5) Replacing blown fuses.
6) Installing temporary jumpers.

3. Testing laboratory responsibilities:
a. Perform acceptance tests specified in this Section.
b. Provide required equipment, materials, labor, and technical support during acceptance tests.

C. Sequencing:
1. Prior to testing:
a. At least 30 days before commencement of the acceptance tests, submit the manufacturer's complete field testing procedures to the Engineer and to the testing laboratory, complete with expected test results and tolerances for equipment to be tested.
2. Perform testing in the following sequence:
a. Perform routine tests as the equipment is installed including:
1) Insulation-resistance tests.
2) Continuity tests.
3) Rotational tests.
b. Adjusting and preliminary calibration.
c. Acceptance tests.
d. Demonstration.
e. Commissioning and plant start-up.

1.10 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

A. Test instrument calibration:
1. Utilize a testing laboratory with a calibration program which maintains applicable test instrumentation within rated accuracy:
a. Calibrating standard shall be of better accuracy than that of the equipment tested.

2. Accuracy shall be traceable to the NIST in an unbroken chain.
3. Calibrate instruments in accordance with the following frequency schedule:
    a. Field instruments: 6 months maximum.
    b. Laboratory instruments: 12 months maximum.
    c. Leased specialty equipment where the accuracy is guaranteed by the lessor (such as Doble): 12 months maximum.
4. Dated calibration labels shall be visible on test equipment.
5. Maintain an up-to-date instrument calibration record for each test instrument:
    a. Records shall show the date and results of each calibration or test.
6. Maintain an up-to-date instrument calibration instruction and procedure for each test instrument.

B. Requirements prior to testing:
1. Do not begin testing until the following conditions have been met:
    a. Instruments required are available and in proper operating condition.
    b. Required dispensable materials such as solvents, rags, and brushes are available.
    c. Equipment handling devices such as cranes, vehicles, chain falls, and other lifting equipment are available or scheduled.
    d. Instruction books, calibration curves, or other printed material to cover the electrical devices are available.
    e. Datasheets to record test results are available.

3.03 INSTALLATION

A. Test decal:
1. Testing laboratory shall affix a test decal on the exterior of equipment or equipment enclosure of protective devices after performing electrical tests.
2. Color coded to communicate the condition of maintenance of the protective. Color scheme for condition of maintenance of overcurrent protective devices shall be:
    a. White: Electrically and mechanically acceptable.
    b. Yellow: Minor deficiency not affecting fault detection and operation, but minor electrical or mechanical condition exists.
3. Shall include the following information at a minimum:
    a. Testing organization.
    b. Project identifier.
    c. Test date.
    d. Technician identifier.

3.04 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training.

B. Functional Testing:
1. Also called Field Acceptance Testing.

C. Panelboards:
   1. Cleaning:
      a. Visually inspect panelboard for evidence of discoloration, abnormal dust accumulation, metal shards, or any other indication of overheating, wear, or other abnormal conditions prior to cleaning.
      b. Clean cabinet with a brush, vacuum cleaner, or clean, dry, lint-free rags to remove any accumulation of dust, dirt, or other foreign matter. Do not use liquids, solvents or detergents when cleaning panelboards or components.
      c. Avoid blowing dust into panelboards. Do not use a blower or compressed air.
      d. Clean supports, terminals, and other major insulating surfaces with clean, dry, lint-free rags or soft bristled brushes.
      e. Remove dust, soot, grease, moisture, and foreign material from surface of circuit breakers.
   2. General:
      a. Compare equipment nameplate data with the Contract Documents.
      b. Check panelboard circuit schedule for accuracy.
      c. Verify appropriate anchorage, required area clearances, and correct alignment.
      d. Inspect overall general condition for physical damage:
         1) Check for broken studs and loose or damaged wires, connector, terminations, etc.
         2) Check bolts, nuts, washer, and pins for tightness.
         3) Tighten or use manufacturer's replacement parts as required.
      e. Inspect cabinets for signs of rust, corrosion, or deteriorating paint. Inspect cabinets for evidence of localized heat damage to the paint. Investigate sources of heat. Repair painted surfaces.
      f. Check that covers are in place and fastened. Plug any open unused knockouts.
      g. Inspect panelboard for moisture. Seal off any cracks or openings which have allowed moisture to enter the cabinet. Inspect component devices. Replace any components that show evidence of damage from moisture.
      h. Look for any recent changes in sprinklers or other plumbing that might expose indoor panelboards to a source of liquids. Eliminate sources of water, moisture, or liquids, or provide adequate barriers to protect panelboards from sources of water, moisture, or liquids.
      i. Inspect panelboards and internal components for evidence of overheating, arc spatter, sooty deposits, and tracking:
         1) Investigate and correct sources of arcing or overheating.
         2) Consult the panelboard manufacturer for recommendations.
      j. Verify that fuse and/or circuit breaker sizes and types correspond to record drawings, if available, as well as to the circuit breakers' address for microprocessor communications packages, if equipped.
      k. Set adjustable circuit breakers in accordance with engineering coordination study supplied by the Contractor.

3. Terminations, connections, and lugs:
    a. Inspect bolted electrical connections for high resistance using one of the following methods:
        1) Use of low-resistance ohmmeter:
            a) Compare bolted connection resistance values to values of similar connections:
                (1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
        2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
            a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
    b. Inspect terminations, connection, and lugs for alignment, physical damage, burns, corrosion, discoloration, flaking, heat damage, arcing, pitting, melting, deterioration, carbonization, cracks, chips, breaks, partial discharge, or moisture. Investigate and eliminate sources of any damage.
    c. Follow manufacturer recommendations for cleaning, repairing, and replacing damaged parts.
    d. Replace overheated connections. Tighten connections to proper torque levels as specified above.
4. Conductors and raceways:
    a. Inspect supply conductors and terminations for overheating, discoloration, and oxidation. Investigate and correct any deficiencies.
    b. Ensure the conductors are protected within their ampacities.
    c. Visually check panelboard, cables, and raceways for proper bonding and grounding. Correct improper bonding and grounding.
    d. Inspect conductors for discoloration, arcing, pitting, melting, flaking of insulation and/or metal parts. Repair or replace damaged components in accordance with the manufacturer's recommendations.
    e. Inspect for frayed or broken wires. Replace or repair damaged components in accordance with manufacturer recommendations.
    f. Inspect for frayed or broken wires. Replace or repair conductors as necessary.
    g. Inspect conduits for moisture. Seal conduits which are a source of moisture and provide means to drain moisture away from the panelboard.
5. Circuit breakers:
    a. Perform visual and mechanical inspection as specified in this Section.
    b. Operate several times in order to exercise the mechanisms and the contacts, and to ensure smooth operation. Do not oil or grease parts of molded case circuit breakers.
    c. Visually check for evidence of overheating and thermal damage. Investigate and eliminate sources of overheating.
    d. Check for visual defects, chipping, cracks, breaks, burns, and deterioration. Replace damaged circuit breakers.
    e. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and anti-pump function.
    f. Inspect interchangeable trip-unit circuit breakers for tightness of trip units.
    g. Check terminals and connections for tightness as specified above.
    h. Breakers rated 100 A and higher:
        1) Perform electrical tests as specified in this Section.

D. Dry type transformers:
    1. Visual and mechanical inspection:
        a. Compare equipment nameplate data with the Contract Documents.
        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. Inspect equipment for cleanliness.
        f. 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 the calibrated torque wrench method:
                a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
        g. Verify that as-left tap connections are as specified.
    2. Electrical tests:
        a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
        b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground:
            1) Apply voltage in accordance with the manufacturer's published data.
                a) Refer to NETA ATS tables in the absence of the manufacturer's published data.
        c. Calculate dielectric absorption ration or polarization index.
        d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral after energization and before loading.
    3. Test values:
        a. Compare bolted connection resistance values to values of similar connections:
            1) 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 the manufacturer's published data:
            1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
        c. Tap connections are left as found unless otherwise specified.
        d. Minimum insulation-resistance values of transformer insulation shall be in accordance with the manufacturer's published data:
            1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
            2) Investigate insulation values less than the allowable minimum.
        e. Dielectric absorption ratio or polarization index shall not be less than 1.0.
        f. Turns-ratio results should not deviate more than 1/2 percent from either the adjacent coils or calculated ratio.
        g. Phase-to-phase and phase-to-neutral secondary voltages shall be in agreement with nameplate data.

E. Low voltage cables, 600 volt maximum:
    1. Visual and mechanical inspection:
        a. Compare cable data with the Drawings and Specifications.

b. Inspect exposed sections of cable for physical damage and correct connection as indicated on the Drawings.
c. Inspect bolted electrical connections for high resistance by one of the following methods:
    1) Use of low-resistance ohmmeter.
    2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
        a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
d. Inspect compression applied connectors for correct cable match and indentation.
e. Inspect for correct identification and arrangement.
f. Inspect cable jacket insulation and condition.

2. Electrical tests:
    a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    b. Perform insulation resistance test on each conductor sized #8 AWG or larger with respect to ground and adjacent conductors:
        1) Applied potential shall be 500 volts DC for 300-volt rated cable and 1,000 volts DC for 600-volt rated cable.
        2) Test duration shall be 1 minute.
    c. Perform continuity tests on power and control conductors to ensure correct cable connection.
    d. Verify uniform resistance of parallel conductors.
3. Test values:
    a. Compare bolted connection resistance values to values of similar connections:
        1) 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 the manufacturer's published data:
        1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
        2) Investigate values of insulation-resistance less than the allowable minimum.
    c. Cable shall exhibit continuity.
    d. Deviations in resistance between parallel conductors shall be investigated.

F. Low voltage molded case and insulated case circuit breakers:
1. Visual and mechanical inspection:
    a. Compare equipment nameplate data with the Contract Documents.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage and alignment.
    d. Verify the unit is clean.
    e. Operate the circuit breaker to ensure smooth operation.
    f. Inspect bolted electrical connections for high resistance by one of the following methods:
        1) Use of low-resistance ohmmeter.

2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

g. 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. For breakers 100 A and higher:
1) Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed and across each open pole:
a) Apply voltage in accordance with the manufacturer's published data.
b) Refer to NETA ATS tables in the absence of the manufacturer's published data.
2) Perform a contact/pole-resistance test.
3) Determine long-time pickup and delay by primary current injection.
4) Determine short-time pickup and delay by primary current injection.
5) Determine ground-fault pickup and delay by primary current injection.
6) Determine instantaneous pickup value by primary current injection.
7) Perform minimum pickup voltage tests on shunt trip and close coils in accordance with the manufacturer's published data.
8) 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:
a) Reset trip logs and indicators.
9) Verify operation of charging mechanism.

3. Test values:
a. Compare bolted connection resistance values to values of similar connections:
1) 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 the manufacturer's published data:
1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
c. Insulation-resistance values shall be in accordance with the manufacturer's published data:
1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
2) Investigate values of insulation-resistance less than the allowable minimum.
d. Microhm or DC millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:
1) If the manufacturer's data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.

e. Long-time pickup values shall be as specified, and the trip characteristic shall not exceed the manufacturer's published time-current characteristic tolerance band including adjustment factors:
    1) If the manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS tables.
f. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed the manufacturer's published time-current tolerance band.
g. Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed the manufacturer's published time-current tolerance band.
h. Instantaneous pickup values shall be as specified and within the manufacturer's published tolerances:
    1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
i. Pickup values and trip characteristics shall be within the manufacturer's published tolerances.
j. Determine energy reducing maintenance switch pickup value by primary current injection.
k. Breaker open, close, trip, trip-free, anti-pump, and auxiliary features shall function as designed.
l. Charging mechanism shall operate in accordance with the manufacturer's published data.

G. Grounding systems:
1. Visual and mechanical inspection:
    a. Inspect ground system for compliance with the Contract Documents and the NEC.
    b. Inspect physical and mechanical condition.
    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:
            a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
    d. Inspect anchorage.
2. Electrical tests:
    a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    b. Perform fall of potential test or alternative test in accordance with 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 major electrical equipment frames, the system neutral and any derived neutral points.
3. Test values:
    a. Grounding system, electrical, and mechanical connections shall be free of corrosion.
    b. Compare bolted connection resistance values to values of similar connections:
        1) 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 the manufacturer's published data:
    1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
d. Resistance between the main grounding electrode and ground shall be as specified in Section 26_05_26 - Grounding and Bonding.
e. Investigate point-to-point resistance values that exceed 0.5 ohm.

H. Rotating machinery, AC induction motors:
1. Visual and mechanical inspection:
    a. Compare equipment nameplate information with the Contract Documents.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage, alignment, and grounding.
    d. Inspect air baffles, filter media, cooling fans, slip rings, brushes, and brush rigging.
    e. 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:
            a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
    f. Manually rotate the rotor and check for problems with the bearings or shaft.
    g. Rotating equipment:
        1) Operate at rated design load conditions.
        2) Confirm that equipment is properly assembled.
        3) Confirm the equipment moves or rotates in the proper direction.
        4) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
        5) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
    h. Verify correct application of appropriate lubrication and lubrication systems.
2. Electrical tests - AC induction:
    a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    b. Perform insulation-resistance test in accordance with IEEE 43:
        1) On motors 200 horsepower and smaller, test duration shall be 1 minute. Calculate dielectric absorption ratio for 60/30-second periods.
    c. Perform insulation-resistance test on insulated bearings in accordance with the manufacturer's published data.
    d. Test surge protection devices as specified in this Section.
    e. Test motor starter as specified in this Section.
    f. Verify operation of motor space heater, if applicable.
3. Test values:
    a. Inspection:
        1) Air baffles shall be clean and installed in accordance with the manufacturer's published data.
        2) Filter media shall be clean and installed in accordance with the manufacturer's published data.
        3) Cooling fans shall operate.

4) Slip ring alignment shall be within the manufacturer's published tolerances.
5) Brush alignment shall be within the manufacturer's published tolerances.
6) Brush rigging shall be within the manufacturer's published tolerances.

b. Compare bolted connection resistance values to values of similar connections:
1) 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 the manufacturer's published data:
1) Refer to NETA ATS tables in the absence of the manufacturer's published data.

d. Airgap spacing and machine alignment shall be in accordance with the manufacturer's published data.

e. Recommended minimum insulation-resistance ($IR_{1\ min}$) test results in megohms shall be in accordance with NETA ATS tables.
1) Polarization index value shall not be less than 2.0.
2) Dielectric absorption ratio shall not be less than 1.4.

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 test specimen is considered to have passed the test.

g. Investigate phase-to-phase stator resistance values that deviate by more than 5 percent.

h. Power factor or dissipation factor values shall be compared to the manufacturer's published data:
1) In the absence of the manufacturer's published data, compare values of similar machines.

i. Tip-up values shall indicate no significant increase in power factor.

j. If no evidence of distress, insulation failure, or waveform nesting is observed by the end of the total time of voltage application during the surge comparison test, the test specimen is considered to have passed the test.

k. Bearing insulation-resistance measurements shall be within manufacturer's published tolerances:
1) In the absence of the manufacturer's published data, compare values of similar machines.

l. Test results of surge protection devices shall be as specified in this Section.

m. Test results of motor starter equipment shall be as specified in this Section.

n. RTD circuits shall conform to the design intent and machine protection device manufacturer's published data.

o. Heaters shall be operational.

p. Vibration amplitudes of the uncoupled and unloaded machine shall be in accordance with the manufacturer's published data:
1) In the absence of the manufacturer's published data, vibration amplitudes shall not exceed values in NETA ATS tables.
2) If values exceed those in the NETA ATS tables, perform a complete vibration analysis.

l. Surge arresters, low voltage:
1. Visual and mechanical inspection:
a. Compare equipment nameplate data with the Contract Documents.

b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, grounding, and clearances.
d. Verify the arresters are clean.
e. 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 the calibrated torque wrench method:
        a) Refer to the manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
f. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
g. Verify that stroke counter is correctly mounted and electrically connected, if applicable.
h. Record stroke counter reading.

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:
        1) Apply voltage in accordance with manufacturer's published data.
        2) Refer to NETA ATS tables in the absence of the manufacturer's published data.
    c. Test grounding connection as specified in this Section.
3. Test values:
    a. Compare bolted connection resistance values to values of similar connections:
        1) 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 the manufacturer's published data:
        1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
    c. Insulation-resistance values shall be in accordance with the manufacturer's published data:
        1) Refer to NETA ATS tables in the absence of the manufacturer's published data.
        2) Investigate insulation values less than the allowable minimum.
    d. Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm.

3.05 FIELD QUALITY CONTROL (NOT USED)

3.06 ADJUSTING (NOT USED)

3.07 CLEANING

A. Dispose of testing expendables.

B. Vacuum cabinets.

C. Sweep clean surrounding areas.

END OF SECTION

SECTION 26_09_13

ELECTRICAL POWER MONITORING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Power meters and accessories.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American National Standard Institute (ANSI):
   1. C12.20 - Electricity Meters - 0.2 and 0.5 Accuracy Classes.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. C57.13.6 - Standard for High Accuracy Instrument Transformers.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. FS - Full scale.
   2. SSM - Solid state multifunction power meter.
   3. THD - Total harmonic distortion.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Product data:
   1. Power meter data, including, but not limited to:
      a. Power requirements.
      b. Communications protocols.
      c. Input/outputs.
      d. Dimensions.
      e. Measurement functions.
      f. Front panel controls.
      g. Display characteristics.

2. Accessory data:
    a. Test switch dimensions and wiring diagrams.

C. Owner Training Submittals:
1. As specified in Section 01 91 00 - Commissioning.

D. Operation and maintenance manuals:
1. As specified in Section 01 78 23 - Operation and Maintenance Data.
2. Descriptive and technical bulletins and sales aids edited to reflect only the equipment to be provided and covering each of the components in the system.
3. A maintenance section including instruction leaflets and technical data necessary to setup, change setup and maintain the power meters.
4. Original licensed copies of software and software manuals.

E. Configuration files and reports:
1. Settings, including, but not limited to:
    a. Device tag name.
    b. IP addresses.
    c. Alarm settings.
    d. Time synchronization settings.
    e. Security settings.
2. Configuration files are to be provided in the selected manufacturer’s native format.
3. Configuration reports are to be submitted in .PDF format, listing each configured parameter setting and description of each parameter.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.10 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA (NOT USED)

2.03 MANUFACTURERS

A. One of the following or equal:
1. ABB.
2. Allen-Bradley.

3. Eaton.
4. Electro Industries/GaugeTech Power Meters.
5. GE Multilin.
6. Schneider Electric.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

A. Power meters:
   1. Power meter type 1 (SSM1) device shall be used in MCCs and shall include at a minimum:
      a. Individual phase currents, within 0.5 percent FS.
      b. Phase-to-phase and phase-to-neutral voltages, within 0.5 percent FS.
      c. Watts, VARs, VA, within 1 percent FS.
      d. Watt-hours, VAR-hours, VA-hours, within 1 percent FS.
      e. PF (apparent and displacement), within 2 percent FS.
      f. Frequency, within 1 percent hertz.
      g. Demand:
         1) Ampere, within 0.5 percent FS.
         2) Watt, VAR, VA, within 1 percent FS.
      h. Minimum and maximum values:
         1) Volts (L-L), volts (L-N), current, watts, VARS, VA.
         2) Power factor:
            a) Apparent.
            b) Displacement.
            c) Frequency.
      i. Synch-input kilowatts utility.
      j. LCD with LED backlight.
      k. Communications:
         1) EtherNet/IP.

2.08 ACCESSORIES

A. Current transformers:
   1. Ring type:
      a. Suitable for service within low or medium voltage equipment as indicated on the Drawings.
      b. Designed to have a mechanical and thermal rating to withstand short-circuit current, stresses, and heating effects equal to the rating of the equipment of the application.
   2. Current ratio: As indicated on the Drawings.
   3. Rated in accordance with IEEE C57.13.6 with accuracy of the current transformers suitable for relay accuracy class and rated for 200 percent burden for the required connected devices.
   4. Identify polarity with standard marking or symbols.
   5. Capable of carrying rated primary current continuously without damage.

6. Install secondary wiring from current transformers in a suitable wiring trough, or conduit to proper short-circuiting type terminal blocks for connection to relays, instruments, and other devices.
7. 3 CTs for 3-wire systems. 4CTs for 4-wire systems.

B. Test switches:
1. Ten-pole:
a. 3 voltage poles, for phase voltage:
1) 600 V rated.
b. Four 30 A, non-shorting current poles, for neutral current and let-thru phase currents.
c. Three 30 A, shorting current poles, for shorting phase currents.
2. Base to be made of electrical grade plastic.
3. Barriers between poles for pole isolation and separation.
4. Clear cover encapsulating the test switch to enable visual verification of each switch position.
5. Knife-blade type switches, accepting a horizontal gang interlocking bar.
6. Screw type terminals on each switch.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Install power meters in accordance with the manufacturer’s instructions in the electrical equipment as indicated on the Drawings.

3.04 FIELD QUALITY CONTROL

A. Field electrical acceptance testing:
1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

3.05 OWNER TRAINING

A. Perform Owner Training as specified in Section 01 79 00 - Demonstration and Training.
1. Number of sessions:
a. Operations 1.
b. Maintenance 1.

END OF SECTION

SECTION 26_22_14

DRY-TYPE TRANSFORMERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Enclosed dry-type transformers:
      a. Rated 1 to 1,000 kilovolt-amperes, single and 3-phase.
      b. Primary voltage 600 volts and below.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. Institute of Electrical and Electronics Engineers (IEEE):
   1. 389 - IEEE Recommended Practice for Testing Electronics Transformers and Inductors.
   2. C57.96 - IEEE Guide for Loading Dry-Type Distribution and Power Transformers.

B. Underwriters Laboratory (UL):
   1. 1561 - Standard for Dry-Type General Purpose and Power Transformers.

C. United States Department of Energy (DOE):
   1. 10 CFR Part 431 - Energy Efficiency Program for Certain Commercial and Industrial Equipment.

1.03 DELEGATED DESIGN

A. As specified in Section 01_35_73 - Delegated Design Procedures.

B. Anchoring and bracing.

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Product data:
   1. Catalog cutsheets.
   2. Nameplate data.
   3. Dimensions:
      a. Height.

b. Width.
c. Depth.

4. Inrush current.
5. Insulation system and temperature constraints.
6. Number and rating of taps.
7. Sound levels.
8. Connection diagrams:
   a. Primary.
   b. Secondary.
9. BIL rating.
10. Required clearances.
11. Percent impedance.
12. Efficiency.
13. Certification of full capacity capability at the Project elevation and ambient conditions.
14. For equipment installed in structures designated as seismic design category C, D, E, or F, submit the following as specified in technical sections and as indicated on the Drawings:
    a. Manufacturer's statement of seismic qualification with substantiating test data.
    b. Manufacturer's special seismic certification with substantiating test data.

C. Delegated Design Submittals:
   1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in technical sections and as indicated on the Drawings:
      a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
      b. For equipment installed outdoors.

D. Installation instructions:
   1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
   2. Provide manufacturer's installation instructions.

E. Quality Control Submittals:
   1. Manufacturer's Certificate of Source Testing as specified in Section 01 79 00 - Demonstration and Training.

1.05 QUALITY ASSURANCE (NOT USED)

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide equipment and components that are fully rated for the site elevation and operating environment where the equipment will be installed as specified in technical sections and as indicated on the Drawings.

B. Provide 3-phase or 1-phase, 60 hertz dry-type with voltage ratings, kilovolt-ampere capacities, and connections as indicated on the Drawings:
   1. Transformers shall provide full capacity at the Project elevation and environmental conditions as specified in technical sections and as indicated on the Drawings after all derating factors have been applied.
   2. Suitable for continuous operation at full rating with normal life expectancy in accordance with IEEE C57.96.

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Square D.
   2. ACME.

2.04 MATERIALS

A. Cores:
   1. Non-aging, grain-oriented silicon steel.
   2. Magnetic flux densities below the saturation point.

B. Windings:
   1. High-grade magnet wire.
   2. Impregnated assembly with non-hydroscopic, thermo-setting varnish:
      a. Cured to reduce hot-spots and seal out moisture.
   3. Material electrical grade:
      a. Copper.

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

A. General:
   1. 10 kilovolts BIL for 600-volt class windings.

2. Sound levels, in accordance with IEEE 389 test conditions, not to exceed:

Kilovolt-Amperes Range	Audible Sound Level (dB)
10-50	45

3. Taps:
   a. 25 kilovolt-amperes and larger:
      1) Four 2.5 percent full capacity primary taps below rated voltage.
      2) Two 2.5 percent full capacity primary taps above rated voltage.
   b. Operated by a tap changer handle or tap jumpers accessible through a panel.
4. Terminals:
   a. UL listed for either copper or aluminum conductors.
   b. Rated for 75 degrees Celsius.
5. Daily overload capacities, at rated voltage and without reduction in life, in accordance with IEEE C57.96.

B. Energy efficient transformers 15 kilovolt-amperes and larger:
   1. Insulation class: 220 degrees Celsius.
   2. Temperature rise: 150 degrees Celsius, except as noted below:
      a. 150-degree Celsius rise for dry-type transformers located in motor control centers.
   3. Efficiency:
      a. In accordance with DOE 10 CFR Part 431.

C. Enclosures :
   1. Heavy gauge steel:
      a. Outdoor: Moisture and water resistant with rodent screens over openings and in a weather-protected enclosure, NEMA Type 3R.
      b. Indoor: NEMA Type 2.
   2. Louvers to limit coil temperature rise to the value stated above, and case temperature rise to 50 degrees Celsius.
   3. Built-in vibration dampeners to isolate the core and coils from the enclosure:
      a. Neoprene vibration pads and sleeves.

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

A. Nameplates:
   1. Non-corrosive metal or UL listed non-metallic:
      a. Stamped, engraved or printed with the following information:
         1) Phases.
         2) Frequency.
         3) Kilovolt-ampere rating.
         4) Voltage ratings.
         5) Temperature rise.
         6) Impedance.
         7) Insulation class.
         8) BIL rating.
         9) Connection diagram.

10) Weight.
11) Manufacturer.
12) Identification “transformer”.
13) Classes of cooling.
14) Tap voltage(s).
15) Vector diagram.

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Finish to consist of de-greasing, phosphate cleaning, and an electrodeposited manufacturer’s standard gray enamel rust-inhibiting paint.

2.11 SOURCE QUALITY CONTROL

A. Factory tests:
   1. Applied voltage test to each winding and from each winding to the core:
      a. 600-volt class winding 4.5 kilovolt.
   2. Induced voltage test at 2 times normal voltage and 400 hertz for 1,080 cycles.
   3. Voltage ratio and polarity.
   4. Sound level, performed in a test room with ambient sound level not exceeding 24 dB.
   5. Perform tests in accordance with UL 1561.
   6. Furnish test reports and Manufacturer’s Certificate of Source Testing.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

B. General:
   1. Mounted as indicated on the Drawings.
   2. Install where not in direct contact with building structure.
   3. Install on single layer vibration pad under the entire mounting surface:
      a. Manufacturers: The following or equal:
         1) Korfund.

4. Make any necessary connections to the enclosure with liquidtight flexible conduit having neoprene gaskets and insulated ground bushings.
5. Ground the enclosure:
    a. To an equipment ground conductor in the conduit.
    b. To the facility grounding electrode system.

3.04 FIELD QUALITY CONTROL

A. Field electrical acceptance testing:
    1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

3.05 OWNER TRAINING (NOT USED)

3.06 ADJUSTING

A. Set the transformer taps as required to obtain nominal output voltage on the secondary terminals.

END OF SECTION

SECTION 26_24_16

PANELBOARDS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Panelboards serving feeder circuits and branch circuits.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

B. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).

C. Underwriters Laboratories, Inc. (UL):
   1. 67 - Standard for Panelboards.

1.03 DELEGATED DESIGN

A. As specified in Section 01_35_73 - Delegated Design Procedures.

B. Anchoring and bracing.

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Product data:
   1. Manufacturer of panelboard.
   2. Bill of material.
   3. Assembly ratings including:
      a. Voltage.
      b. Phase.
      c. Continuous current.
      d. Short circuit interrupting rating.
   4. NEMA enclosure type.
   5. Cable terminal sizes based upon actual feeder and sub-feeder conductors used.

6. Furnish circuit breaker Submittals as specified in Section 26_28_01 - Low Voltage Molded Case Circuit Breakers.
7. For equipment installed in structures designated as seismic design category C, D, E, or F, submit the following as specified in technical sections and as indicated on the Drawings:
    a. Manufacturer's statement of seismic qualification with substantiating test data.
    b. Manufacturer's special seismic certification with substantiating test data.

C. Shop Drawings:
1. Overall panelboard dimensions, interior panel dimensions, and wiring gutter dimensions:
    a. Height.
    b. Length.
    c. Width.
2. Weight.
3. Anchoring locations.
4. Breaker layout drawing with dimensions:
    a. Location of the main, branches, solid neutral, and ground.
5. Conduit entry/exit locations:
    a. Identify conduit entry/exit locations and restrictions.
6. Individual panel schedules identifying breaker locations, ratings, and nameplate designations within the panelboard, for every panelboard.

D. Calculations:
1. Detailed calculations or details of the actual physical testing performed on the panelboard to prove the panelboard is suitable for the seismic requirements at the Project Site.

E. Delegated Design Submittals:
1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in technical sections and as indicated on the Drawings:
    a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
    b. For equipment installed outdoors.
    c. For wall mounted equipment weighing 125 pounds or more.

F. Installation instructions:
1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
2. Provide manufacturers' installation instructions.

G. Quality Control Submittals:
1. Manufacturer's Certificate of Source Testing as specified in Section 01 79 00 - Demonstration and Training.
2. Test reports.

H. Operations and maintenance manual:
1. As specified in Section 01 78 23 - Operation and Maintenance Data.

2. Provide a complete manual for the operation and maintenance of the panelboard, circuit breakers, devices, and accessories:
    a. Including, but not limited to:
        1) Instruction narratives and bulletins.
        2) Renewal parts lists.
        3) Time-current curves for all devices.

1.05 QUALITY ASSURANCE

A. Where indicated as service entrance equipment, panelboards shall be UL listed and labeled “Suitable for Service Entrance.”

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL

A. Circuit breaker panelboards as indicated in the panelboard schedules, one-lines, and where indicated on the Drawings:
    1. Service voltage and configuration as indicated on the panel schedules.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide equipment and components that are fully rated for the site elevation and operating environment where the equipment will be installed as specified in technical sections and as indicated on the Drawings.

B. Non-conditioned spaces:
    1. Provide additional temperature conditioning equipment to maintain the equipment temperature within a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature.

C. Outdoor installations:
    1. Provide conditioning equipment incorporated into the equipment to maintain the enclosures within the equipment manufacturer’s specified operating ranges.

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Square D.
   2. ACME.

B. Circuit breakers:
   1. Same manufacturer as the panelboard.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

A. Provide panelboards with:
   1. Molded-case circuit breakers with trip ratings as shown on the panel schedules.
   2. Spares and spaces for future circuit breakers in panels as shown on the panel schedules:
      a. Space for future devices as specified in Section 26_05_00 - Common Work Requirements for Electrical.

B. Short circuit rating:
   1. Provide as indicated on the Drawings.
   2. Testing method in accordance with UL 67.
   3. Mark each panelboard with its maximum short circuit rating at the supply voltage.
   4. Panelboards shall be fully rated.

2.07 COMPONENTS

A. Enclosure:
   1. NEMA enclosure type as indicated on the Drawings:
      a. Where not indicated on the Drawings, as specified in Section 26_05_00 - Common Work Results for Electrical for the installed location.
   2. Minimum width: 20 inches.
   3. Gutter space in accordance with the NEC:
      a. Minimum of 4 inches.
   4. Dead-front, no live parts when the panelboard is in service.
   5. Enclose entire panelboard bus assembly in a corrosion resistant galvanized steel cabinet.
   6. 4-piece front to provide ease of wiring access.
   7. Lockable, hinged door over the protective devices with a flush, cylinder tumbler-type lock with catch and door pull:
      a. Minimum 2 keys per panelboard.
      b. Key all panelboard locks alike:
         1) Match locks on existing panelboards to the extent possible.
   8. Circuit directory frame and card on the inside of the door.
   9. Interior design such that replacement of circuit breakers does not require disturbing adjacent units or removal of the main bus connectors.

10. Outdoor locations: Provide NEMA Type 4X enclosures with a NEMA Type 4X stainless steel outer enclosure (with a hinged door) and a NEMA Type 1 interior panelboard, unless otherwise indicated.

B. Bus:
   1. General:
      a. Tin-plated copper.
   2. Phase bus:
      a. Full size and height without reduction.
      b. Dimensions and temperature rise in accordance with UL 67:
         1) Limit current density to less than 1,000 amps per square inch.
      c. Insulate current carrying parts from ground and phase-to-phase with a high dielectric strength insulator.
   3. Ground bus:
      a. Copper, solidly bonded.
   4. Neutral bus:
      a. Provide where indicated on the Drawings.
      b. 100 percent rated.
      c. Provide lugs for each outgoing feeder requiring a neutral connection.
   5. Provide insulation barriers over the vertical bus behind the dead front shield to provide increased safety during field service.

C. Lugs:
   1. UL listed for copper and aluminum wire:
      a. Rated for 75-degree Celsius terminations.
      b. Provide bolted or compression main lug terminations as required for the incoming cable size.

D. Circuit breakers: As specified in Section 26_28_01 - Low Voltage Molded Case Circuit Breakers and as indicated on the Drawings:
   1. Provide with bolt-on connections:
      a. Plug-in circuit breakers are not allowed.

2.08 ACCESSORIES

A. Surge protective devices:
   1. Furnish panelboards with surge protective devices as indicated on the Drawings.
   2. As specified in Section 26_43_14 - Surge Protective Devices.

B. Nameplates:
   1. As specified in Section 26_05_53 - Identification for Electrical Systems.
   2. Install on outside of door.
   3. Indicating:
      a. Panel designation.
      b. Voltage.
      c. Number of phases and configuration.

C. Circuit identification labels:
   1. Provide index cards behind heavy clear plastic in cardholders on the inside of the doors.

2. Type all information on the cards using designations in the panel schedules.
3. Laminated on both sides.

D. Pad locking mechanism:
1. Provide a pad locking attachment to allow circuit breakers to be locked in the off position.
2. At a minimum, provide 1 mechanism per panelboard:
a. Provide multiple mechanisms if required to accommodate all circuit breaker frame sizes in the panelboard.

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Finish panelboards mounted in motor control centers to match the motor control center finish and color.

2.11 SOURCE QUALITY CONTROL

A. Source Testing:
1. Perform standard factory tests on the panelboards.
2. Test in accordance with NEMA and UL standards.
3. Furnish test reports and Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

A. Anchoring and bracing to structures:
1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
2. Install anchors of type and material indicated on approved anchoring designs.
3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

B. General:
1. Mounted as indicated on the Drawings.
2. Mount rigidly to structural members with exposed surfaces plumb and level to within 1/32 inch.
3. Perform Work in accordance with the manufacturer's instructions and Shop Drawings.
4. Provide brackets, hangers, supports, and hardware for mounting as required.

5. In NEMA Type 4 and NEMA Type 4X locations, mount panelboards on 7/8-inch deep stainless steel preformed channel, with channel running vertically from top to bottom of panelboard:
    a. Use only stainless steel mounting hardware.
6. Mount panelboard so that top operating handle is not more than 6 feet-7 inches above the operating floor.

C. Provide typewritten schedule in each panelboard.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 26_05_00 - Common Work Results for Electrical.

B. Field electrical acceptance testing:
    1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

END OF SECTION

SECTION 26_24_20

LOW VOLTAGE MOTOR CONTROL CENTERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Low voltage motor control centers.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
   2. ICS 18-2001 - Motor Control Centers.

B. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).

C. Underwriters Laboratories (UL):
   1. 845 - Motor Control Centers.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning:
   1. SELV: Safety extra-low voltage.

1.04 DELEGATED DESIGN

A. As specified in Section 01_35_73 - Delegated Design Procedures.

B. Anchoring and bracing.

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Product data:
   1. Manufacturer of motor control center.
   2. Manufacturer of motor control center parts.
   3. Nameplate schedule.

4. Bill of material.
5. Enclosure:
    a. NEMA rating.
    b. Finish color.
6. Ratings:
    a. Voltage.
    b. Phase.
    c. Current:
        1) Horizontal bus ampacity.
        2) Vertical bus ampacity.
        3) Ground bus ampacity.
    d. Short circuit withstand rating.
    e. Protective device interrupting rating.
7. List of recommended spare parts.
8. Catalog cutsheets:
    a. Submit complete manufacturer's catalog information:
        1) Clearly indicate the features of the equipment, including any options necessary to meet the required functionality.
9. Furnish component Submittals as specified in the appropriate Section.
10. For equipment installed in structures designated as seismic design category C, D, E, or F, submit the following as specified in technical sections and as indicated on the Drawings:
    a. Manufacturer's statement of seismic qualification with substantiating test data.
    b. Manufacturer's special seismic certification with substantiating test data.

C. Shop Drawings:
1. Layout drawings:
    a. Provide fully dimensioned and to scale layout drawings which include:
        1) Dimensions:
            a) Overall length.
            b) Overall width.
            c) Overall height.
            d) Overall weight and weight of individual shipping splits.
2. Interfaces to other equipment.
3. Shipping splits.
4. Allowable top and bottom conduit windows.
5. Complete component and unit layout drawings, including control, networking, and metering components.
6. Indicate lug sizes, type, and manufacturer based on the cable size specified in the Contract Documents and as indicated on the Drawings.
7. Elementary schematics:
    a. Provide 1 custom schematic diagram for each compartment:
        1) Include remote devices.
        2) Show wire numbers on the schematics:
            a) Provide wire numbering as specified in Section 26_05_53 - Identification for Electrical Systems.
8. External connection diagram showing the wiring to the external controls and devices associated with the motor control center.
9. One-line diagrams:

a. Provide complete one-line diagrams for each motor control center, including, but not limited to: Protective devices, starters, drives, metering, and other equipment.
b. Indicate electrical ratings of the equipment shown on the one-line diagrams.

D. Calculations:
1. Detailed calculations or details of the actual physical testing performed on the motor control center to prove the motor control center is suitable for the seismic requirements at the Project Site.

E. Delegated Design Submittals:
1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in technical sections and as indicated on the Drawings:
a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
b. For equipment installed outdoors.

F. Installation instructions:
1. Detail the complete installation of the equipment, including rigging, moving, and setting into place.
2. Provide manufacturer's installation instructions.

G. Quality Control Submittals:
1. Manufacturer's representative qualifications.
2. Manufacturer's Certificate of Source Testing.
3. Manufacturer's Certificate of Installation Verification as specified in Section 01 79 00 - Demonstration and Training.

H. Owner Training Submittals:
1. As specified in Section 01 79 00 - Demonstration and Training.

I. Operation and maintenance manuals:
1. Provide complete operating and maintenance instructions presenting full details for care and maintenance of all types of equipment furnished and/or installed under this Section. Include the following:
a. Electrical ratings:
1) Phase.
2) Wire.
3) Voltage.
4) Ampacity.
5) Bus bracing and protective device interrupting ratings.
b. Manufacturer's operating and maintenance instructions for the motor control center and component parts, including:
1) Starters.
2) Overload relays and heater elements.
3) Variable frequency drives.
4) Protective devices, including, but not limited to, fuses, circuit breakers and protective relays.
5) Pilot devices.
c. Complete renewal parts list.

J. Test forms and reports:
   1. Submit complete factory acceptance test procedures and forms used during the test.
   2. Submit complete control description checklist and IO checklist organized by individual starter or VFD for use during the control logic portion of the witnessed factory acceptance testing as well as the witnessed field acceptance testing.

K. Record documents:
   1. Elementary schematics:
      a. Furnish as-built elementary schematics indicating final:
         1) Wire numbers.
         2) Interfaces with other equipment.
      b. Provide 1 custom schematic diagram for each compartment:
         1) Include remote devices.
         2) Show wire numbers on the schematics.
      c. Layout drawings: Provide complete dimensioned component and unit layout drawings.
   2. Record documents shall reflect modifications made during the submittal review process and during construction.

1.06 QUALITY ASSURANCE

A. All portions of the motor control center, vertical bays, and components shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Ship the motor control center and associated equipment to the job site on a dedicated air ride vehicle that will allow the Contractor to utilize on-site off-loading equipment.

B. Furnish temporary equipment heaters within the motor control center to prevent condensation from forming.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.09 ADMINISTRATIVE REQUIREMENTS

A. Sequencing:
   1. Conduct factory acceptance test.
   2. Submit manufacturer’s test results.
   3. Ship equipment to the Project Site after successful completion of factory acceptance test.
   4. Assemble equipment in the field.
   5. Conduct field acceptance test and submit results for the Engineer’s review.
   6. Submit manufacturer’s certification that the equipment has been properly installed and is fully functional for the Engineer’s review.

7. Conduct Owner's Training sessions.
8. Commissioning and process start-up as specified in Section 01 79 00 - Demonstration and Training.

1.10 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL

A. Factory assembled, factory wired, and factory tested motor control centers:
   1. Motor control centers and major components to be products of a single manufacturer.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide equipment and components that are fully rated for the Site elevation and operating environment where the equipment will be installed as specified in technical sections and as indicated on the Drawings.

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Eaton.
   2. ABB.
   3. Allen-Bradley.
   4. Schneider Electric.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

A. General:
   1. Arrange the equipped sections to form continuous motor control center lineups as indicated on the Drawings:
      a. Identify any deviations from the Drawings in writing and submit for approval.
   2. Provide wire markers at each end of every wire as specified in Section 26_05_53 - Identification for Electrical Systems.
   3. Provide complete and functional motor control centers.
   4. Provide devices or accessories not specified in this Section but necessary for the proper installation and operation of the equipment.

B. Bus system:
   1. Material:
      a. Tin-plated copper.

b. Short-circuit rating:
    1) As indicated on the Drawings.
c. Bus bar supports:
    1) High impact strength, non-tracking glass-polyester material that is impervious to moisture and gases.

2. Horizontal power bus:
    a. Current-carrying capacity as indicated on the Drawings.
    b. Mounting:
        1) Mount horizontal bus bars edgewise, one above the other, and fully isolated from wireways and units.
    c. Temperature rise:
        1) In accordance with UL 845.
        2) De-rate the temperature rating of the bus for the specified conditions of ambient temperature and altitude as specified in technical sections and as indicated on the Drawings.
3. Vertical power bus:
    a. Current-carrying capacity of not less than 600 amps.
    b. Mounting:
        1) Enclose the vertical bus in a polyester-glass cover with small openings to permit unit stabs to mate with the bus:
            a) Provide a shutter mechanism to cover the stab openings when plug-in units are removed.
        2) Provide top and bottom bus covers for insulation and isolation of the ends of the bus.
    c. Isolated from the unit compartments by a full height barrier.
4. Ground bus:
    a. Horizontal ground bus:
        1) Current-carrying capacity:
            a) 300 amps when the horizontal bus is 2,000 amps or less.
        2) Mounting:
            a) Full width, firmly secured to each vertical section structure:
                (1) Located in the top or bottom wireway.
            b) Pre-drilled and furnished with lugs for connection to equipment ground wires:
                (1) Furnish a minimum of 10 lugs per vertical section of MCC.
    b. Vertical ground bus:
        1) Mounting:
            a) Furnish in each vertical section.
            b) Bolted to the horizontal ground bus.
            c) Install parallel to the vertical power bus.
            d) Mount vertical ground bus such that plug-in units engage the ground bus before any connection to the power bus is made. Upon removal of plug-in units, ground stabs are disconnected from the ground bus after the power stabs have been disconnected.
5. Bus splice bars:
    a. Provided to join the bus at the splits.
    b. Connected to each horizontal bus bar with a minimum of 2 bolts.

c. Employ conical or spring washers at connections, designed to maintain constant pressure against the splice joint.
d. Same ampacity rating as the horizontal bus.

6. Provide bus system configured for back-to-back MCCs, where required.

C. Enclosures:
1. Each motor control center shall consist of one or more vertical sections bolted together:
a. Freestanding.
b. Totally enclosed.
c. Dead-front assembly.
d. Form each vertical section of heavy gauge steel.
2. Enclosure rating:
a. Outdoor:
1) NEMA Type 3R non-walk-in with separate interior enclosure:
a) Interior enclosure:
(1) NEMA Type 1 gasketed.
3. Standard section dimensions:
a. Nominal height: 90 inches.
b. Nominal depth: 20 inches.
c. Vertical section width as indicated on the Drawings.
4. Wireways:
a. Provide each vertical section with a horizontal wireway at the top and bottom of the section:
1) Arranged to provide a full-width metal enclosed wiring trough across the entire motor control center assembly.
b. Provide each vertical section with a full-height vertical wireway.
c. Completely isolated from the vertical and horizontal bus bars.
d. Provide a removable, hinged door.
5. Shipping splits:
a. No more than 3 vertical sections and not more than 60 inches in width.
b. Solid bussing between vertical sections in a shipping split is not acceptable.
6. Lifting angles:
a. Furnish each vertical section and/or shipping split with a removable lifting angle mounted to the top of the enclosure:
1) Extending the entire width of the shipping split.
7. Mounting channels:
a. Mount each vertical section and/or shipping split on an external 1.5-inch by 3-inch mounting channel.

D. Units:
1. A plug-in unit consists of:
a. Assembly.
b. Support pan.
c. Door assembly.
2. Completely enclosed and isolated from adjacent units, buses, and wireways, except for conductor entries into the unit, by a metal enclosure.
3. Supported and guided by a removable unit support pan:
a. Re-arrangement of units and the removal of a unit so that a new and possibly larger unit can be added without the removal of an in-service unit to gain access to the unit support pan.

4. Held in place by screws or other positive locking means after insertion.
5. Provide a test position with the unit supported in the structure but disengaged from the bus.
6. Integral plug-in ground stab.
7. Stabs:
    a. Free floating.
    b. Self-aligning.
    c. Backed by spring steel clips to ensure high pressure contacts.
    d. Electrolytically tin-plated copper.
8. Handle:
    a. Provide a flange mounted handle mechanism to operate each disconnect switch or circuit breaker.
    b. Door mounted operators or operator handles are not acceptable.
    c. Engaged with the disconnect device at all times as an integral part of the unit independent of the door position.
    d. Lockable in the “OFF” position with up to 3 padlocks.
    e. Mechanically interlocked so that the door cannot be opened with the handle in the “ON” position:
        1) Provide a means for qualified personnel to defeat this interlock.
    f. Interlocked so the unit cannot be inserted or withdrawn with the handle in the “ON” position.
    g. Lockable in the “ON” position:
        1) This shall not prevent the circuit breaker from operating and opening the contacts in the event of a fault condition.
    h. Color-coded to indicate position.
    i. Located so the center of the grip when it is in its highest position is not more than 6 feet-7 inches above the finished floor, including the height of the housekeeping pad and mounting channels.
9. Space for future devices:
    a. Provide spaces as indicated on the Drawings.
    b. As specified in Section 26_05_00 - Common Work Requirements for Electrical.

2.07 COMPONENTS

A. Provide components contained within the motor control center as specified in:
1. Section 26_05_18 - 600-Volt or Less Wires and Cables.
2. Section 26_05_21 - Low Voltage Wire Connections.
3. Section 26_05_53 - Identification for Electrical Systems.
4. Section 26_22_14 - Dry-Type Transformers.
5. Section 26_24_16 - Panelboards.
6. Section 26_28_01 - Low Voltage Molded Case Circuit Breakers.
7. Section 26_29_05 - Motor Starters.
8. Section 26_29_24 - Variable Frequency Drives 0.50 - 50 Horsepower.
9. Section 26_43_14 - Surge Protective Devices.

2.08 ACCESSORIES

A. Wiring:
   1. Wire the motor control center in accordance with the following NEMA class and type as defined by NEMA ICS 18-2001:
      a. NEMA Class II-S:
         1) Furnish wiring diagrams for individual units consisting of drawings that identify electrical devices, electrical connections, and indicate terminal numbering designations.
         2) Furnish individual unit diagrams with each unit and include inter-wiring between units, i.e., electrical interlocking, etc., as specifically specified in the Contract Documents.
         3) Provide custom drawings with unique terminal numbering designations in lieu of standard manufacturer drawings.

B. Lugs and terminals:
   1. For external connections of No. 6 AWG wire or larger:
      a. UL listed for copper or aluminum conductors.
   2. Compression type, requiring a hydraulic press and die for installation.
   3. Provide additional terminal blocks as needed for control conductors passing through the MCC.
   4. Provide 30 percent spare control block terminals.

C. Nameplates:
   1. Provide nameplates as specified in Section 26_05_53 - Identification for Electrical Systems:
      a. Identifying the motor control center designation as indicated on the Drawings.
   2. Furnish individual nameplates for each unit indicated on the Drawings:
      a. 1 nameplate to identify the unit designation.
      b. 1 nameplate to identify the load served.
      c. Furnish space units with blank nameplates.
   3. Manufacturer's labels:
      a. Furnish each vertical section with a label identifying:
         1) Serial number.
         2) Bus rating.
         3) Vertical section reference number.
         4) Date of manufacture.
         5) Catalog number of section.

2.09 FINISHES

A. Finish metal surfaces and structural parts with phosphatizing, or equal, treatment before painting.

B. Finish interior surfaces, including bus support angles, control unit back plates, and top and bottom barrier plates with baked white enamel.

2.10 SOURCE QUALITY CONTROL

A. Source Testing (Factory Acceptance Tests):
   1. Not witnessed.
   2. Test the complete motor control center at the manufacturer's establishment. Completely assemble, wire and test the motor control center:
      a. Detailed inspections before and after assembly to ensure correctness of design and workmanship.
   3. Provide groups of wires leaving the shipping-assembled equipment with terminal blocks with suitable numbering strips.
   4. Furnish test reports and Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 PREPARATION (NOT USED)

3.02 INSTALLATION

A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

B. General:
   1. Furnish cables, conduit, lugs, bolts, and other accessories necessary to completely install the motor control center for the line, load, and control connections.
   2. Make bus splice connections.
   3. Perform Work in accordance with the manufacturer's instruction and Shop Drawings.
   4. Furnish components and equipment necessary to complete the installation.
   5. Replace hardware, lost or damaged during installation or handling, in order to provide a complete installation.

C. Provide openings in the top or bottom of the motor control center for conduit only:
   1. No additional openings will be accepted:
      a. Miscut holes will require that the entire vertical section or removable panel be replaced.
      b. No hole closers or patches will be accepted.

D. Bundle circuits together and terminate in each unit:
   1. Tie with nylon wire ties as specified in Section 26_05_18 – 600-Volt or Less Wires and Cables.
   2. Label wires at each end with wire markers as specified in Section 26_05_53 - Identification for Electrical Systems as shown on the approved elementary schematics.

E. Furnish Manufacturer's Certificate of Installation Verification.

3.03 FIELD QUALITY CONTROL

A. Functional Testing:
   1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

B. Manufacturer's services:
   1. Provide the services of a manufacturer's representative to:
      a. Inspect, verify, and certify that the motor control center installation meets the manufacturer's requirements.

3.04 OWNER TRAINING

A. Not required.

3.05 ADJUSTING

A. Make adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

END OF SECTION

SECTION 26_28_01

LOW VOLTAGE MOLDED CASE CIRCUIT BREAKERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Low voltage molded case circuit breakers.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).

B. Underwriters Laboratories (UL):
   1. 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.

1.03 DELEGATED DESIGN

A. As specified in Section 01_35_73 - Delegated Design Procedures.

B. Anchoring and bracing.

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Product data:
   1. Catalog cutsheets.
   2. Manufacturer’s time-current curves for molded case circuit breakers furnished.

C. Delegated Design Submittals:
   1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in technical sections and as indicated on the Drawings:
      a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
      b. For equipment installed outdoors.
      c. For wall mounted equipment weighing 125 pounds or more.

D. Owner Training Submittals:
   1. As specified in Section 01 79 00 - Demonstration and Training.

1.05 QUALITY ASSURANCE

A. Low voltage molded case circuit breakers shall be UL listed and labeled.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL

A. Molded case thermal magnetic, solid-state, or motor circuit protector type circuit breakers as indicated on the Drawings and connected to form a completed system.

2.02 DESIGN AND PERFORMANCE CRITERIA (NOT USED)

2.03 MANUFACTURERS

A. One of the following or equal:
   1. ABB.
   2. Eaton.
   3. Schneider Electric.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

A. General:
   1. In accordance with UL 489.
   2. Operating mechanism:
      a. Quick-make, quick-break, non-welding silver alloy contacts.
      b. Common Trip, Open and Close for multi-pole breakers such that all poles open and close simultaneously.
      c. Mechanically trip free from the handle.
      d. Trip indicating handle - automatically assumes a position midway between the manual ON and OFF positions to clearly indicate the circuit breaker has tripped.
      e. Lockable in the “OFF” position.

3. Arc extinction:
    a. In arc chutes.
4. Voltage and current ratings:
    a. Minimum ratings as indicated on the Drawings.
    b. Minimum frame size 100A.
5. Interrupting ratings:
    a. Minimum ratings as indicated on the Drawings.
    b. Not less than the rating of the assembly (panelboard, switchboard, motor control center, etc.).

B. Motor circuit protectors:
1. Instantaneous only circuit breaker as part of a listed combination motor controller.
2. Each pole continuously adjustable in a linear scale with “LO” and “HI” settings factory calibrated.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

A. Terminals:
1. Line and load terminals suitable for the conductor type, size, and number of conductors indicated on the Drawings and in accordance with UL 489.

B. Case:
1. Molded polyester glass reinforced.
2. Ratings clearly marked.

C. Trip units:
1. Provide thermal magnetic or solid-state trip units as indicated on the Drawings.
2. Thermal magnetic:
    a. Instantaneous short circuit protection.
    b. Inverse time delay overload.
    c. Ambient or enclosure compensated by means of a bimetallic element.
3. Solid state:
    a. With the following settings as indicated on the Drawings:
        1) Adjustable long time current setting.
        2) Adjustable long time delay.
        3) Adjustable short time pickup.
        4) Adjustable short time delay.
        5) Adjustable instantaneous pickup.

D. Molded case circuit breakers for use in panelboards:
1. Bolt-on type:
    a. Plug-in type breakers are not acceptable.
2. Ground fault trip devices as indicated on the Drawings.

2.08 ACCESSORIES

A. Key interlocks:
   1. Provide key operated interlocks to ensure safe switching procedures as indicated on the Drawings.

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Test breakers in accordance with:
   1. UL 489.
   2. Manufacturer's standard testing procedures.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

A. Install breakers to correspond to the accepted Shop Drawings.

3.04 FIELD QUALITY CONTROL

A. Field electrical acceptance testing:
   1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

3.05 OWNER TRAINING

A. Not required.

3.06 ADJUSTING

A. Adjust trip settings in accordance with Protective Device Coordination Study as accepted by the Engineer and in accordance with manufacturer's recommendations.

B. Adjust motor circuit protectors in accordance with NEC and the manufacturer's recommendation based on the nameplate values of the installed motor.

END OF SECTION

SECTION 26_28_17

DISCONNECT SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Knife blade fusible and non-fusible disconnect switches.
   2. Switch-rated plugs and receptacles.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. National Electric Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
   2. KS 1-2001 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

B. Underwriters Laboratories Inc. (UL):
   1. 98 - Enclosed and Dead-Front Switches.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Safety switches and disconnect switches are to be considered synonymous.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Product data:
   1. Manufacturer.
   2. Manufacturer’s specifications and description.
   3. Ratings:
      a. Voltage.
      b. Current.
      c. Horsepower.
      d. Short circuit rating.
   4. Fused or non-fused.

5. NEMA enclosure type.
6. Dimensions:
    a. Height.
    b. Width.
    c. Depth.
7. Weight.
8. Cross-referenced to the disconnect schedule indicated on the Drawings.

C. Shop Drawings:
1. Manufacturer's installation instructions:
    a. Indicate application conditions and limitations of use stipulated by product testing agency specified under Quality Assurance, Regulatory Requirements below.
    b. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
2. For each switch, indicate nameplate inscription, including voltage, circuit, fuse size (if applicable), and equipment served.

D. Installation instructions:
1. Provide manufacturers' installation instructions.

1.06 QUALITY ASSURANCE

A. Regulatory requirements:
1. NEMA Type KS 1- Enclosed and Miscellaneous Distribution Switches (600 V Maximum).
2. UL 98 - Enclosed and Dead-Front Switches.

B. Disconnect switches shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.10 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide knife blade disconnect switches and switch-rated plugs and receptacles as indicated on the Drawings and specified in the Contract Documents.

B. Provide equipment with the number of poles, voltage, current, short circuit, and horsepower ratings as required by the load and the power system.

2.03 MANUFACTURERS

A. Knife-blade disconnect switches:
   1. One of the following or equal:
      a. ABB.
      b. Appleton.
      c. Crouse-Hinds.
      d. Eaton.
      e. Schneider Electric.
      f. Siemens.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

A. Knife-blade style switch disconnects:
   1. Switch mechanism:
      a. Quick-make, quick-break heavy-duty operating mechanisms:
         1) Provisions for padlocking the switch in the Off position.
         2) A minimum of 90-degree handle travel position between Off and On positions:
            a) Provide handle position indicators to identify the handle position.
         3) Full cover interlock to prevent opening of the switch door in the On position and to prevent closing the switch mechanism with the door open:
            a) With an externally operated override.
   2. Switch interior:
      a. Switch blades visible when the switch is Off, and the cover is open.
      b. Lugs:
         1) Front accessible.
         2) Removable.
         3) UL listed for 60/75-degree Celsius copper conductors.
      c. Current carrying parts completely plated to resist corrosion.
      d. Removable arc suppressors to facilitate easy access to line side lugs.
      e. Furnish equipment ground kits for every switch.
   3. Ratings:
      a. UL horsepower rated for AC or DC with the rating not less than the load served.
      b. Current:
         1) 30 to 1,200 amps.
      c. Voltage:
         1) 250 volts AC, DC.
         2) 600 volts (30 A to 200 A, 600 volts DC).
      d. Poles:
         1) 2, 3, 4, and 6 poles.

e. UL listed short circuit ratings:
    1) 10,000 RMS symmetrical amps when used with or protected by Class H or K fuses (30 to 600 amps).
    2) 200,000 RMS symmetrical amps when used with or protected by Class R or J fuses (30 to 600 amps employing appropriate fuse rejection).
    3) 200,000 RMS symmetrical amps when used with or protected by Class L fuses (800 to 1,200 amps).

B. Where not indicated on the Drawings, provide switches with the NEMA ratings specified in Section 26_05_00 - Common Work Results for Electrical for the installed location.

C. Size, fusing and number poles as indicated on the Drawings or as required:
    1. Provide solid neutral where indicated on the Drawings.

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

A. Disconnect switches to have provisions for a field installable “B” type electrical interlock for position indication as indicated on the Drawings.

B. NEMA Type 7 and Type 9 enclosures furnished with drain and breather kit when used in outdoor applications.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

A. Anchoring and bracing to structures:
    1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
    2. Install anchors of type and material indicated on approved anchoring designs.
    3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

B. General:
    1. Use Myers hubs or bolt-on hubs for conduit penetrations on NEMA Type 12, Type 4, and Type 4X enclosures.
    2. Provide mounting brackets, stands, supports and hardware as required:
        a. Match finish and materials for brackets, stands, and hardware with the switch installed.

b. Provide adequate supporting pillar(s) for disconnect switches in accordance with the approved seismic calculations, and locate aboveground or above decks, where there is no structural wall or surface for box.

3. When possible, mount switches rigidly to exposed building structure or equipment structural members:
   a. For NEMA Type 4 and Type 4X locations, maintain a minimum of 7/8 inch air space between the enclosure and supporting surface.
   b. When mounting on preformed channel, position channel vertically so that water may freely run behind the enclosure.
4. Provide a nameplate for each disconnect switch:
   a. As specified in Section 26_05_53 - Identification for Electrical Systems.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 26_05_00 - Common Work Results for Electrical.

B. Field electrical acceptance testing:
   1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

END OF SECTION

SECTION 26_29_05

MOTOR STARTERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Motor starters and contactors.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. Abbreviations:
   1. FVNR: Full voltage non-reversing.

B. Standards:
   1. Institute of Electrical and Electronics Engineers (IEEE).
   2. International Electrotechnical Commission (IEC):
      a. 801-1 - Electromagnetic Compatibility for Industrial-Process Measurement and Control Equipment - Part 1: General Information.
      b. 947-4 - Low-Voltage Switchgear and Control Gear.
   3. National Electrical Manufacturer’s Association (NEMA):
      a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
      b. ICS 2-230 - Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 V.
   4. Underwriters Laboratories, Inc. (UL):
      a. 508 - Standard for Industrial Control Equipment.
      b. 508A - Standard for Industrial Control Panels.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Overload relay class: A classification of an overload relay time current characteristic by means of a number which designates the maximum time in seconds at which it will operate when carrying a current equal to 600 percent of its current rating.

1.04 DELEGATED DESIGN

A. As specified in Section 01_35_73 - Delegated Design Procedures.

B. Anchoring and bracing.

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures:
   1. Submit motor starter data with equipment Submittal.

B. Product data:
   1. Manufacturer.
   2. Catalog cutsheets.
   3. Technical information.
   4. Complete nameplate schedule.
   5. Complete bill of material.
   6. List of recommended spare parts.
   7. Confirmation that the overload relay class for each starter meets the requirements of the equipment and motor supplier.
   8. Electrical ratings:
      a. Phase.
      b. Wire.
      c. Voltage.
      d. Ampacity.
      e. Horsepower.
   9. Furnish circuit breaker submittals as specified in Section 26_28_01 - Low Voltage Molded Case Circuit Breakers.

C. Shop Drawings:
   1. Elementary and schematic diagrams:
      a. Provide 1 diagram for every starter and contactor.
      b. Indicate wire numbers for control wires on the diagrams:
         1) Wire numbering as specified in Section 26_05_53 - Identification for Electrical Systems.
      c. Indicate interfaces with other equipment on the Drawings.

D. Delegated Design Submittals:
   1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in technical sections and as indicated on the Drawings:
      a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
      b. For equipment installed outdoors.
      c. For wall mounted equipment weighing 125 pounds or more.

E. Quality Control Submittals:
   1. Manufacturer’s representative qualifications.
   2. Manufacturer’s Certificate of Source Testing as specified in Section 01 91 00 - Commissioning.
   3. Test reports.

F. Owner Training Submittals:
    1. As specified in Section 01 91 00 - Commissioning.

G. Operation and maintenance manuals:
    1. As specified in Section 01 78 23 - Operation and Maintenance Data.
    2. Submit complete operating and maintenance instructions presenting full details for care and maintenance of equipment furnished or installed under this Section, including, but not limited to:
        a. Electrical ratings:
            1) Phase.
            2) Wire.
            3) Voltage.
            4) Ampacity.
        b. Complete bill of material.
        c. Manufacturer's operating and maintenance instructions starter and/or contactor component parts, including:
            1) Protective devices (fuses, breakers, overload relays, heater elements, etc.).
            2) Pilot devices.
        d. Complete renewal parts list.
        e. As-built drawings:
            1) Furnish as-built drawings for each starter and contactor indicating final:
                a) Wire numbers.
                b) Interfaces with other equipment.
            2) 11-inch by 17-inch format.

1.06 QUALITY ASSURANCE

A. Regulatory requirements:
    1. Starters and components shall be UL listed and labeled:
        a. UL 508 - Industrial Control Equipment.
        b. UL 508A - Industrial Control Panels.
    2. NEMA ICS 2 - Industrial Control and System Controllers; Contactors and Overload Relays Rated: 600 Volts.
    3. Combination starters shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.09 ADMINISTRATIVE REQUIREMENTS

A. Sequencing:
    1. Conduct the initial fault current study as specified in Section 26_05_74 - Electrical System Studies and submit results for the Engineer's review.
    2. After successful review of the initial fault current study, as specified in Section 26_05_74 - Electrical System Studies, submit complete equipment Submittal.

3. Conduct factory acceptance test.
4. Ship equipment to the Project Site after successful completion of factory acceptance test.
5. Assemble equipment in the field.
6. Submit Manufacturer's Certificate of Installation Verification.
7. Conduct field acceptance test and submit results for the Engineer's review.
8. Conduct Owner Training sessions.
9. Commissioning and process start-up as specified Section 01 91 00 - Commissioning.

1.10 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

1.11 MAINTENANCE

A. Spare parts:
   1. Provide the following spare parts, suitably packaged and labeled with the corresponding equipment number:
      a. 1 spare fuse of each size and type per starter.

PART 2 PRODUCTS

2.01 GENERAL

A. Starters for motor control centers, individual enclosed starters, or control panels.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide equipment and components that are fully rated for the Site elevation and operating environment where the equipment will be installed as specified in technical sections and as indicated on the Drawings.

B. Non-conditioned spaces:
   1. For equipment located in non-conditioned spaces, provide additional temperature conditioning equipment to maintain the equipment temperature within a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature.

C. Outdoor installations:
   1. Provide conditioning equipment incorporated into the equipment to maintain the enclosures within the equipment manufacturer's specified operating ranges.

2.03 MANUFACTURERS

A. One of the following or equal:
   1. NEMA starters and contactors:
      a. ABB.
      b. Allen-Bradley.
      c. Eaton.
      d. Schneider Electric.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

A. General:
   1. Provide combination type starters with motor circuit protector or thermal-magnetic circuit breaker and control power transformer with ratings as indicated on the Drawings.
   2. NEMA size, design, and rated:
      a. NEMA Size 1 minimum.
   3. Coordinate motor circuit protector, thermal magnetic circuit breaker, or fusible disconnect, and overload trip ratings with nameplate horsepower and current ratings of the installed motor.
      a. If motors provided are different in horsepower rating than those specified or indicated on the Drawings, provide starters coordinated to the actual motors furnished.
   4. Provide starters NEMA Size 2 and larger with arc quenchers on load breaking contacts.
   5. Mount extended overload reset buttons to be accessible for operation without opening starter enclosure door.

B. Full voltage starters (FVNR):
   1. Across-the-line full voltage magnetic starters.
   2. Rated for 600 volts.
   3. Electrical characteristics as indicated on the Drawings.
   4. Provide positive, quick-make, quick-break mechanisms, padlockable enclosure doors.
   5. Furnish starter with bi-metallic or solid state overload relays as indicated on the drawings.
   6. Double-break silver alloy contacts.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

A. Molded case circuit breakers:
   1. Circuit breaker type and ratings as indicated on the Drawings.
   2. Provide as specified in Section 26_28_01 - Low Voltage Molded Case Circuit Breakers.

B. Contactors:
   1. NEMA size as indicated on the Drawings.
   2. Electrically held:
      a. For lighting loads designed to withstand the initial inrush currents of ballast and lamp loads.
   3. Factory adjusted and chatter free.
   4. Auxiliary contacts:
      a. Contact ratings in accordance with NEMA A600 rating:
         1) Auxiliary contacts rated 10 amps at 600 volts.
      b. Provide contacts indicated on the Drawings and any additional contacts required for proper operation.

c. Provide at least 1 normally open and 1 normally closed spare auxiliary contact.

5. Constructed in accordance with the following standards:
   a. UL 508.
   b. IEC 947-4:
      1) Type 1 coordination when protected by a circuit breaker.
      2) Type 2 coordination when protected by a suitable UL listed fuse.
   c. IEC 801-1 parts 2 through 6.

C. Overloads:
1. Solid state electronic:
   a. Selectable Class 10, 20, 30 protection.
   b. Ambient insensitive:
      1) Operating temperature: -20 to 70 degrees Celsius.
   c. Thermal memory.
   d. Protective functions:
      1) Motor overcurrent.
      2) Phase unbalance (adjustable).
      3) Phase loss.
      4) Ground fault protection.
   e. Self-powered.
   f. Provide current transformers for metering of motor current.
   g. Visible trip indicator.
   h. Push-to-trip test.
   i. Isolated normally open alarm contact.
   j. Normally closed trip contact.
   k. Automatic reset.

D. Control power transformer:
1. Furnish integral control power transformer capacity to power:
   a. Motor controls: Motor and starter accessories indicated on the Drawings or specified.
2. Primary and secondary fusing as indicated on the Drawings:
   a. Fusing sized by the manufacturer for the rating of the transformer furnished.
3. Control power transformer secondary voltage:
   a. As indicated on the Drawings.

2.08 ACCESSORIES

A. Lugs and terminals:
1. For external connections of No. 6 AWG and larger.
2. UL listed for either copper or aluminum conductors.

B. Surge protective devices:
1. Furnish surge protection devices across the coil of each starter, contactor, and relay.

C. Pilot devices:
1. Provide pilot lights, switches, elapsed time meters, and other devices as specified or as indicated on the Drawings.

2. As specified in Section 40_67_01 - Control Systems: Panels, Enclosures, and Panel Components.

D. Nameplates and wire markers:
   1. As specified in Section 26_05_53 - Identification for Electrical Systems.

E. Conformal coating:
   1. Provide conformal coating material applied to electronic circuitry and printed circuit boards to act as protection against moisture, dust, temperature extremes, and chemicals such as H_2S and chlorine.

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Source Testing:
   1. Not witnessed.
   2. Furnish test reports and Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

B. Starters in motor control centers:
   1. As specified in Section 26_24_20 - Low Voltage Motor Control Centers.

C. Starters in control panels:
   1. As specified in Section 40_67_01 - Control Systems: Panels, Enclosures, and Panel Components.

3.04 FIELD QUALITY CONTROL

A. Field electrical acceptance testing:
   1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

3.05 OWNER TRAINING

A. Perform Owner Training as specified in Section 01 79 00 - Demonstration and Training.
   1. Number of sessions:
      a. Operations 2.
      b. Maintenance 2.

3.06 ADJUSTING

A. Make adjustments as necessary and as recommended by the manufacturer, Engineer, or testing firm.

B. Set overloads and motor circuit protectors based on the nameplate values of the installed motor.

END OF SECTION

SECTION 26_29_24

VARIABLE FREQUENCY DRIVES 0.50 - 50 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Variable frequency drives (VFD) 0.5 to 50 horsepower for control of NEMA Design B squirrel cage induction motors.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. International Organization for Standardization (ISO):
   1. 9001 - Quality Management Systems - Requirements.

B. National Electrical Manufacturers Association (NEMA).

C. Underwriters Laboratories (UL):
   1. 508A - Standard for Safety for Industrial Control Panels.
   2. 845 - Standard for Motor Control Centers.
   3. 61800-5-1 - Standard for Adjustable Speed Electrical Power Drive Systems.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Point of common coupling: The point of common coupling for all harmonic calculation and field measurements for both voltage and current distortions is defined as the closest directly connected bus supplying power to the VFD.

1.04 DELEGATED DESIGN

A. As specified in Section 01_35_73 - Delegated Design Procedures.

B. Anchoring and bracing.

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures:
   1. Custom prepared by the VFD manufacturer and specific for the equipment furnished.

B. Product data:
   1. Manufacturer of the VFD.
   2. Manufacturer of all components of the VFD.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
      d. Weight.
   4. Nameplate schedule.
   5. Bill of material.
   6. Ratings:
      a. Voltage.
      b. Phase.
      c. Input current.
      d. Output current.
      e. Interrupting rating.
      f. Momentary current rating.
   7. List of recommended spare parts.
   8. Catalog cutsheets for major components.
   9. Design data:
      a. Efficiency and power factor values.
      b. Certification that the drive is sized for the full nameplate motor horsepower and current of the driven load at the installed altitude and ambient temperature.
      c. Certification that based upon VFD design, cable length to motor, and motor dielectric insulation level that the VFD will not damage motor insulation due to carrier frequency, reflected wave, dv/dt, or other VFD produced characteristics.
      d. Certification that electronic circuits and printed circuit boards are conformally coated.
   10. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in technical sections and as indicated on the Drawings:
      a. Manufacturer’s statement of seismic qualification with substantiating test data.
      b. Manufacturer’s special seismic certification with substantiating test data.

C. Shop Drawings:
   1. Complete plan and elevation drawings showing:
      a. Dimensions.
      b. Panel, sub-panel, and component layout indexed to the bill of material.
      c. Conduit connections.
   2. Block diagram showing the basic control and protection systems specifying the protection, control, trip and alarm functions, the reference signals and commands and the auxiliary devices.
   3. Complete schematic, wiring and interconnection diagrams showing connections to both internal and external devices:
      a. Include terminal number and wire numbers.
   4. Complete single-line and 3-line diagrams, including, but not limited to, circuit breakers, motor circuit protectors, contactors, instrument transformers, meters,

relays, timers, control devices, and other equipment comprising the complete system:
    a. Clearly indicate device electrical ratings on the Drawings.

D. Delegated Design Submittals:
    1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in technical sections and as indicated on the Drawings:
        a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
        b. For equipment installed outdoors.
        c. For wall mounted equipment weighing 125 pounds or more.

E. Installation instructions:
    1. Detail the complete installation of the equipment, including rigging, moving, and setting into place.
    2. Provide manufacturer's installation instructions.

F. Quality Control Submittals:
    1. Manufacturer's representative qualifications.
    2. Manufacturer's Certificate of Source Testing as specified in Section 01 91 00 - Commissioning.
    3. Manufacturer's Certificate of Installation Verification as specified in Section 01 91 00 - Commissioning.
    4. Test reports.
    5. Report listing the setting of VFD adjustable parameters and their values after start-up.

G. Owner Training Submittals:
    1. As specified in Section 01 79 00 - Demonstration and Training.

H. Operation and maintenance manuals:
    1. As specified in Section 01 78 23 - Operation and Maintenance Data.
    2. Spare parts list with supplier names and part numbers.
    3. Startup and commissioning instructions and data.
    4. Operating manuals:
        a. Submit operating instructions and a maintenance manual presenting full details for care and maintenance of each model of VFD provided under this Contract.
    5. Operating instructions:
        a. Written descriptions detailing the operational functions of controls on the front panel.
    6. Maintenance manual:
        a. Furnish maintenance manuals with instructions covering details pertaining to care and maintenance of equipment as well as identifying all parts.
        b. Manuals shall include, but are not limited to, the following:
            1) Adjustment and test instructions covering the steps involved in the initial test, adjustment, and start-up procedures.
            2) Detailed control instructions which outline the purpose and operation of every control device used in normal operation.

3) Schematic wiring and external diagrams:
   a) Furnish Drawings in a reduced 11-inch by 17-inch format that are fully legible at that size.

I. Test forms and reports:
   1. Submit complete factory acceptance test procedures and forms used during the test.

1.06 QUALITY ASSURANCE

A. Qualifications:
   1. Any third-party certification, safety or protection requirements shall be applied to the VFD system as a whole. Certification or protection of system elements or individual components by themselves is not acceptable.
   2. VFDs shall be UL 61800-5-1 listed and labeled:
      a. UL 61800-5-1 for individual units.
      b. UL 508A for VFD systems in control panels.
      c. UL 845 for VFD systems in motor control centers.
   3. VFDs shall be manufactured by the VFD manufacturer at its own facility which shall have a quality assurance program certified in accordance with ISO 9001.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Ship the VFDs and associated equipment to the job site on a dedicated air ride vehicle that will allow the Contractor to utilize on-site off-loading equipment:
   1. VFDs shall be delivered to the Site preassembled and wired.

B. Furnish temporary equipment heaters within the VFD to prevent condensation from forming.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawing.

1.09 ADMINISTRATIVE REQUIREMENTS

A. Sequencing:
   1. Conduct factory acceptance test and submit certified test results for the Engineer’s review.
   2. Ship equipment to Project Site after successful completion of factory acceptance test.
   3. Assemble equipment in the field.
   4. Conduct field acceptance test and submit results for the Engineer’s review.
   5. Submit Manufacturers Certificate of Installation and Functionality Compliance.
   6. Conduct Owner Training sessions.
   7. Commissioning and process start-up as specified in Section 01 91 00 - Commissioning.

1.10 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

1.11 SYSTEM START-UP

A. VFD manufacturer shall be responsible for start-up of the VFDs in the presence of the equipment suppliers, Contractor, Engineer, and Owner.

1.12 MAINTENANCE

A. Spare parts:
   1. The following shall be furnished:
      a. 1 set of power and control fuses for each VFD.
      b. 1 complete main control keypad for each type and rated size of VFD.
      c. 1 spare fan for each VFD unit.
      d. 2 sets of ventilation filters for each VFD unit (if applicable in VFD cabinet louvers).
      e. 1 set of thyristors or power electronics for each type and rated size of VFD.
      f. Any special dedicated tools for emergency service and troubleshooting.
      g. Hardware and software required for configuration, maintenance, troubleshooting, and inquiry of drive parameters.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide equipment and components that are fully rated for the Site elevation and operating environment where the equipment will be installed as specified in technical sections and as indicated on the Drawings.

B. Non-conditioned spaces:
   1. Provide additional temperature conditioning equipment to maintain the equipment temperature within a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature.

C. Outdoor installations:
   1. Provide conditioning equipment incorporated into the equipment to maintain the enclosures within the equipment manufacturer’s specified operating ranges.

D. Design requirements:
   1. Each VFD system consists of components required to meet the performance, protection, safety, testing, and certification criteria of this Section.
   2. VFD system:
      a. Is a fully integrated package.
      b. Includes material necessary to interconnect VFD system elements, even if shipped separately.
   3. Coordinate bearing protection methods with the supplier of the driven equipment.

E. Any modifications to a standard product necessary to meet this Section shall be made only by the VFD manufacturer:
   1. Each VFD shall be completely factory pre-wired, assembled, and then tested as a complete system by the VFD manufacturer to ensure a properly coordinated, fully integrated drive system.
   2. VFD shall be capable of operating standard NEMA Design B motors. It is the responsibility of the VFD manufacturer to ensure that the drive will not damage motor insulation due to high carrier frequency, reflected wave, dv/dt or other drive electrical characteristics based upon the installed conditions:
      a. Provide equipment necessary to mitigate potential damage to motor insulation.
      b. Motors as specified in Section 26_05_09 - Low Voltage Motors up to 500 hp.

F. Performance:
   1. Operating envelope:
      a. Speed and torque requirements:
         1) Provide a variable torque or constant torque VFD as required by the driven load.
         2) VFD shall be capable of producing a variable alternating voltage/frequency output to provide continuous operation over the 40 to 200 percent (25 to 120 hertz) speed range.
      b. Current requirements:
         1) Full rated current output on a continuous basis.
         2) Variable torque VFD:
            a) Minimum 110 percent current overload for 1 minute.
         3) Constant torque VFD:
            a) Minimum 150 percent current overload for 1 minute.
   2. Minimum VFD system efficiency:
      a. 96 percent when operating at the rated kW output.
      b. VFD system efficiency shall be calculated as follows:

$$\textit{Efficiency (\%)} = \frac{\textit{Power (Load)}}{\textit{Power (Supply)}} \textit{ X 100}$$

         1) Power (Load) is the total power measured at the output terminals of the drive system, including VFD, output filters, or transformers.
         2) Power (Supply) is the total power measured at the input terminals of the VFD, including input filters, line reactors, isolation transformers, harmonic distortion attenuation equipment and auxiliary equipment (e.g., controls, fans) for complete system operation.
   3. Total power factor:
      a. Minimum of 0.96 lagging across the entire speed range.
      b. At no speed shall the VFD have a leading power factor.
   4. Frequency accuracy:
      a. Minimum of within 0.01 percent.
   5. Speed regulation:
      a. Minimum of within 0.5 percent across the entire speed range.

2.03 MANUFACTURERS

A. One of the following:
   1. Danfoss.
   2. Grundfos.
      a. Only allowable if providing a Grundfos submersible well pump.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

A. General:
   1. Sinusoidal pulse width modulated (PWM) type drive.
      a. 6-pulse insulated gate bipolar transistor (IGBT) power section.
      b. Microprocessor based controls.
      c. Line reactor and output device as specified in this Section.

B. Ratings:
   1. Voltage:
      a. Input voltage as indicated on the Drawings.

C. Operational features:
   1. Protective features:
      a. Provide the following minimum protective features:
         1) Motor overload protection.
         2) Instantaneous overcurrent.
         3) Instantaneous overvoltage.
         4) Undervoltage.
         5) Power unit overtemperature.
         6) Phase loss.
         7) VFD output short circuit.
   2. Control mode:
      a. Operation in either a constant volts/hertz or sensorless vector mode:
         1) Control mode selectable using the programming keypad.
   3. Frequency control:
      a. Minimum of 3 selectable skip frequencies with adjustable bandwidths.
      b. Programmable minimum frequency.
      c. Programmable maximum frequency.
   4. Acceleration/deceleration:
      a. Separately adjustable acceleration and deceleration rates:
         1) Each rate adjustable from 0.01 to 1,800 seconds.
   5. Spinning load:
      a. VFD shall be capable of determining the speed and direction of a spinning load, “catch” the load and accelerate or decelerate it without damage to the load.
   6. Programmable loss of signal:
      a. Upon loss of speed reference, the VFD shall be programmable to either:
         1) Stop.

2) Maintain current speed.
3) Default to pre-selected speed.

7. Power interrupt ride-through:
   a. VFD shall be capable of continuous operation in the event of a power loss of 5 cycles or less.
8. Inputs/outputs:
   a. Manufacturer's standard number the following:
      1) Analog inputs:
         a) Configurable as either 0 to 10 V or 4 to 20 mA.
      2) Analog outputs:
         a) Programmable 4 to 20 mA isolated.
      3) Discrete inputs:
         a) Programmable.
      4) Discrete outputs:
         a) Programmable.
         b) Form C relay contacts.
      5) Potentiometer 3-wire input.
   b. Provide additional inputs/outputs as required to meet the control functions indicated on the Drawings.
9. Automatic control:
   a. PID capability utilizing an internal or external setpoint:
      1) Selectable setpoint source.
10. Diagnostics:
    a. Store a minimum of 4 fault conditions in non-volatile memory on a first in-first out basis.
    b. Operational parameters stored at the time of the fault:
       1) Operating frequency.
       2) Drive status.
       3) Power mode.
    c. Fault memory accessible via RS-232, RS-422, or RS-485.
11. Automatic restart:
    a. User selectable automatic restart feature allowing the VFD to restart following a momentary power failure or other VFD fault:
       1) Programmable for up to 9 restart attempts.
       2) Adjustable time delay between restart attempts.

2.07 COMPONENTS

A. Enclosure:
   1. NEMA Type 12 or motor control center as indicated on the Drawings.
   2. Provide cooling devices required to maintain the VFD within the manufacturer's specified temperature limits for the Project conditions:
      a. Provide cooling device failure alarm.

B. Power disconnect:
   1. Flange-mounted thermal magnetic circuit breaker.
   2. Lockable in the OFF position.

C. Input reactor:
   1. 3 percent input line reactor.

D. Output device:
    1. 3 percent output load reactor.

E. Keypad:
    1. Provide each VFD with a keypad for programming and control.
    2. Keypad requirements:
        a. Password security to protect drive parameters.
        b. Mounted on the door of the VFD enclosure.
        c. Back-lit LCD:
            1) Minimum of 2 lines with a minimum of 16 characters per line.
        d. Programming and display features language: English.
        e. Capable of displaying the following parameters:
            1) Speed (percent).
            2) Output current (amperes).
            3) Output frequency (hertz).
            4) Input voltage.
            5) Output voltage.
            6) Total 3-phase kilowatt.
            7) Kilowatt-hour meter.
            8) Elapsed run time meter.
            9) Revolutions per minute.
            10) Direct current bus voltage.
    3. In addition to keys required for programming, provide the following controls on the keypad:
        a. Auto/manual selector.
        b. Start pushbutton.
        c. Stop pushbutton.
        d. Jog pushbutton.
        e. Speed increment.
        f. Speed decrement.
        g. Forward/reverse selector.
        h. Run LED indicator.
        i. Program LED indicator.
        j. Fault LED indicator.
    4. Provide the VFD with the hardwired controls as indicated on the Drawings.

F. Control power transformer:
    1. Furnish a control power transformer mounted and wired inside the VFD enclosure.
    2. With primary and secondary fusing.
    3. Sized to power VFD controls and options as well as any external devices indicated on the Drawings, including the motor winding heater.

2.08 ACCESSORIES

A. Metal oxide varistors:
    1. Provide protection for the VFD against:
        a. Line transients: 5,000-volt peak minimum.
        b. Line to ground transients: 7,000-volt peak minimum.

B. Conformal coating:
   1. Provide conformal coating material applied to electronic circuitry and printed circuit boards to act as a protection against moisture, dust, temperature extremes, and chemicals such as H_2S and chlorine.

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Enclosure finish shall be manufacturer's standard gray.

2.11 SOURCE QUALITY CONTROL

A. Source Testing (Factory Acceptance Tests):
   1. Not witnessed.
   2. General:
      a. Incoming inspection of components and raw materials based on strategic supplier base and experience.
      b. VFDs furnished under this Section shall be tested and inspected as specified below. Testing of VFDs based on sampling plans is not allowed.
      c. Testing procedures specified are the minimum acceptable requirements. Manufacturer may perform additional tests at its discretion.
   3. Failure of any component during testing requires repair of the faulted component and complete retest.
   4. Perform manufacturer's standard factory acceptance tests.
   5. Furnish test reports and Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

B. General:
   1. Furnish cables, conduit, lugs, bolts, and other accessories needed to complete the installation of the VFD (free-standing or within motor control center).
   2. Assemble and install the VFD in the locations and with the layouts indicated on the Drawings.
   3. Perform Work in accordance with the manufacturer's instructions and Shop Drawings.

4. Furnish components and equipment as required to complete the installation.
5. Replace any hardware lost or damaged during the installation or handling to provide a complete installation.
6. Provide openings in top or bottom of the VFD (free-standing or within motor control center) enclosure for conduit only, no additional openings will be allowed:
    a. Improperly cut holes will require that the entire panel be replaced:
        1) No hole closers or patches will be allowed.
7. Bundle circuits together and terminate in each unit:
    a. Tie with nylon wire ties.
    b. Label wires at each end with wire numbers shown on the approved control drawings.
    c. Connections to and from the VFD (free-standing or within motor control center) enclosure must be made via terminal blocks.

C. Furnish Manufacturer's Certificate of Installation Verification.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 26_05_00 - Common Work Results for Electrical.

B. Field electrical acceptance testing:
1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

C. Provide the services of a VFD manufacturer representative for startup assistance:
1. Inspection and field adjustment:
    a. Supervise the following and submit written certification that the equipment and controls have been properly installed, aligned, adjusted, and readied for operation.
2. Startup field testing:
    a. Provide technical direction for testing, checkout, and startup of the VFD equipment in the field.
    b. Under no circumstances are any portions of the drive system to be energized without authorization from the manufacturer's representative.

3.05 OWNER TRAINING

A. Perform Owner Training as specified in Section 01 79 00 - Demonstration and Training.
1. Number of sessions:
    a. Operations 2.
    b. Maintenance 2.

3.06 ADJUSTING

A. Make adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

B. Provide the services of a VFD manufacturer factory technician to make drive parameters and protective device settings:
1. Protective device settings provided by the VFD manufacturer in accordance with the manufacturer of the driven equipment requirements.

2. Provide documentation of VFD settings, including, but not limited to:
    a. Minimum speed.
    b. Maximum speed.
    c. Skip speeds.
    d. Current limit.
    e. Acceleration time.
    f. Deceleration time.

END OF SECTION

SECTION 26_43_14

SURGE PROTECTIVE DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. High-energy surge protective devices.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. Institute of Electrical and Electronics Engineers (IEEE):
   1. C62.41.1 - Guide on the Surge Environment in Low-Voltage (1,000 V and less) AC Power Circuits.
   2. C62.41.2 - Recommended Practice on Characterization of Surges in Low-Voltage (1,000 V and Less) AC Power Circuits.
   3. C62.45 - Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1,000 V and Less) AC Power Circuits.
   4. C62.62- Standard Test Specifications for Surge Protective Devices (SPDs) for Use on the Load Side of the Service Equipment in Low Voltage (1,000 V and less) AC Power Circuits.

B. International Electrotechnical Commission (IEC).

C. National Electrical Manufacturers Association (NEMA).

D. National Fire Protection Agency (NFPA):
   1. 20 - Standard for the Installation of Stationary Pumps for Fire Protection.
   2. 70 - National Electrical Code (NEC).
   3. 75 - Standard for the Fire Protection of Information Technology Equipment.
   4. 780 - Standard for the Installation of Lightning Protection Systems.

E. Underwriters Laboratory (UL):
   1. 96A - Standard for Installation Requirements for Lightning Protection Systems.
   2. 1283 - Standard for Electromagnetic Interference Filters.
   3. 1449 - Standard for Surge Protective Devices.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. I_n: Nominal discharge current.
   2. MCOV: Maximum continuous operating voltage.
   3. MOV: Metal oxide varistor.
   4. SAD: Silicon avalanche diode.
   5. SCCR: Short circuit current rating.
   6. SPD: Surge protective device.
   7. VPR: Voltage protection rating.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Product data:
   1. Furnish complete product data confirming detailed compliance or exception statements to all provisions of this Section.
   2. Manufacturer's catalog cutsheets indicating:
      a. Manufacturer and model numbers.
      b. Ratings of each SPD, including, but not limited to:
         1) Short circuit current rating.
         2) Nominal discharge current.
         3) Maximum continuous operating voltage.
         4) Voltage protection rating.
         5) System voltage.
         6) System frequency.
         7) Surge current capacity.
   3. Submit independent test data from a nationally recognized testing laboratory verifying the following:
      a. Overcurrent protection.
      b. UL 1449.

C. Shop Drawings:
   1. Provide electrical and mechanical drawings by the manufacturer that detail:
      a. Unit dimensions.
      b. Weights.
      c. Components.
      d. Field connection locations.
      e. Mounting provisions.
      f. Connection details.
      g. Wiring diagram.

D. Quality Control Submittals:
   1. Manufacturer's representative qualifications.
   2. Manufacturer's Certificate of Source Testing as specified in Section 01 79 00 - Demonstration and Training.

E. Owner Training Submittals:
   1. As specified in Section 01 79 00 - Demonstration and Training.

F. Operation and maintenance manuals:
   1. As specified in Section 01 78 23 - Operation and Maintenance Data.
   2. Provide the manufacturer's manual with installation, start-up, and operating instructions for the specified system.

1.06 QUALITY ASSURANCE

A. Provide SPD units that are designed, manufactured, tested and installed in compliance with the following codes and standards:
   1. IEEE C62.41.1, C62.41.2, C62.45, C62.62.
   2. Federal Information Processing Standards Publication 94 (FIBS PUB 94).
   3. NEMA.
   4. NFPA 20, 70, 75, and 780.
   5. UL 1449 current edition and UL 1283.

B. IEC 801.

C. Provide surge protective devices that are suitable for application in IEEE C62.41.1, C62.41.2 Category A, B, and C3 environments, as tested to IEEE C62.45.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.09 ADMINISTRATIVE REQUIREMENTS

A. Sequencing:
   1. Coordinate with and provide SPD equipment to the electrical equipment manufacturer before final assembly and factory testing.

1.10 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide surge protection as indicated on the Drawings.

2.03 MANUFACTURERS

A. One of the following or equal:
   1. ABB.

2. Eaton.
3. Southern Tier Technologies.
4. Schneider Electric.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

A. Provide Type 1 or Type 2 SPD units as required for the locations indicated on the Drawings.

B. Electrical requirements:
   1. SPD ratings are to be consistent with the nominal system operating voltage, phase, and configuration as indicated on the Drawings.
   2. MCOV:
      a. For the SPD and all components in the suppression path (including all MOVs, SADs, and selenium cells): Greater than 115 percent of the nominal system operating voltage.
   3. Operating frequency:
      a. 47 to 63 hertz.
   4. SCCR:
      a. 65 kAIC minimum, but not less than the equipment it is connected to as indicated on the Drawings.
      b. Marked on the SPD in accordance with UL 1449 and the NEC.
   5. Nominal discharge current I_n:
      a. 20 kA.
   6. Maximum VPR:

Modes	240/120 3W	208Y/120	480Y/277	480 V
L-N, L-G, N-G	700	700	1,200	1,800
L-L	1,200	1,200	2,000	1,800

   7. Peak surge current:
      a. Service entrance locations:
         1) 240 kA per phase minimum.
         2) 120 kA per mode minimum.
      b. Branch locations:
         1) 120 kA per phase, minimum.
         2) 60 kA per mode minimum.

C. Protection modes:
   1. Provide SPD protection modes as follows:
      a. Line to Neutral (L-N) where applicable.
      b. Line to Ground (L-G).
      c. Neutral to Ground (N-G), where applicable.

D. Environmental requirements:
   1. Storage temperature:
      a. -40 to 122 degrees Fahrenheit.

2. Operating temperature:
    a. 32 to 140 degrees Fahrenheit.
3. Relative humidity:
    a. 5 to 95 percent.
4. Audible noise:
    a. Less than 45 dBa at 5 feet (1.5 m).
5. Operating altitude:
    a. Zero to 12,000 feet above sea level.

2.07 COMPONENTS

A. Enclosure:
    1. Located in electrical equipment as indicated on the Drawings.

B. Internal connections:
    1. Provide low impedance copper plates for intra-unit connections:
        a. Attach surge modules using bolted connections to the plates for low impedance connections.
    2. Size connections, conductors, and terminals for the specified surge current capacity.

C. Surge diversion modules:
    1. MOV:
        a. Where multiple MOVs are used in parallel, utilize computer matched MOVs to within 1 volt variance and tested for manufacturer's defects.

D. Overcurrent protection:
    1. Individually fuse components, including suppression, filtering, and monitoring components:
        a. Rated to allow maximum specified nominal discharge current capacity.
        b. Overcurrent protection that limits specified surge currents is not acceptable.

E. Connections:
    1. Provide terminals to accommodate wire sizes up to #2 AWG.

2.08 ACCESSORIES

A. Unit status indicators:
    1. Provide red and green solid-state indicators, with printed labels, on the front cover to redundantly indicate on-line unit status:
        a. The absence of the green light and the presence of the red light indicate that surge protection is reduced and service is needed to restore full operation.
        b. Indicates the status of protection on each mode or phase.

B. Dry contacts for remote monitoring:
   1. Electrically isolated Form C dry contacts (1 A/125 VAC, or 2 A/24 VDC) for remote monitoring of system integrity, and indication of under voltage, phase and/or power loss.

C. Provide an audible alarm which activates under any fault condition:
   1. Alarm On/Off switch to silence the alarm.
   2. A visible LED will confirm whether alarm is On or Disabled.
   3. Locate both switches and the audible alarm on the unit's front cover.

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Source Testing:
   1. Perform manufacturer's standard factory test:
      a. Perform testing in accordance with UL 1449.
   2. Furnish test reports and Manufacturer's Certificate of Source Testing.

B. Permanently affix surge rating to the SPD.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Follow the manufacturer's recommended installation practices and comply with all applicable codes.

B. Special techniques:
   1. Install SPDs internal to equipment with as short and straight conductors, including ground conductor as practically possible:
      a. Twist the input conductors together to reduce input conductor inductance.
   2. Do not subject SPD to insulation resistance testing.

3.04 FIELD QUALITY CONTROL

A. Field electrical acceptance testing:
   1. As specified in Section 26_08_50 - Field Electrical Acceptance Tests.

3.05 OWNER TRAINING

A. Perform Owner Training as specified in Section 01 79 00 - Demonstration and Training:
   1. Number of sessions:
      a. Operations 1.
      b. Maintenance 1.

END OF SECTION

SECTION 31_00_00

EARTHWORK

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loosening, excavating, filling, grading, borrow, hauling, preparing subgrade, compacting in final location, wetting and drying, and operations pertaining to Site grading for buildings, basins, reservoirs, boxes, roads, and other facilities.
   2. Backfilling and compacting under and around structures.

B. Contractor shall complete earthwork operations in accordance with City of Santa Cruz Water System Standard Specifications and this Section. City of Santa Cruz Water System Standard Specifications and Public Works Standards shall govern in the event of a conflict.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

B. ASTM International (ASTM):
   1. D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3).
   2. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

C. City of Santa Cruz Water System Standard Specifications.

D. City of Santa Cruz Public Works Standards.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning:
   1. Backfill adjacent to structure: Backfill within volume bounded by the exterior surfaces of structure, the surface of undisturbed soil in the excavation around structure, and finish grade around structure.
   2. Embankments: Dikes, levees, berms, and similar facilities.
   3. Excavation: Consists of loosening, removing, loading, transporting, depositing, and compacting in final location, wet and dry materials, necessary to be removed for purposes of construction of structures, ditches, grading, roads, and such other purposes as are indicated on the Drawings.

1.04 SUBMITTALS

A. Copy of Property Owner's Agreement allowing placement of surplus soil material on their property.

B. Excavation plan.

C. Testing lab: Submit the Contractor's proposed testing laboratory capabilities and equipment.

D. Test reports:
   1. Submit certified test reports of tests specified to be performed by the Contractor.
   2. Sign and seal test reports by a registered geotechnical engineer or civil engineer who practices geotechnical engineering registered in California.

1.05 QUALITY ASSURANCE

A. Initial compaction demonstration:
   1. Adequacy of compaction equipment and procedures: Demonstrate adequacy of compaction equipment and procedures before exceeding any of following amounts of earthwork quantities:
      a. 50 cubic yards of backfill adjacent to structures.
      b. 100 cubic yards of embankment work.
      c. 100 cubic yards of fill.
      d. 50 cubic yards of roadway base material.
      e. 100 cubic yards of road fill.
   2. Compaction sequence requirements: Until specified degree of compaction on previously specified amounts of earthwork is achieved, do not perform additional earthwork of the same kind.
   3. After satisfactory conclusion of initial compaction demonstration and at any time during construction, provide confirmation tests as specified under the Field Quality Control article.

B. Perform Work related to this Section in accordance with the approved Water Pollution Control Plan (WPCP).

1.06 SEQUENCING AND SCHEDULING

A. Schedule earthwork operations to meet requirements specified in this Section for excavation and uses of excavated material.

B. If necessary, stockpile excavated material in order to use it at specified locations.

C. Excavation, backfilling, and filling: Perform excavation, backfilling, and filling during construction in manner and sequence that provides drainage at all times.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Performance requirements:
   1. Where mud or other soft or unstable material is encountered, remove such material and refill space with stabilization material. Wrap stabilization material with stabilization fabric.
   2. Obtain acceptable import material from other sources if surplus obtained within the Project Site does not conform to specified requirements or are not sufficient in quantity.
   3. No extra compensation will be made for hauling of fill materials nor for water required for compaction.

2.02 MATERIALS

A. Water for compacting: Use water from source acceptable to the Engineer.

B. Soil and rock materials:
   1. General:
      a. Provide aggregate base course, controlled low-strength material, drain rock, gravel, native soil-select material, sand, select material, and stabilization material where specified or indicated on the Drawings.
      b. If suitable surplus materials are available, obtain native soil-select material and select material from cut sections or excavations or imported fill.
   2. Aggregate base course materials: As specified in City of Santa Cruz Water Department Standard Specifications and Public Works Standards.
   3. Drain rock: As specified in Section 31_05_15 - Soils and Aggregates for Earthwork.
   4. Gravel: As specified in Section 31_05_15 - Soils and Aggregates for Earthwork.
   5. Native soil-select material: As specified in Section 31_05_15 - Soils and Aggregates for Earthwork.
   6. Sand: As specified in City of Santa Cruz Water Department Standard Specifications and Public Works Standards.
   7. Select material: As specified in Section 31_05_15 - Soils and Aggregates for Earthwork.
   8. Stabilization material: As specified in Section 31_05_15 - Soils and Aggregates for Earthwork.

C. Controlled low-strength material: As specified in City of Santa Cruz Water Department Standard Specifications and Public Works Standards.

D. Geotextile fabrics:
   1. Stabilization: As specified in Section 31_32_18.04 - Stabilization Fabric.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions:
   1. Character and quantity of material:
      a. Verify character and quantity of rock, gravel, sand, silt, water, and other inorganic or organic materials to be encountered in Work to be performed.
      b. Determine gradation, shrinkage, and swelling of soil, and suitability of material for use intended in Work to be performed.
      c. Determine quantity of material, and cost thereof, required for construction of backfills, cuts, embankments, excavations, fills, and roadway fills, whether from on-site excavations or imported fill. Include in cost of Work to be performed.
      d. Include wasting of excess material, if required, in the cost of Work to be performed.

3.02 PREPARATION

A. Backfills:
   1. After clearing and excavation are completed, scarify entire areas that underlie backfills or structures to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
   2. Recompact scarified areas to density specified before placing backfill material or concrete.
   3. Do not place backfill against walls until:
      a. Walls have been cast full height of structure and concrete has reached the specified strength.
      b. Connecting slabs and beams have been cast, and concrete has reached the specified strength.
   4. Prior to backfilling:
      a. Remove forms.
      b. Clean trash and debris from the excavation site.
   5. After inspection of foundation, walls, and pipes, place backfill symmetrically around structures to prevent eccentric loading of structures.

B. Embankments:
   1. After clearing is completed, scarify entire areas that underlie embankments to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
   2. Recompact scarified areas to density specified for embankments before placing of embankment material.

C. Fills:
   1. After clearing is completed, scarify entire areas that underlie fill sections or structures to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
   2. Recompact scarified areas to density specified for compacted fills before placing of fill material or concrete.

D. Roadway fills:
   1. After clearing is completed, scarify entire areas that underlie roadway fills to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
   2. Recompact scarified areas to density specified for roadway fills before placing of roadway fill material.

E. Sloped surfaces for fill or foundations:
   1. Foundations for fill having slopes in excess of 1 vertical to 4 horizontal:
      a. Bench or terrace to adequately key existing ground and fill built thereon.
   2. Slopes of original hillsides and old fills: Bench minimum of 10 feet horizontally as fill is placed.
   3. Provision of new benches:
      a. Start new bench wherever vertical cut of next lower bench intersects existing grade.
      b. Recompact material thus cut out along with new embankment material at no additional cost to the Owner.

3.03 INSTALLATION

A. General:
   1. Dispose of excavated materials that are not required or are unsuitable for fill and backfill in lawful manner.
   2. Dispose of surplus material on private property only when written permission agreement is furnished by the owner of the property. Submit copies of such agreements.
   3. Rocks, broken concrete, or other solid materials larger than 4 inches in greatest dimension: Remove from the Project Site at no additional cost to the Owner.
   4. Stabilization of subgrade: Provide materials used, or perform Work required, to stabilize subgrade so it can withstand loads that may be placed upon it by the Contractor’s equipment.

B. Borrow area: There is no borrow area on the Project Site.
   1. Where material is required, import material from source located off Project Site selected by the Contractor and subject to acceptance by the Engineer.
   2. There will be no additional cost to the Owner for use of imported fill.

C. Compaction:
   1. Provide specified compaction for backfills, cuts, embankments, fills, roadway fills, and other earthwork.
   2. Perform confirmation tests to verify and confirm that Work has complied, and is complying at all times, with compaction requirements specified in this Section for initial compaction demonstration and field quality control testing.
   3. In-place density of compacted backfills, cuts, embankments, fills, and roadway fills determined in accordance with ASTM D6938.
   4. Maximum density, laboratory compaction: Soil maximum density and optimum water content when tested in accordance with ASTM D1557.
   5. To prevent damage to structures due to backfilling operations, place backfill with equipment that does not exceed AASHTO Standard Specifications for

Highway Bridges, H-20 vehicle loading, within a distance from the face of the structure of not less than 1/2 the depth of backfill.

a. Depth of backfill is the distance between the level being compacted and the bottom of the excavation. Outside this distance, heavier compaction equipment may be used.

6. Compact to percentage of maximum density as follows:
   a. Backfill adjacent to structures: 90 percent.
   b. Backfilling voids: 90 percent.
   c. Other areas: 90 percent.
   d. Under present and future structures: 95 percent.
   e. Under roadways, parking and storage areas, curbs, and sidewalks: 95 percent.
   f. Upper 6 inches of cuts: 95 percent.
   g. Fills: 90 percent.

D. Dewatering: As specified in City of Santa Cruz Water System Standard Specifications and Public Works Standards.

E. Excavation:
   1. Excavations for trenching: As specified in Section 31_23_35 - Trenching.
   2. Excavations for structures:
      a. Provide excavations conforming to the dimensions and elevations indicated on the Drawings for each structure.
      b. After clearing is complete, excavate for the structure, down to the elevation indicated on the Drawings. Unless directed by the Engineer, do not carry excavations below elevation indicated on the Drawings.
      c. Where soil is encountered having unsuitable bearing value, the Engineer may direct in writing that excavation be carried to elevations below those indicated on the Drawings.
      d. Where excavations are made below elevations indicated on the Drawings, adjust elevations of excavations in accordance with the following requirements:
         1) Under slabs: Restore to proper elevation in accordance with procedure specified for backfill in this Section.
         2) Under footings: Restore to the proper elevation using one of the following:
            a) Aggregate base course.
            b) Controlled low-strength material.
      e. Excavation width:
         1) Extend excavations at least 2 feet clear from walls and foundations of structures to allow for placing and removal of forms, installation of services, and inspection.
         2) Do not undercut slopes.
      f. Difficulty of excavation: No extra compensation will be made for removal of rock or any other material due to difficulty of excavation.
   3. Excavation of lined channels:
      a. Excavations in open cut for lined channels may be made so as to place concrete directly against excavated surfaces providing faces of excavations are:
         1) Firm and unyielding.
         2) Will stand or can be made to stand without sloughing.

b. Excavations to provide subgrade for lined channel or subdrainage material: Excavate to lines and grades indicated on the Drawings.

4. Excavation of unlined channels and basins:
   a. Excavate to lines and grades indicated on the Drawings.
   b. Perform excavation and grading so that finish surfaces are in uniform planes with no abrupt breaks in surface.
5. Excavation of ditches and gutters:
   a. Cut ditches and gutters accurately to cross sections and grades indicated on the Drawings.
   b. Take care not to excavate ditches and gutters below grades indicated on the Drawings.
   c. Backfill excessive ditch and gutter excavations to grade with suitable material acceptable to the Engineer.
   d. Do not deposit any material within 3 feet of edge of ditch unless otherwise indicated on the Drawings.
6. Necessary over excavation:
   a. Where it becomes necessary to excavate beyond normal lines of excavation in order to remove boulders or other interfering objects, backfill voids remaining after removal as specified in backfilling of voids below, or as acceptable to the Engineer.
   b. Backfill voids with material acceptable to the Engineer:
      1) With acceptance of the Engineer, backfill with one of the following:
         a) Aggregate base course.
         b) Controlled low-strength material.

F. Materials for backfills, embankments, fills, and roadway fills:
1. General:
   a. Obtain import material from other sources if surplus materials from cuts and excavations obtained from within the Project Site do not conform to specified requirements or are not sufficient in quantity for construction of Project.
2. Backfills:
   a. Backfill adjacent to structures, slabs, or walls: Native soil-select or imported fill meeting the requirements of Section 31_05_15 - Soils and Aggregates for Earthwork.
   b. Backfill material under concrete structures: Aggregate base course material, except in areas where controlled low-strength material or concrete encasement are indicated on the Drawings.
   c. Extend backfill in any area under concrete structures from undisturbed soil or rock to the bottom aggregate base course material layer.
3. Embankments:
   a. Native soil-select material or imported fill meeting the requirements of Section 31_05_15 - Sils and Aggregates for Earthwork or as indicated on the Drawings.
4. Fills:
   a. Native soil-select material or imported fill meeting the requirements of Section 31_05_15 - Soils and Aggregates for Earthwork or as indicated on the Drawings.
   b. Extend fill in any area under concrete structures from undisturbed soil or rock to the bottom aggregate base course material layer.

5. Roadway fills: One of the following, unless otherwise specified or indicated on the Drawings:
    a. Aggregate base course material.
    b. Native soil-select material or imported fill meeting the requirements of Section 31_05_15 - Soils and Aggregates for Earthwork.
    c. Stabilization fabric meeting the requirements of Section 31_32_18.04 - Stabilization Fabric.

G. Placement:
1. General:
    a. Lines and grades:
        1) Construct backfills, embankments, fills, and road fills, at locations and to lines and grades indicated on the Drawings.
        2) Overbuild permanent fill slopes by at least 1 foot and then cut to final grade to provide adequate compaction of the remaining fill.
2. Backfills:
    a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
    b. Bring each layer to a moisture content between optimum moisture content and percent above optimum moisture content before compacting.
    c. Defective compacted backfills: Remove and recompact.
3. Fills:
    a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
    b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
    c. Defective compacted fills: Remove and recompact.
4. Embankments:
    a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
    b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
    c. Defective compacted embankments: Remove and recompact.
5. Roadway fills:
    a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
    b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
    c. Defective compacted roadway fills: Remove and recompact.

3.04 FIELD QUALITY CONTROL

A. Confirmation tests:
1. Contractor’s responsibilities:
    a. Adequacy of compaction equipment and procedures:
        1) Demonstrate adequacy of compaction equipment and procedures.
        2) At each test location include tests for each type or class of backfill from bedding to finish grade.
    b. Compaction sequence requirements:
        1) Do not perform additional earthwork of the same kind until specified degree of compaction has been demonstrated.

c. Cost of confirmation tests: Paid for by the Contractor.
d. Qualifications of the Contractor's testing laboratory: Acceptable to the Engineer.
e. Copies of confirmation test reports: Submit promptly to the Engineer.

2. Frequency of confirmation testing:
   a. Maximum dry density versus moisture:
      1) Backfill: Once per 500 cubic yards.
      2) Cuts: Once per 1,000 cubic yards.
      3) Fills: Once per 500 cubic yards.
      4) Roadway fills: Once per 500 cubic yards.
   b. Cost of confirmation tests:
      1) Paid for by the Contractor.
   c. Qualifications of the Contractor's testing laboratory:
      1) Perform confirmation testing by soils testing laboratory acceptable to the Engineer. Copies of confirmation test reports: Submit promptly to the Engineer.

B. Tolerances:
   1. Finish grading of backfills, cuts, embankments, fills, and roadway fills:
      a. Perform fine grading under concrete structures such that finish surfaces are never above the grade or cross section indicated on the Drawings and are never more than 0.10 feet below.
      b. Provide finish surface for areas outside of structures that are within 0.10 feet of grade or cross section indicated on the Drawings.
   2. Unlined channels and basins:
      a. In both cut and fill and levee and access road side slopes in cut: Vertical tolerance of none above and 3 inches below grade indicated on the Drawings on bottom and side slopes.
      b. On top surface of levee and access road in both cut and fill and levee and access road side slopes in fill: Vertical tolerance of none below and 3 inches above grade indicated on the Drawings.
   3. Areas which are not under structures, concrete, asphalt, roads, pavements, sidewalks, dikes, and similar facilities:
      a. Provide finish graded surfaces of either undisturbed soil, or cohesive material not less than 6-inches deep.
      b. Intent of proceeding is to avoid sandy or gravelly areas.
   4. Finish grading of surfaces:
      a. Reasonably smooth, compacted, and free from irregular surface changes.
      b. Provide degree of finish that is ordinarily obtainable from blade grader operations, except as otherwise specified.
      c. Uniformly grade areas that are not under concrete.
      d. Finish ditches and gutters so that they drain readily.

C. Compliance tests:
   1. Frequency of testing: Periodic compliance tests will be made by the Engineer to verify that compaction is meeting requirements previously specified.

3.05 ADJUSTING

A. Finish grades of excavations, backfills, and fills:
   1. Repair and reestablish grades to required elevations and slopes due to any settlement or erosion that may occur from action of the elements or any other cause prior to final acceptance.

3.06 PROTECTION

A. Finish grades of backfills, cuts, excavations, and fills:
   1. Protect newly graded areas from erosion and deterioration by action of the elements.

B. Ditches and gutters:
   1. Maintain ditches and gutters free from detrimental quantities of debris that might inhibit drainage until final acceptance.

END OF SECTION

SECTION 31_05_15

SOILS AND AGGREGATES FOR EARTHWORK

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Material requirements for soils and aggregates.

B. Contractor shall complete earthwork operations in accordance with City of Santa Cruz Water System Standard Specifications and this Section. City of Santa Cruz Water System Standard Specifications and Public Works Standards shall govern in the event of a conflict.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C117 - Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing.
   2. C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   3. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   4. C535 - Standard Test Method for Resistance to Degradation of Larger-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   5. D2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
   6. D2844 - Standard Test Method for Resistance R-Value and Expansion Pressure of Compacted Soils.
   7. D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
   8. D4829 - Standard Test Method for Expansion Index of Soils.

B. California State Transportation Agency, Department of Transportation (CALTRANS):
   1. (Standard Specifications).
   2. California Test Methods (CTM):
      a. California Test 205 - Method of Test for Determining Crushed Particles.
      b. California Test 211 - Method of Test for Abrasion of Coarse Aggregate by Use of the Los Angeles Abrasion Testing Machine.
      c. California Test 217 - Method of Test for Sand Equivalent.
      d. California Test 229 - Method of Test for Durability Index.
      e. California Test 301 - Method of Test for Determining the Resistance “R” Value of Treated and Untreated Bases, Subbases, and Basement Soils by the Stabilometer.

C. City of Santa Cruz Water System Standard Specifications.

D. City of Santa Cruz Public Works Standards.

1.03 SUBMITTALS

A. Product data:
   1. Material source.
   2. Gradation.
   3. Testing data.

B. Quality control for aggregate base course:
   1. Test reports: As required by Sections of Standard Specifications.
   2. Certificates of compliance: As required by Sections of Standard Specifications.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Storage and protection: Protect from segregation and excessive moisture during delivery, storage, and handling.

B. Comply with Standard Specifications storage requirements, if applicable.

PART 2 PRODUCTS

2.01 MATERIALS - GENERAL

A. Provide material having maximum particle size not exceeding 4 inches and that is free of trash, lumber, debris, leaves, grass, roots, stumps, and other organic matter.

B. Materials derived from processing demolished or removed asphalt concrete are not acceptable.

C. Comply with soil and aggregate material requirements in the Standard Specifications, unless specified otherwise.

2.02 NATIVE MATERIAL

A. Native soil-select:
   1. Sound earthen material.
   2. Sum of plasticity index when tested in accordance with ASTM D4318 and the percent of material by weight passing a No. 200 sieve shall not exceed 23 when tested in accordance with ASTM C136.
   3. Organic content is not greater than 3 percent by volume.
   4. Organic, deleterious material, and cobbles are smaller than 2 inches.
   5. Corrosion resistance requirements:
      a. Resistivity minimum (wet aggregates): 5,000 ohm-cm.
      b. pH: 5.0 to 12.0.
      c. Chlorides maximum: 100 parts per million.
      d. Sulfates maximum: 200 parts per million.

2.03 AGGREGATE BASE COURSE

A. As specified per City of Santa Cruz Water Department Standard Specifications and Public Works Standards.

2.04 GRAVEL

A. Material requirements:
   1. Consists of hard, durable particles of stone or gravel; or crushed to the specified sizes and gradations; and free from organic matter, lumps or balls of clay, and other deleterious matter.
   2. Crush or waste coarse material and add or waste fine material in order to meet the specified gradations.
   3. Fraction of material passing No. 40 sieve: Material having plasticity index not greater than 5 when tested in accordance with ASTM D4318.
   4. Durability: Percentage of wear not greater than 40 percent when tested in accordance with ASTM C131.
   5. Durability: Percentage of wear not greater than 40 percent when tested in accordance with California Test 211.
   6. Conforms to sizes and grade within the following limits when tested in accordance with ASTM C117 and ASTM C136:

Sieve Size (Square Openings)	Percent by Weight Passing Sieve		
	Type A	Type B	Type C
2 inch	100	--	--
1-1/2 inch	95 - 100	100	--
3/4 inch	35 - 60	55 - 85	100
3/8 inch	15 - 40	35 - 65	50 - 100
No. 4	0 - 25	20 - 35	30 - 45
No. 30	--	5 - 15	10 - 20
No. 200	0 - 5	2 - 9	2 - 9

2.05 DRAIN ROCK

A. Material requirements:
   1. Durability: Percentage of wear not greater than 40 percent when tested in accordance with ASTM C131.
   2. Durability index: Percentage of wear not greater than 40 percent when tested in accordance with California Test 229.
   3. Consists of hard, durable particles of stone or gravel; screened or crushed to specified size and gradation; and free from organic matter, lumps or balls of clay, or other deleterious matter.
   4. Crush or waste coarse material and waste fine material as required to meet gradation requirements.

5. Conforms to size and grade within the following limits when tested in accordance with ASTM C117 and ASTM C136:

Sieve Size (Square Openings)	Percent by Weight Passing Sieve
2 inch	100
1-1/2 inch	95 - 100
3/4 inch	50 - 100
3/8 inch	15 - 55
No. 200	0 - 2

2.06 IMPORTED FILL

A. Material requirements:
   1. Granular, well graded, with sufficient binder to allow utility trenches to stand open.
   2. Minimum Sand Equivalent of 20 and Resistance “R” Value of 30.
   3. Free of deleterious material, organics and rocks larger than 2 inches in size.
   4. Non-expansive with a Plasticity Index below 12.

2.07 SAND

A. As specified per City of Santa Cruz Water Department Standard Specifications and Public Works Standards.

2.08 STABILIZATION MATERIAL

A. Durability: Percentage of wear not greater than 40 percent when tested in accordance with ASTM C131.

B. Durability: Percentage of wear not greater than 40 percent when tested in accordance with California Test 211.

C. Consists of clean, hard, durable particles of crushed rock or gravel; screened or crushed to the specified sizes and gradations; and free of any detrimental quantity of soft, friable, thin, elongated, or laminated pieces, disintegrated material, organic matter, oil, alkali, or other deleterious substance.

D. Shall be free of slaking or decomposition under the action of alternate wetting and drying.

E. The portion of material retained on the 3/8-inch sieve shall contain at least 50 percent of particles having 3 or more fractured faces:
   1. Not over 5 percent shall be pieces that show no such faces resulting from crushing. Of that portion which passes the 3/8-inch sieve but is retained on the No. 4 sieve, not more than 10 percent shall be pieces that show no faces resulting from crushing.

F. Conforms to size and grade within the following limits when tested in accordance with ASTM C117 and ASTM C136:

Sieve Size (Square Openings)	Percent by Weight Passing Sieve
1 inch	100
3/4 inch	90 - 100
No. 4	0 - 10
No. 200	0 - 2

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 31_23_22

DEWATERING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Requirements to dewater trench excavations.

1.02 COORDINATION REQUIREMENTS

A. Coordinate the dewatering system design with excavation and shoring design.

B. Do not place concrete or masonry foundations or concrete slabs in water. Do not allow water to rise over these elements until concrete or mortar has set for at least 24 hours.
   1. Maintain operation of dewatering system:
      a. Until complete structure has been constructed, including walls, slabs, beams, struts, and other structural elements.
      b. Concrete has attained its specified compressive strength.
      c. Backfill has been completed to finished grade.

C. Contractor is advised that perched groundwater may be present at the project site. Refer to Supplemental Information SI-4 Geotechnical Report for additional information. If perched groundwater is encountered during trenching and excavation activities, Contractor shall be responsible for dewatering and discharging or disposing of the dewatering water in compliance with all applicable permit requirements.

D. Contractor shall not be permitted to discharge groundwater from trenching and excavation activities to the sanitary sewer without prior approval from the City and Santa Cruz County. Refer to Section 01 14 00 - Work Restrictions, and Section 01 35 43 - Environmental Procedures for dewatering discharge requirements and constraints.

E. Dewatering discharges to the sanitary sewer require that the Contractor apply for a permit from the County of Santa Cruz to dispose of the water and complying with the water quality requirements in the permit.

F. Contractor shall not be permitted to discharge groundwater from the trench and excavation activities to the storm drain.

1.03 SUBMITTALS

A. Submit as specified in Sections 01 33 00 - Submittal Procedures and 01 61 00 - Common Product Requirements.

B. Dewatering Work Plan

1. The Dewatering Work Plan shall be submitted a minimum of 4 months prior to the Contractor's proposed start date for all discharges.
2. Refer to Section 01 35 43 – Environmental Procedures for additional requirements and information.
3. Excavation dewatering discharges to the sanitary sewer:
    a. Contractor shall apply for a special discharge permit from the Santa Cruz County Sanitation District. Permit fee is $150 plus the cost for total discharge volume. The permit application shall include the discharge location, start date, and duration of the project.
    b. Treat water for identified pollutants of concern,
    c. Use settling tanks prior to discharge
    d. Use a turbidity meter for monitoring of NTU.
    e. Total Suspended Solids and pH shall be monitored during discharge.
    f. Flow shall be controlled and monitored.

C. Copies of correspondence with the authorities having jurisdiction, regarding dewatering operations.

D. Submit encroachment permit to City of Capitola if work will be performed in the right of way.

1.04 CONTROLS

A. Dewatering shall be performed at the discretion of the Contractor as approved by the Engineer.

B. Demonstrate the system proposed and verify that adequate equipment, personnel, and materials are provided to dewater the excavations.

C. Discharge water without damaging adjacent property, and in conformance with discharge permit and regulations, including meeting discharge limitation parameters:
    1. Any penalties and fees due to non-conformance with permit shall be the responsibility of the Contractor.

D. Contractor shall be responsible for ensuring dewatering operations shall be adequate to ensure the integrity of the finished project.

PART 2 PRODUCTS

2.01 SYSTEM DESCRIPTION

A. Design the dewatering system to keep excavations reasonably free from water.

B. Dewatering design and analysis. Include the following:
    1. Evaluation of anticipated subsurface conditions.
    2. Pump size.
    3. Plans for groundwater treatment.
    4. Plans for de-silting of groundwater before discharge.

C. Provide dewatering design sealed by a registered Professional Engineer, licensed in the project location.

2.02 DESIGN CRITERIA

A. Prior to excavation, submit a detailed dewatering plan and operation schedule for dewatering of excavations.

B. Design the dewatering system to keep excavations reasonably free from water:
   1. Select appropriate method to dewater, subject to Engineer's review and concurrence.
   2. Shored excavation dewatering as specified in Section 31_23_35 - Trenching.
   3. Dewatering analysis shall determine the following:
      a. Evaluation of anticipated subsurface conditions.
      b. Pump size.
      c. Plans for groundwater treatment.
      d. Plans for de-silting of groundwater before discharge.
   4. Prevent unstable excavation due to pumping and heave.
   5. Dewatering plan prepared by a professional Engineer licensed in the state where the project is located.
   6. Dewatering plan shall include, but not be limited to, the following:
      a. Dewatering design analysis and supporting calculations.
      b. Required permits.
      c. Arrangement, location, and depths of dewatering system components.
      d. Type of proposed pumps to be used and their locations.
      e. Header piping size, material, and piping alignments.
      f. Meter type and locations.
      g. Valve type and locations.
      h. Proposed discharge locations, as identified in this Section.
      i. Settling tanks and filters.
      j. Pipeline material, alignment, and connection details.
      k. Standby pumping equipment.
      l. Required power supply equipment.
      m. Design of any needed water treatment facilities shall comply with the special discharge permit to the sanitary sewer.

C. Locate dewatering facilities where they will not interfere with utilities and construction work.

D. Design and install a water treatment system if necessary to comply with discharge limitation parameters.

E. Decommissioning:
   1. Obtain Engineer's approval to begin decommissioning activities.
   2. Decommission and remove dewatering system.

2.03 EQUIPMENT

A. Provide and maintain equipment necessary for dewatering.

B. Keep standby equipment available at all times to ensure efficient dewatering and maintenance of dewatering operation during power failure.

2.04 DEWATERING PUMPS

A. Specifically designed for dewatering applications where pumping sand may be encountered:
   1. Impeller and rotor shaft shall be hardened, heat-treated stainless steel. Mechanical seal material shall be silicon carbide.
   2. Pump motor shall have thermal overload protection.

2.05 FLOWMETER AND CHART RECORDER

A. Flowmeter and chart recorder: One of the following, or equal:
   1. Badger Turbo Series Meter with totalizer.

PART 3 EXECUTION

3.01 DEWATERING PROCEDURES

A. Designer of the dewatering system shall oversee dewatering operations.

B. Site grading shall promote drainage. Surface runoff shall be diverted away from excavations.

C. Complete dewatering prior to excavation:
   1. Ensure that the subsurface soil is not being removed by the dewatering operation.

D. Continue dewatering operations throughout construction to achieve the following:
   1. Maintain the groundwater level a minimum of 3 feet below bottom of excavation.
   2. Preserve the undisturbed bearing capacity of the subgrade soils at proposed bottom of excavation.

E. Make provisions to maintain continuous dewatering:
   1. Provide standby power to maintain dewatering during power outages and interruptions.
   2. Provide 24-hour monitoring by personnel skilled in operation and maintenance of the system, and capable of providing or obtaining work required to maintain system operation.

F. If foundation soils are disturbed or loosened by the upward seepage of water or an uncontrolled flow of water, excavate the affected areas and replaced with drain rock at no additional cost to Owner.

G. Maintain a trench bottom free from standing water.

H. Prevent flotation by maintaining a positive and continuous removal of water.

I. Contractor shall be fully responsible and liable for damages that may result from failure to adequately keep excavations dewatered.

J. Do not place concrete or masonry foundations or concrete slabs in water:
   1. Do not allow water to rise over these elements until concrete or mortar has set for at least 24 hours.

K. Maintain operation of dewatering system until the pipeline has been installed and backfill has been completed to finished grade.

3.02 SETTLEMENT AND GROUNDWATER LEVEL MONITORING

A. Conduct dewatering operation in a manner that will protect adjacent structures and facilities.

B. Repair damage to adjacent structures and restore facilities at no expense to Owner.

3.03 WATER DISPOSAL

A. Discharge water in accordance with the following:
   1. Discharges to the sanitary sewer may not be allowable during City operations and maintenance activities or if the City is notified that the County sanitary sewer system is near capacity. Contractor shall coordinate with the City for all discharges to the sanitary sewer.
   2. Contractor shall not be permitted to discharge dewatering water to the storm drain.
   3. Alternatively, Contractor shall arrange for off-site hauling and disposal of dewatering water.

B. Dispose of water from the Work in suitable manner:
   1. Without damage to adjacent property.
   2. That will not be a menace to public health or safety.
   3. In compliance with applicable permits and sanitary sewer Special Discharge Permit.

C. Do not drain dewatering water or associated debris into the Work built or under construction. water or associated debris into the Work built or under construction.

3.04 FIELD QUALITY CONTROL

A. Flowmeter and chart recorder:
   1. Provide flowmeter and continuous 24-hour chart recorder for recording dewatering flow.
   2. Maintain meter recorder and provide continuous reading charts with minimum capacity of 24 hours each.
   3. Calibrate flowmeter and recorder device to provide accuracy within 5 percent.
   4. Submit written evidence of calibration of meter and recorder signed by a Professional Engineer registered in the state where Project is located.
   5. Portable recorder (bench mount), dual scale, and mounted in NEMA Type 4X enclosure with transparent plastic door and latch. Operate unit off 115-volts, 60-hertz power supply.
   6. Submit reading to the Engineer on a weekly basis.

END OF SECTION

SECTION 31_23_24

CONTROLLED LOW STRENGTH MATERIAL (CLSM)

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Controlled low strength material (CLSM), also known as "flowable fill."

B. Contractor shall place CLSM in accordance with City of Santa Cruz Water System Standard Specifications and this Section. City of Santa Cruz Water System Standard Specifications and Public Works Standards shall govern in the event of a conflict.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 229R - Report on Controlled Low-Strength Materials.
   2. 301 - Specifications for Structural Concrete.

B. ASTM International (ASTM):
   1. C94 - Standard Specification for Ready Mix Concrete.
   2. C143 - Standard Test Method for Slump of Hydraulic Cement Concrete.
   3. C150 - Standard Specification for Portland Cement.
   4. C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
   5. C494 - Standard Specification for Chemical Admixtures for Concrete.
   6. C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
   7. D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3(600 kN-m/m^3).
   8. D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3(2,700 kN-m/m^3)).
   9. D4832 - Standard Test Method of Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.
   10. D5971 - Standard Practice for Sampling Freshly Mixed Controlled Low Strength Material.
   11. D6023 - Standard Test Method for Density (Unit Weight), Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low-Strength Material.

C. City of Santa Cruz Water System Standard Specifications.

D. City of Santa Cruz Public Works Standards.

1.03 SUBMITTALS

A. Product data: Submit data completely describing materials in the mix and demonstrating compliance with the requirements of this Section:
   1. Cement: Mill tests. Indicate alkali content representative of each shipment.
   2. Fly ash: Identify source and type of fly ash.
   3. Water: Identify source and quality if not from a municipal treatment source.
   4. Admixtures: Manufacturer's product data indicating suitability for use in CLSM mixes and recommended dosage rates.
   5. Aggregate:
      a. Submit source, type, and sieve analyses. Include testing to demonstrate that materials in accordance with ASTM C33 requirements.
      b. Resubmit at any time there is a significant change in grading of materials.

B. Mix design:
   1. Submit full details, including mix design calculations for mix proposed for use.
   2. Trial batch test data:
      a. Submit data for each test cylinder.
      b. Submit data that identifies mix and slump for each test cylinder.

1.04 DELIVERY, STORAGE AND HANDLING

A. Store or stockpile cement, fly ash, and aggregate in accordance with ACI 301.

B. Store admixtures in accordance with the manufacturer's recommendations.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Mixture of Portland cement, water, pozzolan, fine aggregate and admixtures, proportioned in accordance with the recommendations of ACI 229 to produce a homogeneous mixture that is flowable, that will readily work into corners and angles; that will not segregate in the plastic state; and that is self-compacting at the time of placement without the use of mechanical vibration.

B. Performance requirements:
   1. Air content, total calculated in accordance with ASTM D6023: Not less than 8.0 percent, nor greater than 12.0 percent.
   2. Compressive strength, measured in accordance with ASTM D4832 at 28 days: Not less than 50 pounds per square inch, nor greater than 150 pounds per square inch.
   3. Wet density: Not greater than 132 pounds per cubic foot.
   4. Slump, measured in accordance with ASTM C143 at the point of placement: 7 to 9 inches and that allows CLSM to flow freely and to be self-compacting during placement.

2.02 MATERIALS

A. Cement:
   1. Portland cement in accordance with ASTM C150, Type I or Type II.
   2. Having total alkali content not more than 0.60 percent.

B. Fly ash: Class C or Class F fly ash in accordance with ASTM C618.

C. Water:
   1. Potable water: Clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances.

D. Admixtures: Products of a single manufacturer specifically manufactured or recommended by that manufacturer for use in CLSM.
   1. Air entraining admixture: In accordance with ASTM C260.
   2. Water reducing admixture: In accordance with ASTM C494, Type A.

E. Aggregate:
   1. Non-expansive, non-reactive, inert natural sand conforming to the following requirements:
      a. Not more than 12 percent passing a No. 200 sieve.
      b. No plastic fines present.
      c. Including pea gravel no larger than 3/8 inch.

2.03 MIXES

A. See Design and Performance Criteria for performance requirements of the plastic and hardened mix.

2.04 SOURCE QUALITY CONTROL

A. Trial batch:
   1. After mix design has been accepted by Engineer, have trial batch of the accepted mix design prepared by testing laboratory acceptable to Engineer.
   2. Prepare trial batches using the specific cement, fly ash, admixtures, aggregates, and water proposed for the Work.
   3. Prepare trial batch with quantity sufficient to determine slump, workability, and consistency; and to provide test cylinders as indicated in this Section.

B. Trial batch testing:
   1. Determine slump in accordance with ASTM C143, with the following modifications:
      a. Do not rod the concrete material.
      b. Place material in slump cone in one semi-continuous filling operation, slightly overfill, tap lightly, strike off, and then measure and record slump.
   2. Prepare and test trial batch specimens in accordance with ASTM D4832, with the following modifications:
      a. Provide cylindrical test specimens, each 6 inches in diameter by 12 inches high.
      b. Provide a minimum of 8 cylinders for testing of each trial batch.
      c. Fill the molds to overflowing and tap sides lightly to settle the mix.

d. Do not rod the mix for consolidation in the cylinder.
e. Strike off the excess material.

3. Place test cylinders in a moist curing room. Exercise caution in moving and transporting the cylinders since they are fragile and will withstand only minimal bumping, banging, or jolting without damage.
4. Do not remove the test cylinder from mold until that cylinder is to be capped and tested:
   a. Perform the capping carefully to prevent premature fractures.
   b. Do not perform initial compression test until the cylinders reach a minimum age of 3 days.
5. Provide compressive strength tests:
   a. Test 4 test cylinders at 7 days after casting, and another 4 cylinders at 28 days after casting.
   b. The compression strength of the 4 test cylinders tested at 28 days shall be equal to or greater than the minimum required compression strength but shall not exceed maximum compression strength.

C. If the trial batch tests do not meet the Specifications for strength or density, revise and re-submit the mix design, prepare additional trial batch(es), and complete additional trial batch tests. Repeat until an acceptable trial batch is that conforms to the Specifications is produced:
   1. All the trial batches and acceptability of materials shall be paid by the Contractor.
   2. After acceptance, do not change the mix design without submitting a new mix design, trail batches, and test information.

PART 3 EXECUTION

3.01 PREPARATION

A. Do not place CLSM until preparation and condition of surfaces receiving the fill have been observed and accepted by the Engineer.

B. Remove debris foreign matter and standing or running water from excavations and areas receiving CLSM before placement.

3.02 INSTALLATION

A. Pipes and trenches:
   1. Install cellular concrete as indicated on the Drawings and specified.
   2. Where CLSM is placed around and over pipes, secure pipes in place, or place CLSM in lifts to prevent pipe flotation.
   3. Where CLSM is placed in long, open trenches, confine material using bulkheads of sandbags, earth dams, or stiffer concrete at open ends of placement.

3.03 MEASURING, BATCHING, MIXING AND TRANSPORTING

A. Measure, batch, mix and transport CLSM in accordance with the requirements of ASTM C94 and this Section.

B. Mix until there is uniform distribution of materials.

C. Discharge mixer completely prior to recharging.

D. After trial batch testing and mix acceptance, maintain slump during construction within plus or minus 1 inch of the design slump.

3.04 PLACING

A. Place controlled low strength material by method that preserves the quality of the material in terms of compressive strength and density.

B. Maintain fluid properties of the mix during placement:
   1. At point of placement, provide material that flows easily around, beneath, or through walls, pipes, conduits, or other structures.
   2. Do not place CLSM that has partially hardened or that has been contaminated by foreign materials.
   3. Handle and place CLSM using methods that minimize segregation of the mix.
   4. Deposit mix as near its final position as possible to avoid segregation due to rehandling or flowing.
   5. Contain and confine mix while it is fluid. Design containment structures and bracing at walls and forms to withstand lateral pressures of wet mix.

C. Lifts:
   1. Limit lift heights of CLSM placed against structures and other facilities that could be damaged due to the pressure from the CLSM, to the lesser of 3 feet or the lift height indicated on the Drawings.
   2. Do not place another lift of CLSM until the last lift of CLSM has set and gained sufficient strength to prevent additional lateral load against the forms or structure due to the weight of the next lift of CLSM.

D. Water conditions:
   1. Do not place CLSM in standing or flowing water.
   2. Do not permit water to flow over the surface of freshly placed or un-hardened CLSM.
   3. Do not submerge CLSM in water within 24 hours after placement.

E. Manage CLSM bleed water:
   1. Grade top surface of CLSM to drain away from the fill.
   2. Provide side containment that permits bleed water to drain to a contained management area away from the fill.

3.05 CURING AND PROTECTION

A. Curing:
   1. Prior to and during curing, install barriers to prevent equipment or personnel from falling into or becoming entrapped in CLSM.

B. Protect CLSM from:
   1. Damage from the elements.
   2. Damage of any nature during surrounding construction operations.

3.06 FIELD QUALITY CONTROL

A. Provide quality control over the Work of this Section as specified in Section 01 43 05 - Quality Assurance and Quality Control Requirements and as specified in this Section.

B. General:
   1. Engineer inspection and acceptance required prior to placement.
   2. Make provisions for and furnish all material for the test specimens and provide manual assistance to assist the Owner's Third-Party Testing Laboratory in preparing said specimens.

3.07 FIELD QUALITY ASSURANCE

A. Provide quality control over the work of this Section as specified in Section 01 43 05 - Quality Assurance and Quality Control Requirements.

B. Field inspections:
   1. Engineer shall provide on-site inspection for the Work of this Section.
   2. Advise Engineer of readiness to proceed at least 24 hours prior to each placement of CLSM.
   3. Required inspections:
      a. Engineer will observe the prepared areas. Do not place CLSM until Engineer has observed and accepted preparations.
   4. Record of inspections.

C. Field sampling and testing:
   1. During construction, Owner shall provide sampling and testing to determine whether the CLSM, as produced and placed, complies with the requirements specified.
      a. Make provisions for and furnish material for test specimens. Cooperate by allowing free access for Owner's independent testing firm to sample and test materials. Provide assistance in obtaining and preparing said specimens.
   2. Sample CLSM for testing in accordance with ASTM D5971.
   3. Required tests:
      a. Air content: Prepare sample and test in accordance with ASTM D6023.
      b. Compressive strength: Prepare and test cylinder specimens in accordance with ASTM D4832:
         1) Prepare 6-inch diameter by 12-inch high specimens for testing:
            a) Provide one set of specimens for each 150 cubic yards of CLSM placed, but not less than 1 set for each half day's placement.
            b) Prepare and test not less than 3 cylinders for each set.
            c) Place CLSM in the molds in accordance with ASTM D4832. Do not rod or otherwise consolidate the material in the mold.
            d) In accordance with ASTM D4832 recommendations for displacing bleed water at the top of the molds and refilling the molds before covering with a lid. Do not use air-tight lids.
         2) Place the cylinders in a safe location away from construction activities:
            a) Protect cylinders from bumping and impact.

b) Maintain temperature surrounding cylinders between 60- and 80-degrees Fahrenheit until delivery to the laboratory for testing.
c) After the first day, surround molds with a high humidity environment by covering with wet burlap, or equivalent highly absorptive material. Maintain saturation of the cover. Do not sprinkle water directly on the cylinders.

3) After 4 days, place the cylinders in a protective container for transport to the laboratory for testing:
a) Exercise caution in moving and transporting the cylinders since they are fragile and will withstand only minimal bumping, banging, or jolting without damage.
b) Transport container may be a box with a Styrofoam or similar lining that will limit jarring and bumping of the cylinders.

4) Upon receipt at the testing laboratory, place test cylinders in a moist curing room until dates for testing.

5) Do not remove test cylinders from molds until the day that cylinders is to be capped and tested.

6) Cap and test for compressive strength in accordance with ASTM D4832:
a) Do not perform initial compression test until the cylinders reach an age of at least 4 days.
b) Test 1 cylinder at 7 days and 2 at 28 days.

7) Compressive strength of the cylinders tested at 28 days shall be equal to or greater than the minimum required compression strength but shall not exceed maximum compression strength specified.

3.08 NON-CONFORMING WORK

A. When testing or observation indicates CLSM with properties outside the specified and accepted range, Engineer will issue instructions regarding disposition of nonconforming materials.

B. Engineer may:
1. Reject CLSM represented by those test specimens and require its removal and replacement.
2. Require modification of the mix design to provide CLSM with the properties specified.

C. Make such modifications at no additional expense to the Owner and with no adjustment to the schedule.

END OF SECTION

SECTION 31_23_35

TRENCHING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Trench excavation and trench backfill for pipelines, manholes, vaults, and appurtenances.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3).
   2. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

B. City of Santa Cruz Water System Standard Specifications.

C. City of Santa Cruz Public Works Standards.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning:
   1. Backfill: Material placed in trench above the pipe embedment zone.
   2. Bedding: Material placed under, around, and over pipes or ducts in trenches.
   3. Fine grading: Bedding material placed directly below pipes or ducts to provide support at the bottom of the trench and to bring those elements to required grades and elevations.
   4. Flexible pipe: Includes steel, ductile iron, thermoplastics such as polyvinyl chloride (PVC) and high-density polyethylene (HDPE), thermosetting plastics such as fiberglass-reinforced polymer (FRP), bar-wrapped concrete cylinder pipe, and corrugated steel pipes.
   5. Haunch zone: Material placed below and beside the pipe up to the pipe springline.
   6. Lift: A layer of soil or aggregate material, measured before compaction.
   7. Maximum density, Field Compaction: Soil density and water content when tested in accordance with ASTM D6938.
   8. Maximum density, Laboratory Compaction: Soil maximum density and optimum water content when tested in accordance with ASTM D1557.
   9. Pavement section: Includes pavement plus underlying courses such as base course and subgrade.
   10. Pipe embedment zone: Includes bedding, fine grading, and haunch zone.
   11. Pipe foundation: Material placed at the bottom of trench to provide support.

12. Pipe foundation: Stabilization material placed at the bottom of trench to provide support when the trench bottom is not firm, dry or uniform.
13. Pipe springline: A horizontal reference line located at mid-height, or halfway point, of a circular conduit, pipe, or tunnel. It is the maximum horizontal dimension or diameter of a circular conduit, pipe, or tunnel.
14. Rigid pipe: Includes reinforced non-cylinder concrete, reinforced concrete cylinder, prestressed concrete cylinder, vitrified clay, polymer concrete, cast iron, asbestos cement and cast-in-place pipes.

1.04 SUBMITTALS

A. As specified in Section 01 33 00 - Submittal Procedures.

B. Product data on soils and aggregates:
   1. Material source.
   2. Gradation.
   3. Test data to demonstrate compliance with requirements as specified in this Section.

C. Samples:
   1. Provide 50-pound sample of materials when requested by the Engineer.

D. Confirmation testing:
   1. Certification of Contractor's testing laboratory.
   2. Record copy report for tests performed by Contractor's testing laboratory.

PART 2 PRODUCTS

2.01 MATERIALS

A. As specified in Section 31_05_15 - Soils and Aggregates for Earthwork.

B. Class C concrete: As specified in Section 03_30_01 - Concrete Work.

C. Controlled low-strength material: As specified in Section 31_23_24 - Controlled Low Strength Material (CLSM).

PART 3 EXECUTION

3.01 PREPARATION

A. Stabilize excavations as specified in Section 31_50_00 - Excavation Support and Protection.

B. Perform subsurface utility engineering (SUE) for utility locating and verification prior to any excavation work and as specified in Section 33_05_01 - Subsurface Utility Engineering.

3.02 DEWATERING

A. As specified in City of Santa Cruz Water System Standard Specifications and Public Works Standards.

B. Refer to Section 31_23_22 - Dewatering for additional requirements.

3.03 TRENCH EXCAVATION

A. Excavate bottom of trench to depth indicated on the Drawings.

B. Areas of new fill or embankment:
   1. Prior to laying pipes or electrical service, place fill and compact as specified to not less than 2 feet above top of pipe, conduit, or duct bank.
   2. Excavate through fill for pipe trench.

C. Trench widths as specified in the following table:

Buried Pipe or Accessory	Minimum Trench Width	Maximum Trench Width
Nominal Pipe Diameter: 4-inch to 24-inch	OD + 18 inches	OD + 24 inches
Nominal Pipe Diameter: Greater than 24-inch	OD + 24 inches	OD + 36 inches
Manholes, vaults, valves, or other accessories	12 inches between outer surface and trench side or shoring	Not applicable

D. Potable water pipe and appurtenances:
   1. Lay in trenches separate from those used for sewers and recycled water.
   2. Unless otherwise specified or indicated on the Drawings, lay in trenches having cover of not less than 3 feet below surface of ground located at distance of not less than 10 feet clear horizontally from any parallel sewer and 1 foot clear vertically above any parallel sewer.

E. At road crossings or existing driveways:
   1. Provide notification, vehicular access, and traffic control as required by permits and special conditions.
   2. Provide temporary asphalt or plating for traffic or access at the end of each workday unless approved in writing by the Engineer.
   3. If unexpected utility conflicts or changed site conditions require trenchless technologies or temporary bridges, immediately notify the Engineer in writing. Approval is required before proceeding with construction.
   4. When trench width at top of pipe is increased beyond width specified in this Section because of soil conditions, safety requirements, or other reasons, Engineer approval for remedy is required without additional cost to the Owner:
      a. Remedy may include upgrade laying conditions or install stronger pipe designed in accordance with Specifications.

3.04 TRENCH BACKFILL - GENERAL

A. Trench area terminology and locations as indicated on the Drawings.

B. Place material, except CLSM and concrete, in maximum 6-inch lifts, measured before compaction.

C. Backfilling of manhole excavation: Conform to backfilling requirements for trenches as specified in this Section.

3.05 PIPE FOUNDATION

A. Provide trench bottom with firm, dry, uniform bearing surface at the grade indicated on the Drawings.

B. Excess excavation below elevation indicated on the Drawings will require installation of pipe foundation material to bring the trench bottom back to the elevation indicated on the Drawings at no additional cost to the Owner.
   1. Materials and placement:
      a. Stabilization material:
         1) Wrap stabilization material as specified in Section 31_32_18.04 - Stabilization Fabric.

C. If bottom of trench excavation consists of soil:
   1. Scarify bottom of trench to a depth of 8 inches below the grade indicated on the Drawings.
   2. Materials and placement:
      a. Recompact scarified material to 95 percent of maximum density.
      b. Stabilization fabric as specified in Section 31_32_18.04 - Stabilization Fabric.

D. If bottom of trench excavation consists of rock or any material that, by reason of its hardness, cannot be excavated to provide uniform bearing surface:
   1. Remove such rock or other material to a depth of not less than 4 inches below pipe embedment zone.
   2. Materials:
      a. CLSM.
      b. Class C concrete.

E. If bottom of trench excavation consists of mud or other soft unstable material:
   1. Remove such unacceptable material to a depth of not less than 18 inches below pipe embedment zone.
   2. Material and placement:
      a. Stabilization material:
         1) Wrap stabilization material as specified in Section 31_32_18.04 - Stabilization Fabric.

3.06 PIPE EMBEDMENT ZONE

A. Pipe displacement:
   1. Take necessary precautions in placement and compaction of bedding material to prevent displacement of piping.
   2. In event there is movement or floating of the piping, re-excavate, re-lay, and backfill the pipe.

B. Fine grading:
   1. Place 6 inches of approved haunch zone bedding material from the trench bottom to the bottom of the pipe or duct to provide support at the bottom of the trench and to bring those elements to required line and grade.

C. Depressions for joints or couplings:
   1. Excavate holes in the fine grading material at the bottom of the trench.
   2. Provide holes of sufficient width to provide ample room for grouting, banding, or welding as necessary for making joints and to ensure that pipe rests upon prepared trench bottom and not supported by any portion of the joint.

D. Flexible pipe:
   1. Pipe embedment zone:
      a. Compacted to a depth above pipe: 12-inch minimum.
      b. Materials and placement:
         1) Aggregate base course compacted to 95 percent maximum dry density.
         2) CLSM. Place gravel bags to support and set pipe to line and grade prior to CLSM placement. Place CLSM in lifts as necessary to prevent floatation.
         3) Sand.

3.07 BACKFILL

A. Trenches:
   1. Materials and placement:
      a. Native soil - select compacted to 90 percent maximum dry density.
      b. Imported fill compacted to 90 percent maximum dry density.
      c. Aggregate base course compacted to 90 percent maximum dry density.
      d. CLSM.

B. Trenches in rock:
   1. Backfill to top of rock.
      a. Materials and placement:
         1) CLSM.
         2) Class C concrete.
   2. Backfill from top of rock to grade, if applicable:
      a. Materials and placement:
         1) Aggregate base course compacted to 90 percent of maximum density.

C. Trenches below or within 10 feet of the outside perimeter of structures:
   1. Backfill to underside of aggregate base course below structure.

2. Materials and placement:
    a. Aggregate base course compacted to 95 percent of maximum density.
    b. CLSM.

D. Trenches in roadways and paved areas:
1. Backfill trench to underside of pavement.
2. Materials and placement:
    a. Aggregate base course compacted to 95 percent of maximum density.
    b. CLSM.

E. Trenches in areas outside the improved section of roadways or in open country:
1. Backfill to finished grade.
2. Materials and placement:
    a. Native soil, native soil - select, imported material, or aggregate base course compacted to 90 percent of maximum density.

F. Trenches under existing intersecting pipes, duct banks, or conduits larger than 3 inches in diameter:
1. Backfill from above top of new pipe embedment zone to springline of intersecting pipe or conduit:
    a. Extend backfill at least 2 feet on either side of intersecting pipe or conduit to ensure backfill material remains in place while other backfill is being placed.
    b. Materials and placement:
        1) CLSM, unless otherwise indicated on the Drawings.
2. Backfill remainder of trench:
    a. Materials and placement:
        1) CLSM.
        2) Class C concrete.

3.08 EXCESS MATERIAL

A. Remove excess excavated material from the Project site as specified in Section 31_00_00 - Earthwork.

3.09 FIELD QUALITY CONTROL

A. Provide field quality control for the Work as specified in Section 01 43 05 - Quality Assurance and Quality Control Requirements.

B. Confirmation tests: As specified in Section 31_00_00 - Earthwork.
1. Minimum frequency of confirmation testing:
    a. At each test location include tests for each type or class of backfill from bedding to finished grade.
    b. For trenches: 1 location every 200 linear feet.
    c. Along dirt or gravel road or off traveled right-of-way: 1 location at every 500 linear feet.
    d. Crossing paved roads: 1 location at each crossing.
    e. Under pavement cuts or within 2 feet of pavement edges: 1 location every 400 linear feet.

C. Compliance tests:
   1. Make periodic compliance tests to verify that compaction is meeting requirements as specified in this Section.
   2. Perform remedial work if compaction test fails to meet specified requirements using one of the following methods:
      a. Remove and replace backfill at the proper density.
      b. Other means acceptable to the Engineer.
   3. Retesting:
      a. Costs of retesting: Contractor is responsible for the costs of retesting required to confirm and verify that remedial work has brought compaction within specified requirements.
      b. Contractor's confirmation tests during performance of remedial work:
         1) Performance: Perform tests in manner acceptable to the Engineer.
         2) Frequency: Double amount specified for initial confirmation tests.

D. Piping system testing:
   1. As specified in Section 40_05_00.09 - Piping Systems Testing.

END OF SECTION

SECTION 31_32_18.04

STABILIZATION FABRIC

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Woven stabilization fabric used for subgrade enhancement.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D4355 - Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
   2. D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
   3. D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
   4. D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
   5. D4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.
   6. D6241 - Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe.

1.03 DEFINITIONS

A. Stabilization Fabric: Woven geotextile fabric manufactured from polypropylene yarns.

1.04 SUBMITTALS

A. Product data.

B. Samples.

C. Quality control submittals:
   1. Certificates of Compliance.
   2. Manufacturer's Installation Instructions.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Storage and protection:
   1. Furnish stabilization fabric in protective covers capable of protecting the fabric from ultraviolet rays, abrasion, and water.

1.06 PROJECT CONDITIONS

A. Field measurements:
   1. Take field measurements to determine the exact lengths and dimensions of the surfaces to receive the fabric.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Propex, Geotex 315ST.
   2. Ten Cate Geosynthetics, Mirafi 600X.

2.02 MATERIAL REQUIREMENTS

A. Physical properties: Meet the following minimum requirements:

Property(1)	Test Method	Unit	Requirements(1)
Grab Tensile Strength	ASTM D4632	lbs	315
Grab Elongation	ASTM D4632	%	15
Trapezoid Tear Strength	ASTM D4533	lbs	120
CBR Puncture Resistance	ASTM D6241	lbs	900
UV Resistance (strength retained at 500 hrs)	ASTM D4355	%	70
Apparent Opening Size (AOS)	ASTM D4751	US sieve	40
Permittivity	ASTM D4491	sec^{-1}	0.05
Flow Rate	ASTM D4491	gpm/ft^2	4
Note: (1) Minimum average roll values.			

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Verify that conditions are satisfactory for the installation of stabilization fabric.

3.02 PREPARATION

A. Surface preparation: During grading operations, take care not to disturb the subgrade. This may require use of lightweight dozers for low strength soils such as saturated, cohesionless, or low cohesion soils.

B. Prior to placement of fabric: Prepare surface to smooth condition free of debris, depressions, or obstructions that may damage the fabric.

3.03 INSTALLATION

A. Follow manufacturer's installation instructions and as complimented in this Section.

B. Place the stabilization fabric smoothly without folds or wrinkles.

C. Use special care when placing the stabilization fabric in contact with the soil so that no void spaces occur between the stabilization fabric and the prepared surface.

D. Overlap the parallel rolls and ends of rolls a minimum of 24 inches and not less than recommended by manufacturer.

E. Do not drag stabilization fabric across subgrade.

F. Make overlaps at ends of rolls in the direction of the aggregate placement with the previous roll on top.

G. Use lightweight dozers, if necessary. Do not allow equipment directly on stabilization fabric.

3.04 FIELD QUALITY CONTROL

A. Inspection: Before covering, the condition of the fabric will be observed by the Engineer to determine that no holes or rips exist in the fabric. Repair all holes or rips by placing a new layer of fabric extending beyond the defect in all directions, a distance equal to the minimum overlap required for adjacent rolls.

END OF SECTION

SECTION 31_50_00

EXCAVATION SUPPORT AND PROTECTION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Designing, providing, maintaining, and removing excavation support and protection.

1.02 REFERENCES

A. American Society of Civil Engineers (ASCE):
   1. Guidelines of Engineering Practice for Braced and Tied-Back Excavations.

B. California Code of Regulations (CCR):
   1. Title 8 - Industrial Relations:
      a. Division 1. Department of Industrial Relations:
         1) Chapter 4. Division of Industrial Safety:
            a) Subchapter 4. Construction Safety Orders:
               (1) Article 6. Excavations.

C. Department of the Navy Naval Facilities Engineering Command (NAVFAC):
   1. Design Manual 7.2 - Foundations and Earth Structures.
   2. Design Manual 7.3 - Soil Dynamics and Special Design Aspects.

D. State of California Department of Transportation (Caltrans):
   1. Caltrans California Trenching and Shoring Manual.

E. United States Steel Corporation (USS):
   1. Steel Sheet Piling Design Manual.

F. City of Santa Cruz Water System Standard Specifications.

G. City of Santa Cruz Public Works Standards.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning:
   1. General engineering design practice: In area of the Project, performed in accordance with recent engineering literature on subject of shoring and stability of excavations.
   2. Shoring: A temporary structural system designed to support vertical faces, or nearly vertical faces, of soil or rock for purposes of excavation. Shoring includes cantilevered sheet piling, internally braced sheet piling, slurry walls,

soldier piles and lagging, and other similar shoring systems. Sloping of the soil is not shoring.

3. Support levels: Level of tiebacks, wales, rakers, bottom of excavation, and other types of support.

1.04 SUBMITTALS

A. Shop Drawings and calculations:
   1. Calculations for different load, support, and other conditions that occur during the sequence of installation of shoring, construction of facilities protected by shoring, and sequence of removal of shoring.
   2. Sketches showing the condition at various stages of installation and removal of shoring.
   3. Show on plan shoring, structures, pipelines, and other improvements located near shoring.
   4. When utilities penetrate shoring, show location of penetrations on elevation of sides of shoring.
   5. Show details for ground support and sealing around utility penetrations.
   6. Indicate method used for installing driven shoring.

B. Control points and schedule of measurements:
   1. Submit location and details of control points and method and schedule of measurements.
   2. Survey data.

C. Detailed sequence of installation and removal of shoring:
   1. Consider effects of ground settlement in sequence of installation and removal of shoring.
   2. Provide sketches showing conditions at various stages in sequence of installation and removal of shoring.

D. Furnish Submittals for excavation support and protection as complete package and include items required in this Section:
   1. Incomplete Submittals will not be reviewed and will be returned for resubmittal as a complete package.

1.05 SEQUENCING

A. Do not begin construction of any shoring or excavation operations until:
   1. Submittals for shoring and dewatering have been accepted.
   2. Control points as specified in this Section and on existing structures and other improvements as indicated on the Drawings have been established and surveyed to document initial elevations and locations.
   3. Materials necessary for installation are on site.

B. Furnish Submittals a minimum of 60 days prior to scheduled date to begin excavation work.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Where general engineering design practice is specified, provide Drawings and calculations that are performed and signed by civil or structural engineer registered in the state where the Project is located:
   1. Clearly disclose assumptions made, criteria followed, and stress values used for materials being used in design calculations.
   2. Submit list of references acceptable to the Engineer that substantiate appropriateness of design assumptions, criteria, and stress values.

B. Design requirements:
   1. General:
      a. In accordance with requirements in CCR, Title 8, Chapter 4, Subchapter 4, Article 6 for trench excavations 5 feet or more in depth and for trenches less than 5 feet in depth when there is potential for cave-in:
         1) Where such designs vary from excavation support standards set forth in CCR, Title 8, Chapter 4, Subchapter 4, Article 6, submit design calculations pursuant to general engineering design practice.
         2) Provide means for safe and stable excavations that are not less effective than required in CCR, Title 8, Chapter 4, Subchapter 4, Article 6.
         3) The preceding requirements do not apply to trench excavation support in accordance with standards set forth CCR, Title 8, Chapter 4, Subchapter 4, Article 6.
      b. Dewatering:
         1) Dewater soil inside shoring as specified in City of Santa Cruz Water System Standard Specifications and Public Works Standards.
         2) Do not lower groundwater outside of shoring more than 1 foot.
         3) Recharge groundwater outside shoring to limit groundwater draw down outside of shoring to amount specified above.
      c. When electing to design with material stresses for temporary construction higher than allowable stresses prescribed in the California Building Code as specified in Division 01, increase in such stresses shall not exceed 10 percent of value of prescribed stresses.
      d. Minimum safety factor used for design shall not be less than 1.5.
      e. Calculated minimum depth of penetration of shoring below bottom of excavation shall be increased not less than 30 percent if full value of allowable passive pressure is used in design.
      f. Maximum height of cantilever shoring above bottom of excavation shall not exceed 15 feet. Use braced shoring when height of shoring above bottom of excavation exceeds 15 feet.
      g. Location of point of fixity for shoring shall not be less than half calculated minimum embedment depth below bottom of excavation.
      h. Generally acceptable references for design of shoring and excavations are as follows:
         1) ASCE Guidelines of Engineering Practice for Braced and Tied-Back Excavations.
         2) Caltrans California Trenching and Shoring Manual.
         3) NAVFAC Design Manual 7.2.

4) NAVFAC Design Manual 7.3.
5) USS Steel Sheet Piling Design Manual.

i. Shoring design shall be performed by one of following engineering firms. Include cost for shoring design in bid:
1) Delve Underground.
2) J.M. Turner Engineering, Inc.

2. Soldier piles and lagging:
a. Provide lagging over full face of excavation. Joints between pieces of lagging shall be tight to prevent loss of soil.
b. Provide full face lagging around penetrations through lagging.
c. If the soldier piles are installed in predrilled holes and are not concrete encased, fill predrilled holes with controlled low strength material as specified in Section 31_23_24 - Controlled Low Strength Material (CLSM) after soldier piles are installed.
d. Assumed effective width for passive soil resistance:
1) Effective width of driven soldier piles shall not exceed 2 times width of pile.
2) Effective width of CLSM encased soldier piles in drilled holes shall not exceed 2 times width of pile.
3) Effective width of concrete encased soldier piles shall not exceed 2 times width of concrete encasement.
e. Fill voids behind lagging with gravel or other material acceptable to the Engineer.
f. Apply loads from tie back soil, rock, or deadman anchors concentrically to soldier piles or wales spanning between soldier piles:
1) Wales shall be back-to-back double channels or other members acceptable to the Engineer.
2) Do not eccentrically load structural section of soldier piles or wales.
g. Design soldier piles for downward loads, including vertical loads from tieback anchors.

3. Soil anchors, rock anchors, and deadman anchors:
a. Design tieback anchors for a safety factor of not less than 2 times calculated load from shoring.
b. Proof load production anchors to 150 percent of calculated load from shoring.
c. Lock off production anchors at calculated load from shoring.
d. Length of soil anchors used to calculate resistance to load from shoring shall not include any length within potential active pressure soil failure zone behind face of shoring.
e. Design tie rods for tieback anchors for 130 percent of calculated load from shoring.
f. Design tie rods for tieback anchors for 150 percent of the calculated load from shoring when tie rod couplers are used and for other conditions where stress concentrations can develop.

4. Set inside face of shoring back from structure not less than greater of following:
a. 5 feet from face of wall.
b. 2 foot-6 inches from edge of foundation.
c. Depth of excavation below bottom of foundation.

C. Performance requirements:
    1. General:
        a. Support faces of excavations and protect structures and improvements in vicinity of excavations from damage and loss of function due to settlement or movement of soils, alterations in ground water level caused by such excavations, and related operations.
        b. Specified provisions:
            1) Complement, but do not substitute or diminish, obligations of the Contractor for furnishing of safe place of work pursuant to provisions of the Occupational Safety and Health Act of 1970 and its subsequent amendments and regulations and for protection of work, structures, and other improvements.
            2) Represent minimum requirement for:
                a) Number and types of means needed to maintain soil stability.
                b) Strength of such required means.
                c) Methods and frequency of maintenance and observation of means used for maintaining soil stability.
    2. Provide safe and stable excavations by means of sheeting, shoring, bracing, sloping, and other means and procedures, such as draining and recharging groundwater and routing and disposing of surface runoff, required to maintain stability of soils and rock.
    3. Provide support for trench excavations for protection of workers from hazard of caving ground.
    4. Provide shoring:
        a. Where, as result of excavation work and analysis performed pursuant to general engineering design practice, as defined in this Section:
            1) Excavated face or surrounding soil mass may be subject to slides, caving, or other types of failures.
            2) Stability and integrity of structures and other improvements may be compromised by settlement or movement of soils, or changes in soil load on structures and other improvements.
        b. For trenches 5 feet and deeper.
        c. For trenches less than 5 feet in depth, when there is potential for cave-in.
        d. Where indicated on the Drawings.
    5. For safe and stable excavations, use appropriate design, construction, and maintenance procedures to minimize settlement of supported ground and to prevent damage to structures and other improvements, including:
        a. Using stiff shoring systems.
        b. Following appropriate construction sequence.
        c. Using shoring system that is tight enough to prevent soil loss through the shoring.
        d. Using shoring system that extends far enough below bottom of excavation to prevent piping, heave, or flow of soil under shoring.
        e. Design for safety factor of not less than 1.50.
        f. Providing surface runoff routing and discharge away from excavations.
        g. Where dewatering inside shoring is necessary, recharge groundwater outside shoring as necessary to prevent settlement in area surrounding shored excavation.

h. Where sheet piling is used, use interlocking type sheets:
    1) Sheet piles shall be continuous and driven in interlock.
    2) If bottom of the excavation is located below the water table, use “ball and socket” or “thumb and finger” type interlock.
i. Not applying shoring loads to existing structures and other improvements.
j. Not changing existing soil loading on existing structures and other improvements.
k. Provide welded steel packing between soil retaining members such as sheet piles and wales and similar members when gap exceeds 1/2 inch before wales are loaded.

PART 3 EXECUTION

3.01 CONSTRUCTION

A. Installation of shoring:
    1. Install means for providing safe and stable excavations as indicated in Submittals.

B. Removal of shoring:
    1. Except for slurry walls, and similar shoring systems, remove shoring by completion of the Work.
    2. Select shoring system and method of removal, which will minimize soil that sticks to shoring from creating voids and causing settlement.
    3. To prevent settlement caused by pulling shoring, fill voids with pressure injected grout:
        a. Inject grout starting at bottom of void and progressively fill void to grade.
        b. Minimize length of shoring removed ahead of grouting operation and limit time void is left ungrouted to prevent void from closing up before being grouted.
    4. Pressure preservative treated wood lagging may be left in place if acceptable to the Engineer.

C. Control points:
    1. Establish control points on shoring and on structures and other improvements in vicinity of excavation for measurement of horizontal and vertical movement:
        a. Set control points on shoring support system:
            1) Set points at distances not exceeding 25 feet at each support level.
    2. Promptly upon completion of construction of control points survey control points. Submit copy of field notes with measurement.
    3. Perform horizontal and vertical survey and measurement of control points at least once every week:
        a. Field notes shall show current measurement and change in measurement from first measurement taken.
    4. Set control points on corners of existing structures and on curbs, manholes, and other improvements at the locations indicated on the Drawings.
    5. Provide plumb bobs with horizontal targets indicating original position of plumb bobs in relation to shoring at control points.

D. Maintenance:
   1. Where loss of soil occurs, plug gap in shoring and replace lost soil with fill material acceptable to the Engineer.
   2. Where measurements and observations indicate possibility of failure or excessive movement of excavation support, determined in accordance with general engineering design practice, take appropriate action immediately.

END OF SECTION

SECTION 32_01_15

PAVEMENT RESTORATION AND REHABILITATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Resurfacing roads and paved surfaces in which surface is removed or damaged by installation of new work.

B. Contractor shall complete pavement restoration and rehabilitation in accordance with City of Santa Cruz Water System Standard Specifications and this Section. City of Santa Cruz Water System Standard Specifications and Public Works Standards shall govern in the event of a conflict.

1.02 REFERENCES

A. City of Santa Cruz Water System Standard Specifications.

B. City of Santa Cruz Public Works Standards.

C. City of Capitola Public Improvement Design Standards.

1.03 SUBMITTALS

A. Mix designs:
   1. Prior to placement of asphalt concrete, submit full details, including design and calculations for the asphalt concrete mix proposed.
   2. Submit gradation of aggregate base.
   3. Submit proposed mix design of Portland cement concrete.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Performance requirements:
   1. Limiting dimensions:
      a. Determine the exact lengths and dimensions of such roads, pavements, parking areas, and walks that will require removal and replacement for new work.
      b. Join existing surfaces to terminals of new surfacing in smooth juncture.

B. Work within the City of Capitola right-of-way (pavement restoration outside of the south driveway required for installation of the 12-inch FL interim connection under the Additive Bid Item) shall comply with City of Capitola Public Improvement Design Standards.

2.02 MATERIALS

A. Aggregate base course: As specified in Section 31_05_15 - Soil and Aggregates for Earthwork.

B. Asphalt pavement:
   1. Asphalts:
      a. Asphalt binder: Steam-refined paving asphalt, PG 64-10, in accordance with conforming to Section 92-1.02B “Performance Grades Asphalt Binders” of the Caltrans Standard Specifications.
      b. Tack coat: Asphaltic emulsion, Grade SS-1, conforming with Section 94 of the Caltrans Standard Specifications.
   2. Asphalt aggregate:
      a. Aggregate shall be in accordance with Section 39-2.02B(4)(b) of the Caltrans Standard Specifications for Type A HMA grading:
         1) For pavement placed in multiple lifts:
            a) Aggregate for the final lift (surface layer) shall be 1/2-inch maximum, medium.
            b) Aggregate for other lifts/layers shall be 3/4-inch maximum, medium.
      b. For pavements placed in a single lift:
         1) Aggregate shall be 1/2-inch maximum, medium.
   3. Asphalt pavement shall be produced in a batch mixing plant, a continuous pugmill mixing plant, or dryer-drum mixing plant:
      a. Proportioning shall be in accordance with Section 39-2.01B(8)(a) of the Caltrans Standard Specifications.
      b. Mixing shall be in accordance with Section 39-2.01B(8)(a) of the Caltrans Standard Specifications.

C. Portland cement concrete replacement material: Class A concrete as specified in Section 03_30_01 - Concrete Work.

2.03 EQUIPMENT

A. Roads, pavements, parking areas, and walks:
   1. Equipment requirements: Good condition, capable of performing work intended in satisfactory manner.

PART 3 EXECUTION

3.01 INSTALLATION

A. Aggregate surface removal replacement:
   1. When trench cut is in aggregate surfaced areas, replace aggregate base course material with material matching existing material compacted to 95 percent of its maximum density.

B. Pavement removal and temporary asphalt replacement:
   1. Install temporary asphalt pavement or first course of permanent pavement replacement immediately following backfilling and compaction of trenches that have been cut through existing pavement.
   2. Except as otherwise provided, maintain this temporary pavement in safe and reasonably smooth condition until required permanent pavement is installed.
   3. Remove and dispose of temporary paving from project site.
   4. Where longitudinal trench is partly in pavement, replace pavement to original pavement edge, on a straight line, parallel to centerline of roadway.
   5. Where no part of longitudinal trench is in pavement, surfacing replacement shall only be required where existing surfacing materials have been removed.

C. Asphalt pavement replacement:
   1. Replace asphalt pavement to same thickness as adjacent pavement and match as nearly as possible adjacent pavement in texture, unless otherwise indicated on the Drawings.
   2. Cut existing asphalt pavements to be removed for trenches or other underground construction by wheel cutter, clay spade, or other device capable of making neat, reasonably straight and smooth cut without damaging adjacent pavement. Cutting device operation shall be subject to acceptance of Engineer.
   3. Cut and trim existing pavement after placement of required aggregate base course and just prior to placement of asphalt concrete for pavement replacement, and paint trimmed edges with material for painting asphalt concrete pavement immediately prior to constructing new abutting asphalt pavements. No extra payment will be made for these items, and costs incurred in performing this work shall be incidental to pipe laying or pavement replacement.
   4. Conform replacement of asphalt pavement to contour of original pavement.

D. Portland cement concrete pavement replacement:
   1. Where trenches lie within Portland cement concrete section of streets, alleys, sidewalks, and similar concrete construction, saw cut such concrete (to a depth of not less than 1-1/2 inches) to neat, vertical, true lines in such manner adjoining surfaces are not damaged.
   2. Place Portland cement concrete replacement material to dimension as indicated on the Drawings.
   3. Provide expansion joints that match existing.
   4. Before placing replacement concrete, thoroughly clean edges of existing pavement and wash with neat cement and water.
   5. Surface finish: Wood float finish.

E. Curb, gutter, and sidewalk replacement:
   1. Where any concrete curb, gutter, or sidewalk has been removed or displaced, replace to nearest construction joints with new Class A curb, gutter, or sidewalk to same dimensions and finish as original construction that was removed:
      a. Provide expansion joints of same spacing and thickness as original construction.

3.02 FIELD QUALITY CONTROL

A. Control the quality of Work and shall provide adequate testing to ensure compliance with these Specifications:
   1. Type and size of the samples shall be suitable to determine conformance with stability, density, thickness, and other specified requirements:
      a. Use an approved power saw or core drill for cutting samples.
      b. Furnish tools, labor, and materials for cutting samples, testing, and replacing the pavement where samples were removed.
      c. Take a minimum of 1 sample for every 4,000 square feet of asphalt pavement placed.
   2. Where open graded friction course is to be placed, core samples shall be taken prior to friction course placement.

B. Asphalt pavement shall match the grades indicated on the Drawings and shall be completely free from unintended hollows and high spots:
   1. After completion of paving work, paving shall be flooded with water:
      a. Any ponding that results in standing water greater than 3/4 inch in depth shall be ringed with chalk.
      b. Such hollows shall be corrected by removing and replacing the asphalt concrete.
      c. Asphalt concrete patch shall be square and at least 1-inch thick when conforming to existing surfacing.
      d. Tapering or feathering is not allowed.

C. Perform in-place density and compaction tests of the completed pavement in accordance with California Test Method Number 375, to determine compliance with the specified requirements. Submit test results to Engineer for approval.

D. Cracks, settling of surface, improper drainage, improper compaction, and sloppy connection to previously laid surfaces will be construed as improper workmanship and will not be accepted.

E. Concrete as specified in Section 03_30_01 - Concrete Work.

F. Inspection:
   1. Asphalt concrete:
      a. Lay 10-foot straightedge parallel to centerline of trench when the trenches run parallel to street, and across pavement replacement when trench crosses street at angle.
      b. Remove and correct any deviation in cut pavement replacement greater than 1/4 inch in 10 feet.
   2. Portland cement concrete replacement pavement:
      a. Lay 10-foot straightedge either across pavement replacement or longitudinal with centerline of gutter or ditch.
      b. Remove and correct any deviation in cut pavement replacement greater than 1/4 inch in 10 feet.

END OF SECTION

SECTION 33_05_01

SUBSURFACE UTILITY ENGINEERING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Requirements for subsurface utility engineering (SUE) as part of the Work for new pipelines.

1.02 REFERENCES

A. American Society of Civil Engineers (ASCE):
   1. 38-02 Standard Guideline for the Collection and Depiction of Existing and Subsurface Utility Data.

1.03 DEFINITIONS

A. General: Definitions used in this Section are in accordance with ASCE 38-02.

1.04 REQUIREMENTS

A. Existing utilities indicated on the Drawings are approximate only and are provided based on the best information available by use of reports listed in Section 00 73 01 - Supplementary Conditions.

B. Existing utilities are shown for the convenience of Contractor only:
   1. It is the Contractor’s responsibility to field verify the vertical and horizontal location of all utilities including those not indicated or incorrectly indicated on the Drawings.

C. Contractor is responsible to review all geotechnical reports, record drawings, and Contract Documents.

D. Coordinate with utility locator, such as CALL BEFORE YOU DIG, and other affected entities when they have jurisdiction over the project site.

E. Contractor is responsible for protecting all utilities encountered:
   1. Before any excavation, follow requirements of Section 01 14 00 - Work Restrictions.
   2. If a conflict exists between what is indicated on the Drawings and what exists in the field, Contractor shall notify Engineer immediately.

F. Where scheduled, provide subsurface utility engineering services by a Civil Engineer registered in the state the project is located in accordance with ASCE 38-02.

G. Requirements: The SUE shall entail the following at a minimum:
   1. Review of existing record drawings.

2. Geophysical methods such as ground-penetrating radar.
3. Soft excavation to locate known utilities along the proposed pipeline alignment.
4. Open trench excavation to locate unknown utilities along the proposed pipeline alignment.
5. Utilization of field survey by a Professional Land Survey licensed in the state the project is located for determination of vertical and horizontal locations.

1.05 QUALIFICATIONS

A. General: Contractor shall utilize the services of a qualified subconsultant for SUE services with minimum qualifications that include but are not limited to:
   1. Minimum of 5 years of SUE experience in the state the project is located in where providing vertical and horizontal locations of utilities in accordance with ASCE 38-02 utility quality level A was required.
   2. Completion of 5 SUE projects of equal or greater magnitude within the past 5 years.

1.06 SUBMITTALS

A. Shop drawings:
   1. Contractor shall submit all SUE information as follows:
      a. Plan drawings that clearly illustrate vertical and horizontal location of known and unknown utilities:
         1) Horizontal location shall include northing and easting coordinates.
      b. Identifies size and material and service for known utilities.
      c. Identify size and material for unknown utilities.
   2. Review of shop drawings and calculations by Engineer and Owner are for record only.
   3. Drawings shall be performed, stamped, and endorsed by a Civil Engineer registered in the state the project is located.
   4. Field survey information shall be performed, stamped, and endorsed by a Surveyor registered in the state the project is located.

B. Detailed sequence of SUE:
   1. Submit a schedule for all SUE events that shows start, end, and intermediate milestones.
   2. Provide sketches showing the conditions at various stages in the sequence of SUE.

C. Submit submittals for stability of excavations as a complete package and include all items required in this Section:
   1. Incomplete submittals will not be reviewed and will be returned for resubmittal as a complete package.

1.07 SEQUENCING AND SCHEDULING

A. Coordinate all Work with restrictions provided in Section 01 14 00 - Work Restrictions.

B. Do not begin Work until submittals have been accepted by Engineer and until equipment and materials necessary for installation are on site.

C. Submit submittals a minimum of 30 days prior to the scheduled date to begin excavation work.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 SUE SCHEDULE

A. Provide SUE services for the following pipelines and utilities.

Description	Reference Drawings
Existing Communication Conduit (multiple)	08C02, 08E01
Existing Electrical Duct Bank (multiple)	08C02, 08E01
Existing 2-inch Backwash	08C02, 08C03
Existing 10-inch Potable Water	08C02
Existing 8-inch Raw Water	08C02
Existing 3-inch Sludge Drain Line	08C02, 08C03
Existing 3-inch Floor Drain Line	08C02, 08C03
Existing 12-inch Storm Drain (Interim Connection)	08C02, 08C03
Existing Unknown “GPR”	08C02
Existing 10-inc Raw Water (Abandoned)	08C02

END OF SECTION

SECTION 33_05_61.01

CONCRETE MANHOLES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Manhole frames and covers.
   2. Manhole grade rings.
   3. Manholes cones and risers.
   4. Manhole bases.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

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

B. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. C33 - Standard Specification for Concrete Aggregates.
   3. C150 - Standard Specification for Portland Cement.
   4. C443 - Standard Specification for Joints for Concrete Pipe and Manholes Using Rubber Gaskets.
   5. C478 - Standard Specification for Circular Precast Reinforced Concrete Manhole Sections.
   6. C990 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint.
   7. C923 - Standard Gide for In-Plant Performance Evaluation of Automatic Pedestrian SNM Monitors.
   8. C1244 - Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill.

C. International Organization of Standardization (ISO):
   1. 9001 - Quality Management Standard.

1.03 SUBMITTALS

A. Submit as specified in Section 01 33 00 - Submittal Procedures.

B. Shop Drawings:
   1. Manufacturer's catalog data and details of following items for approval:
      a. Frame and covers.
      b. Grade rings.
      c. Manhole cones and risers.
      d. Manhole bases, if precast.
   2. Manhole construction details, jointing methods, connection details, materials, and dimensions.
   3. Repair procedures and details.

C. Calculations and criteria used in manhole design including material properties, loadings, load combinations, and dimensions assumed.

D. Test methods and results including certification that the manhole riser exceeds the minimum requirements in accordance with ASTM C478.

E. Sealed drawings and design calculations by a registered Professional Engineer licensed in the State where the project is located.

F. Certificates:
   1. ISO 9001 certificate by a third party confirming that ASTM test reports are valid and up to date at the time of the bid and during construction period.
   2. Manufacturer's Certificate of Source Testing.

1.04 PRODUCT REQUIREMENTS

A. As specified in Section 01 61 00 - Common Product Requirements.

B. Provide suitable quantities of lifting equipment to handle the manholes/risers and castings:
   1. In no case shall any equipment be used that is not rated to handle the intended loading or conditions of use to which it will be subjected, or which will damage or gouge the manhole components.
   2. Dragging or dropping the manhole components shall not be allowed.

C. Source Testing:
   1. Perform pre-production and post-production tests by manufacturer staff with a minimum of five years of experience in quality control, inspection, and testing of manholes.
      a. In lieu of this experience, witness of tests by up to three full-time Owner representatives.
   2. Examine each completed manhole section for dimensional requirements, strength, and workmanship.
   3. Complete required testing in accordance with ASTM C478.
   4. Provide the Manufacturer's Certificate of Source Testing.

1.05 DESIGN CRITERIA

A. Manholes shall not include steps.

B. Manhole lids: Locking type.

C. Manhole bases:
   1. Constructed as part of the pipe installation or using tee risers.

D. Manhole riser:
   1. Made of the same pipe material selected for the project, providing a sealed connection between the pipe base and riser as indicated on the Drawings.
   2. Manufactured specifically for this project and no materials shall be furnished from stock unless approved by the Engineer.

E. Manhole provider shall coordinate with the pipe manufacturer for dimensions and connections.

F. Manhole systems:
   1. Provided by a single manufacturer.

G. Frames and covers:
   1. Provided by a single manufacturer unless approved by the Engineer.

1.06 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manhole grade rings, cones, and risers:
   1. In accordance with City of Santa Cruz Public Works Department Standard Details and Specifications for manholes located within the Beltz 8 site.
   2. In accordance with County of Santa Cruz Public Works Standard Details and Specifications for manholes located within the 38th Avenue right-of-way.

B. Manhole frames and covers: Manufacturers: One of the following, or equal.
   1. In accordance with City of Santa Cruz Public Works Department Standard Details and Specifications for manholes located within the Beltz 8 site.
   2. In accordance with County of Santa Cruz Public Works Standard Details and Specifications for manholes located within the 38th Avenue right-of-way.

2.02 BASIS OF DESIGN

A. Design in accordance with local jurisdiction requirements, DCSWCS, including, but not limited to, the following:
   1. Manhole frames and covers.
   2. Manhole diameter tolerance.
   3. Manhole length.
   4. Manhole cover bolting.
   5. Manhole backfill.

B. Structural design calculations:
    1. Load rating of manhole:
        a. Design to support an AASHTO Standard Specifications for Highway Bridges, H-20 vehicle loading.
    2. Resist buoyancy:
        a. Design with sufficient bottom anchorage and side friction to resist buoyancy.
        b. Depths will be as indicated on the Drawings.
        c. Refer to the geotechnical report for soil condition, including fully saturated soil conditions.
        d. Anti-flotation flange:
            1) Exterior of manhole riser shall incorporate a 3-inch wide flange at its base.
            2) Upon joining of manhole riser to pipe tee, place sufficient concrete around tee and manhole riser to prevent buoyancy.
            3) Encase anti-flotation flange in a minimum of 6 inches of concrete.
        e. Concrete ballast:
            1) Pour sufficient concrete around tee-base pipe fitting and manhole riser base to prevent buoyancy in accordance with manufacturer's recommendations.

C. Manholes, grade rings, risers, and bases:
    1. Manhole:
        a. Nominal size or as indicated on the Drawings.
    2. Grade rings:
        a. At least one but not more than two grade rings shall be used.
        b. Maximum total distance from top of cone section to final grade: 18 inches.
    3. Cone and riser sections:
        a. As specified in this Section and as indicated in the Owner standard details or on the Drawings.
        b. Cone sections shall be concentric or eccentric as indicated in the Owner standard details or as indicated on the Drawings.
    4. Manhole bases:
        a. As specified in this Section and as indicated in the Owner standard details or on the Drawings.
        b. Provide corrosion protection system on unlined concrete.

D. Threaded lifting inserts:
    1. Design inserts to be fully threaded:
        a. Do not fully penetrate through entire manhole wall.
    2. Provide lifting device compatible with spreader bar and chains, hooks and slings.
    3. Design with minimum safety factor of 4.0.
    4. Do not use reinforcing steel bars.

2.03 MATERIALS

A. Cast iron manhole frames and covers.
    1. In accordance with ASTM A48.
    2. Covers: Bolted as specified.

3. Concrete collars: As indicated on the Owner standard details or on the Drawings.

B. Manhole bases, risers, and grade rings:
   1. Cement: Type II or Type V Portland cement in accordance with ASTM C150.
   2. Concrete aggregates: In accordance with ASTM C33, gradation as specified in approved mix design.
   3. Sections: Steel reinforced.
   4. Precast concrete sections: Manufactured by a process that will produce a dense, homogeneous concrete ring.
   5. Top and bottom of sections: Parallel.

C. Joint sealant:
   1. Preformed, cold applied flexible joint sealant in accordance with ASTM C990 and ASTM C443.
   2. Manufacturers: One of the following, or equal.
      a. Henry Corp., Ram-Nek.
      b. Kent Seal - Hamilton Kent Corp.

2.04 COMPONENTS

A. Pipe stubs:
   1. Provide pipe stubs at manhole locations and in accordance with details indicated on the Drawings and as specified.
   2. Plugging stubs:
      a. Plug stubs with vitrified clay stopper, brick plug, or other materials as indicated on the Drawings.
      b. Unless otherwise indicated on the Drawings, comply with following:
         1) Stubs up to and including 21 inches: Vitrified clay stoppers.
         2) Stubs greater than 21 inches: Brick plugs.

B. Resilient pipe connectors:
   1. Unless otherwise indicated on the Drawings or specified, provide a flexible compression type connector between manhole and pipes entering and leaving the manhole in accordance with ASTM C923.
   2. Resilient pipe connectors:
      a. Manufacturers: The following or equal.
         1) A-LOK Premium.

C. Threaded lifting inserts.

D. Drop manholes:
   1. Construct drop manholes at locations and in accordance with details indicated on the Drawings.
   2. Provide inside diameter of drop inlet pipe the same as intercepted sewer unless otherwise indicated on the Drawings or specified in this Section.
   3. Furnish and set fittings as indicated on the Drawings.

2.05 IDENTIFICATION MARKINGS

A. Identification marks on the exterior of bases, risers, grade rings, and include the following information:
   1. Date of manufacture of the item.
   2. Name or trademark of the manufacturer.
   3. Internal diameter in inches.
   4. Number of the manhole as indicated on the Drawings.

2.06 QUALITY CONTROL

A. Manufacturer to provide permanent quality control department and laboratory facility capable of performing inspections and testing as specified by this Section.

B. Material testing, inspection procedures, and manufacturing process are subject to inspection by the Owner or Owner's representative.

C. Perform manufacturer's tests and inspections in accordance with the referenced standards and as specified in this Section including the following:
   1. Provide the Manufacturer's Certificate of Source Testing as specified in Section 01 61 00 - Common Product Requirements.
   2. Manufacturer shall make available services of representative throughout the project duration when deemed necessary by the Engineer.
   3. Calibrate within last 12 months for equipment such as scales, measuring devices and calibration tools used in the manufacturing of pipe:
      a. Each device used in the manufacture of manholes is required to have a tag recording date of last calibration.
      b. Devices are subject to inspection by the Engineer.

D. Furnish labor necessary to assist the Engineer in inspecting manholes upon delivery.

E. Remove rejected manholes immediately.

PART 3 EXECUTION

3.01 MANHOLE INSTALLATION

A. Excavate and backfill as specified in Section 31_23_35 - Trenching and as indicated on the Drawings and in the specifications.

B. Maintain identification markings on installed pieces throughout installation.

C. Do not use sections with chips or cracks in the joint.

D. Engineer may inspect manhole sections, prior to installation.

E. Repair of manhole sections damaged during installation in accordance with manufacturer's repair procedures, with the concurrence of the Engineer.

F. Install joint sealant material in accordance with manufacturer's instructions:
   1. Completed manhole: Rigid and watertight.

G. Fill threaded lifting inserts with grout.

H. Lay grade rings on joint sealant with sides plumb and tops level.

I. Set frame and covers as specified and as indicated on the Drawings.

J. Apply damp proofing as specified in Section 07_11_00 - Dampproofing, and as indicated on the Drawings:
   1. Apply material in accordance with manufacturer recommendations over the entire exterior surface of the completed manhole, including base section, riser sections, cone section, and grade rings prior to backfilling the manhole.
   2. Allow waterproofing material to dry sufficiently before backfilling.

3.02 CLEANING

A. After completing each manhole, remove debris, construction materials, and equipment from the site of the work, grade, and smooth over the surface and leave the entire right-of-way in a clean, neat, and serviceable condition.

B. After completing each manhole, remove construction material debris from inside the manhole.

3.03 FUNCTIONAL TESTING

A. Provide materials for grouting and patching recommended by the manufacturer or an approved equal.

B. Vacuum testing in accordance with ASTM C1244.
   1. Install the vacuum test head on top of the manhole:
      a. Install and brace sealing devices on influent and effluent pipes.
   2. Draw a vacuum of 10 inches of mercury with a vacuum pump, deactivate the pump, and measure the actual elapsed time for the vacuum to drop to 9 inches of mercury.
   3. Compare test results with the minimum time requirements stated in the table below:
      a. If the actual elapsed time is less than the time in the table, the manhole is defective, and it shall be repaired and retested until it is acceptable.

Minimum Elapsed Time, Minutes: Seconds				
Manhole Depth, feet	**Manhole Diameter, inches**			
	36	**48**	**60**	**72**
8	0:14	0:20	0:26	0:33
10	0:18	0:25	0:33	0:41
12	0:21	0:30	0:39	0:49
14	0:25	0:35	0:46	0:57
16	0:28	0:40	0:52	1:07
18	0:32	0:45	0:59	1:13
20	0:35	0:50	1:05	1:21
22	0:38	0:55	1:12	1:29
24	0:42	0:59	1:18	1:37

Minimum Elapsed Time, Minutes: Seconds				
Manhole Depth, feet	**Manhole Diameter, inches**			
	36	**48**	**60**	**72**
26	0:46	1:04	1:25	1:45
28	0:49	1:09	1:31	1:53
30	0:53	1:14	1:38	2:01

END OF SECTION

SECTION 33_71_21

PRECAST ELECTRICAL HANDHOLES AND ELECTRICAL MANHOLES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Precast Portland cement concrete handholes and accessories.

B. Alternates:
   1. Contractor may propose to construct cast-in-place structures in lieu of the precast structures specified:
      a. Obtain the Engineer's acceptance of this alternative before submitting, providing, or installing.
      b. Submit full information on design and detailing of proposed alternatives, including design details and drawings of the same types required by this Section for precast structures.

C. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes "American Iron and Steel (AIS)" requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Association of State Highway Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

B. American Concrete Institute (ACI):
   1. 318 - Building Code Requirements for Structural Concrete and Commentary.

C. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. C857 - Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
   3. C858 - Standard Specification for Underground Precast Concrete Utility Structures.
   4. C891 - Standard Practice for Installation of Underground Precast Concrete Utility Structures.
   5. C1028 - Standard Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method.
   6. C1037 - Standard Practice for Inspection of Underground Precast Concrete Utility Structures.

D. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).

E. National Precast Concrete Association (NPCA).

F. Society of Cable Telecommunications Engineers (SCTE):
   1. 77 - Specification for Underground Enclosure Integrity.

G. Underwriters Laboratories (UL).

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning:
   1. Handhole: An enclosure for use in underground systems that has been sized and detailed to allow personnel to reach into, but not enter, the enclosure to install, operate, or maintain equipment or wiring or both. Reference: NEC, Article 100:
      a. As used in this Section, handhole will refer to a precast electrical handhole.
   2. Manhole: An enclosure for use in underground systems that has been sized and detailed to allow personnel to enter the enclosure to install, operate, or maintain equipment or wiring or both:
      a. As used in this Section, manhole will refer to a precast electrical manhole.
   3. Polymer concrete: A composite material consisting of an organic polymer binder mixed with embedded aggregate particles. Also known as “resin concrete”:
      a. Abbreviated PC as in PC HANDHOLE.
   4. Portland cement concrete: A composite material consisting of a Portland cement binder, water, admixtures, and a combination of fine and coarse mineral aggregates:
      a. Abbreviated PCC as in PCC HANDHOLE or PCC MANHOLE.
   5. Precast concrete: A concrete fabrication designed by a qualified engineer and subsequently fabricated at a qualified fabrication site, which is usually located some distance from the site where the fabrication will be installed.

1.04 DELEGATED DESIGN

A. As specified in Section 01_35_73 - Delegated Design Procedures.

B. Shop Drawings and calculations for precast electrical handhole and manholes.

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Product data: Manufacturer’s catalog data, details, and warranties for the following items:
   1. Polymer concrete handholes:
      a. Materials of construction, and resistance of those materials to water absorption, flammability, sunlight/ultraviolet exposure, and chemicals likely to be found in the area of use.
      b. Available colors.

c. Details for covers, cover support, and cover attachment to the underlying box.

2. Portland cement concrete handholes and manholes:
   a. Materials of construction.
   b. Joint details and joint-sealing materials.
   c. Data for hatches or covers and rings.
   d. Preformed channels and accessories for cable racking.
   e. Drain and sump details, including removable covers.
   f. Pulling iron details.

C. Shop Drawings:
   1. Polymer concrete handholes:
      a. Manufacturer's catalog cuts showing dimensions and details of construction.

D. Delegated Design Submittals:
   1. Portland cement concrete handholes and manholes:
      a. Structural calculations:
         1) Submit complete structural calculations for each structure.
      b. Dimensioned and "to-scale" plans, sections, and details for each structure, including:
         1) Layout plan for that structure.
         2) Sizes, locations, and vertical positions of duct bank windows and knockout panels.
         3) Locations and details for access openings, pulling irons, embedded cable supports and racks, and sumps.
         4) Details of structural reinforcement showing bar size and spacing; true position of reinforcement in structural members with clear concrete cover at both inside and outside faces; location, bar size, and spacing of added reinforcement around openings; and other details relevant to design and fabrication of the structure.
         5) Details of joints between adjacent precast sections, including provisions for overlap and for placement of sealants.

E. Design data:
   1. Portland cement concrete handholes and manholes:
      a. Manufacturer's statement of materials used for fabrication and construction, in accordance with ASTM C858, for record. Include the following:
         1) Concrete mix design: For each concrete mix design to be used for the structures, include data describing:
            a) Source and type of cement.
            b) Sources, grading, and specific gravities of aggregates.
            c) Aggregate reactivity data.
            d) Concrete mix proportions and design strength.
            e) Type, name, and dosage of admixtures included in the concrete mix.
         2) Reinforcing steel: Mill certificates.

F. Test reports:
    1. Polymer concrete handholes:
        a. Independent laboratory test reports bearing the seal of a licensed professional engineer and demonstrating compliance with the requirements of SCTE 77 for the loading conditions specified.
    2. Portland cement concrete handholes and manholes:
        a. Fabricator's tests for compressive strength of concrete used in structures, made in accordance with recommendations of ASTM C858.

G. Certificates:
    1. Polymer concrete handholes:
        a. Manufacturer's certification that polymer concrete handholes are in accordance with the requirements of SCTE 77.
    2. Portland cement concrete handholes and manholes:
        a. Manufacturer's current plant certification under NPCA for the structures to be supplied:
            1) Certification shall be current and in-effect at the time structures are manufactured.
        b. Manufacturer's certification that handholes and manholes are in accordance with the requirements of ASTM C858.

H. Manufacturer's instructions:
    1. Instructions for handling and setting structures in place.
    2. Portland cement concrete handholes and manholes:
        a. Instructions for operation and maintenance of hatches.

I. Manufacturer's field reports:
    1. Portland cement concrete handholes and manholes:
        a. Manufacturer's inspection reports in accordance with ASTM C1037.

J. Closeout documents:
    1. Project record documents:
        a. Portland cement concrete handholes and manholes:
            1) Final, revised plans and details of as-constructed precast handholes and manholes if requested for record by the Engineer.
    2. Warranties:
        a. Manufacturer's standard warranty for:
            1) Polymer concrete handholes.
            2) Portland cement concrete handholes and manholes and accessories.

1.06 QUALITY ASSURANCE

A. Qualifications:
    1. Designer:
        a. Portland cement concrete handholes and manholes:
            1) Professional engineer qualified in the design of concrete structures and holding a current license in the state where the structures will be installed.

2. Manufacturer:
    a. Polymer concrete handholes:
        1) Demonstrating at least 5 years of experience in the design and production of products of the type required for this Work.
        2) Holding product testing records demonstrating load resistance of products to be installed.
    b. Portland cement concrete handholes and manholes:
        1) Holding current NPCA plant certification for the products produced.
        2) Demonstrating at least 5 years of experience in the design, production, and installation of products of the type required for this Work.
        3) Capable of providing structural designs prepared by a professional engineer licensed in the state where the structures will be installed.
        4) Providing inspection during fabrication and handling in accordance with the requirements of ASTM C1037.
3. Installer:
    a. Capable of providing equipment of adequate capacity and mobility to handle and set units with proper bearing on the subgrade and without damage to the unit.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Packing, shipping, handling, and unloading:
    1. Package and brace structures to avoid damage during shipping and handling.
    2. Furnish crane or forklift for unloading and setting of Portland cement concrete handholes and manholes.

B. Acceptance at Site:
    1. Structures delivered to the Site with cracks, damage, and damaged or missing accessories shall be removed from the Site and replaced at no additional cost to the Owner.

C. Storage and protection:
    1. Store handholes and manholes and their appurtenances in areas protected from damage due to weather and Site operations.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.09 SEQUENCING

A. Coordinate installation of precast electrical handholes and manholes with duct banks specified in Section 26_05_44 - Duct Banks.

1.10 WARRANTY

A. Provide manufacturer’s standard warranty for precast handhole and manhole structures and accessories.

PART 2 PRODUCTS

2.01 GENERAL

A. Design, fabricate, and install precast electrical handholes and precast electrical manholes of the size and type indicated on the Drawings and specified:
   1. Construction of cast-in-place concrete electrical structures, including handholes and manholes, are specified in other Sections.

2.02 MANUFACTURED UNITS - PORTLAND CEMENT CONCRETE HANDHOLES AND MANHOLES

A. General:
   1. Provide Portland cement concrete handholes and manholes configured and designed as indicated on the Drawings and specified.
   2. In accordance with ASTM C858, unless otherwise noted:
      a. Concrete: Provide units with minimum specified compressive strength (f'c) of 3,000 pounds per square inch and using Type II/V cement.

B. Manufacturers: One of the following or equal:
   1. Jensen Precast.
   2. Oldcastle Precast.

C. Components:
   1. Floor:
      a. Construct floors as a monolith.
      b. Where sump or low-point drain is included, slope floor to that point.
   2. Roof, walls, and base:
      a. Designed and rated to support vehicle and pedestrian loads at the spans indicated.
      b. See the "Electrical Handhole and Manhole Schedule" indicated on the Drawings for required load rating by structure location.
   3. Floor access doors:
      a. Handholes: Aluminum plate hinged floor access door (hatch).
         1) Load rating:
            a) "Heavy Duty Off-Street" for locations designated for "Sidewalk" loads.
         2) Minimum access door size not less than 36 inches square, unless otherwise indicated on the Drawings.
         3) Provide bearing surface with pre-installed continuous elastomeric gasket to minimize water infiltration at lid.
         4) Provide skid-resistant lid with cast-in or machined-in grid pattern and the word "ELECTRICAL" in block letters at least 1.5 inches high.
      b. Manholes: Cast iron frame and cover:
         1) Manhole rings and covers: As specified in Section 05_50_00 - Metal Fabrications.
         2) Manhole rings and covers:
            a) Gray cast iron in accordance with ASTM A48, Class 30B with ring and cover machined to fit with flat bearing surfaces.
            b) Cover as indicated on the Drawings or in accordance with the Owner's standard design.

c) Cover with word “ELECTRICAL” cast into the top exposed face for electrical manholes.
d) Manhole riser access:
(1) Heavy-duty bottom flange frame with solid cover for placement on grade adjustment rings above top slab.
(2) 36-inch diameter nominal opening.
(3) Manufacturers: The following or equal.
(a) Neenah Foundry Co., R1640-D.
e) Embedded in top slab of structure:
(1) Heavy-duty top flange frame with solid cover for embedment in top slab of a structure.
(2) 36-inch diameter nominal opening.
(3) Manufacturers: The following or equal.
(a) Neenah Foundry Co., R6095.

D. Accessories:
1. Provide accessories as indicated on the Drawings and specified.
2. Materials at duct bank penetrations:
a. Joint filler as specified in Section 03_15_00 - Concrete Accessories.
b. Backer rod and sealant as specified in Section 07_92_00 - Joint Sealants.
3. Pulling irons:
a. Provide non-corroding cable pulling irons located for use with each current duct bank location and additional irons for use with duct banks that may be installed through future knockout panels.
b. Pulling irons may not be located on the floor.
c. Where pulling irons are installed on the wall, any pockets surrounding the irons shall have bottom surfaces sloped to drain.
d. Secure pulling eyes to structure reinforcement.
4. Cable racks and racking hardware:
a. Materials: Stainless steel as specified in Section 26_05_29 - Hangers and Supports.
b. Embedded slots: Maximum depth of 1.5 inches.
5. Sumps and drains:
a. Fiberglass or HDPE fabrications, including removable lids to prevent tripping hazards.
6. Exterior dampproofing:
a. As specified in Section 07_11_00 - Dampproofing.
b. Field applied to wall and roof surfaces exposed to soil.

E. Fabrication:
1. Embeds:
a. Install embedded items with provisions for drainage to remove dripping or standing water, and to minimize corrosion:
1) Pulling irons may not be placed on the floor or in pockets that will collect water.
2) Detail bottom of cable rack channels to provide a downward sloping “sill” at the bottom of each vertical channel, so that the channel slot drains toward the floor.
b. Concrete cover:
1) Provide minimum 0.75-inch clear concrete cover between embeds and surrounding reinforcement.

2) Provide minimum 1.25-inch clear concrete cover between embed and exterior face of wall.

F. Tests and inspections:
1. Test and inspect structures in accordance with ASTM C858 and ASTM C1037.

2.03 DESIGN AND PERFORMANCE CRITERIA

A. General requirements:
1. As specified in Section 26_05_00 - Common Work Results for Electrical for general requirements for electrical work.
2. Provide structures of the sizes and shapes indicated on the Drawings, with layouts, dimensions, and details as indicated on the Drawings and as specified.
3. In accordance with the requirements of:
a. NEC.
b. Project regulatory requirements as specified in Division 01.

B. Polymer concrete handholes:
1. Load resistance of boxes and covers.
a. In accordance with provisions of SCTE 77 for Tier 5, 8, 15, or 22 applications as specified in this Section:
1) Where multiple tiers are specified, handholes shall adequately support compatible covers while providing the highest tier rating specified.
2) Load rating of cover for an assembly shall not exceed the load capability of the box below.
3) Coefficient of friction between cover and box: Not less than 0.50 when measured in accordance with ASTM C1028.
2. Testing and certification:
a. Each handhole to be installed shall have a report certifying that the design and construction of the unit has successfully passed tests for materials and product performance required by SCTE 77:
1) Testing and report shall be by a qualified testing agency, independent of the manufacturer. Test report shall bear the seal of a licensed professional engineer.
2) Provide evidence of UL listing as required by NEC for products to be provided.

C. Portland cement concrete handholes and manholes:
1. Load resistance of boxes and covers.
2. Design requirements: Loads on structures:
a. In accordance with ASTM C857, except as modified in this Section.
b. Loads at the ground surface:
1) See the “Electrical Handhole and Manhole Schedule” indicated on the Drawings for minimum surface loading requirements at each structure. Loads are designated as “sidewalk,” or ”roadway”.
2) Vehicle and pedestrian loadings in the following paragraphs need not be additive; however, structures designated for “roadway” loading shall also support “sidewalk” loads.

3) “Sidewalk”: Load from regular pedestrian traffic with considerations for occasional non-deliberate vehicular traffic:
a) Designation “A-0.3” in ASTM C857 Table 1 (300-psf uniform load).
4) ”Roadway”: Load from heavy, frequently repeated vehicle traffic:
a) Designation “A-16” in ASTM C857 Table 1 (AASHTO HS20-44).

c. Lateral earth pressure loads:
1) Determine in accordance with the following requirements. Include effects of groundwater and seismic accelerations on lateral earth pressures:
a) Surface surcharge load:
(1) In accordance with ASTM C857 Vehicle Load Designation “A-16” for “Roadway” or “A-0.3” for “Sidewalk” where such surcharge exceeds backfill loads described in the preceding paragraph.
b) Groundwater effects:
(1) Include effects from groundwater and soils saturated by flooding to site finished grade elevation.

d. Groundwater and flood loads - buoyancy effects:
1) As specified in technical sections and as indicated on the Drawings, for design groundwater and design flood elevations.
2) Design for site groundwater elevation taken at the level of finished grade around the structure.
3) Buoyancy: For groundwater and flood conditions, provide factor of safety against flotation of at least 1.20:
a) If the weight of soil overlying footing projections on the structure is considered to resist flotation, use a buoyant unit weight of soil equal to not more than 30 pounds per cubic foot.
b) Concrete fill may be provided in the bottom section of precast Portland cement concrete structures to add weight. Submit proposed details.

e. Soil-bearing pressure at base:
1) Maximum 1,000 pounds per square foot total pressure on prepared subgrade soils.

f. Lifting and handling loads:
1) Make provision in the design for the effects of loads or stresses that may be imposed on structures during fabrication, transportation, or erection.

g. Load combinations:
1) Design structures to sustain the specified loads individually or in combination.

3. Design requirements: Structural analysis, design, and detailing:
a. General:
1) Analyze and design structures, including the effects of 2-way action (“plate action”) and of load transfer around current and future openings.
2) Where structures include panels designed for future removal (“knockout panels”), design structures for loads and stresses with any combination of any or all such panels in place or removed.

b. Precast polymer concrete handholes:
1) Design to resist loads with cover in place or removed.

2) Detail cover support and top edges to maintain cover in place over walls and to prevent soil from sloughing into the handhole when cover is removed.

c. Precast Portland cement concrete handholes and manholes:
   1) Design structures in accordance with the requirements of ACI 318 and this Section.
   2) Provide reinforcement at areas subject to tensile stress when loaded with the specified loads and combinations thereof.
   3) Provide temperature and shrinkage reinforcement to equal or exceed ACI 318 requirements in concrete sections.
   4) Provide minimum clear concrete cover over reinforcement at both interior and exterior faces of members in accordance with the following:
      a) Handholes: 1.25 inches.
      b) Manholes: 2 inches.
   5) Reinforcement details:
      a) Walls: For structures with wall thickness of 8 inches or less, locate a single mat of reinforcement at the center of the wall.
      b) Slabs: For structures with slab thickness of 7 inches or less, locate a single mat of reinforcement at the center of the slab.
      c) Structures with wall or slab thicknesses exceeding these limits shall have a reinforcement at each face of the member.
   6) Joints:
      a) Provide structures with watertight joints between sections and detailed to minimize water infiltration at duct bank and conduit penetrations.
      b) Provide structures with non-skid, shiplap, or tongue and groove joints between sections.

4. Design requirements: Materials:
   a. Portland cement concrete handholes and manholes:
      1) In accordance with ASTM C858 except as modified in this Section.

2.04 MATERIALS

A. Cast-in-place concrete for fill at base sections of Portland cement concrete manholes with deep sumps or ballast to resist buoyancy shall be Class A concrete as specified in Section 03_30_01 - Concrete Work.

PART 3 EXECUTION

3.01 GENERAL

A. Furnish and install precast electrical handholes and manholes as indicated on the Drawings and specified.

B. Install additional handholes and manholes required so installation procedures will be in accordance with the cable manufacturer’s pulling tension requirements:
   1. Include proposed locations and details of such additional handholes and manholes with the Submittals under this Section.

3.02 PREPARATION

A. Design:
   1. Prepare detailed and scalable layouts for each manhole structure showing locations of conduit or duct bank penetrations, clearances, locations, and sizes of access openings and major accessories.

B. Protection:
   1. Where handhole and manhole structures are installed adjacent to existing site structures or utilities, provide excavation support or other protection as required to maintain those facilities in service and to prevent damage to both existing and new facilities.

C. Site preparation:
   1. Excavate and prepare exposed subgrade as indicated on the Drawings and as specified.
   2. Install and compact foundation layer as indicated on the Drawings and specified.
   3. Level foundation materials so that structures will be set plumb, and duct banks will be at proper grade and alignment:
      a. Install with uniform bearing on foundation materials.
      b. Wedging or blocking of base sections for leveling over the foundation materials will not be permitted.

3.03 INSTALLATION

A. General:
   1. Protect handholes and manholes from displacement, flooding, or flotation.

B. Polymer concrete handholes:
   1. Install structures in accordance with the manufacturer's recommendations.
   2. Clean joints between adjacent sections for tight fit.
   3. Set covers at elevations indicated on the Drawings:
      a. Securely attach cover to below-grade box.
   4. Backfill polymer concrete handholes as indicated on the Drawings and as specified.

C. Portland cement concrete handholes and manholes:
   1. Install structures in accordance with ASTM C891 and as specified in this Section:
      a. In the event of conflicts, the more restrictive provisions shall apply.
   2. Clean and prime joints between adjacent precast sections:
      a. Install sealing compound between sections and provide watertight joints.
   3. Set covers and hatches at elevations indicated on the Drawings:
      a. Securely attach frames to top of precast structures and grade adjustment rings.
   4. Penetrations:
      a. Holes for duct banks and other penetrations may not be cut into precast handholes and manholes unless they are located at designated locations shown on the Shop Drawings or at knockout panels cast into the structure during manufacturing.

b. Carefully remove concrete from knockout panel areas with saws:
    1) Ensure that break-back does not extend beyond the designated limits of the knockout panel.
c. Coat any reinforcement cut or exposed during removal of knockout panel sections with minimum 2 coats of high solids epoxy as specified in Section 09_96_01 - High-Performance Coatings:
    1) Apply epoxy coating applied over and at least 1 inch past the perimeter of the reinforcement.

5. Install duct banks and conduit penetrations in accordance with the penetration details indicated on the Drawings:
    a. Place joint fillers, caulks, and sealants before coating exterior concrete surface with bituminous dampproofing.
6. Fill holes that were provided for handling or other temporary purposes with non-shrink cement grout using procedures as specified in Section 03_30_01 - Concrete Work, unless otherwise detailed by the manufacturer.
7. After structures are set and before backfilling, coat exterior below-grade surfaces (around the sidewalls, over the top slab, and around any vertical risers to grade) with 2 heavy coats of bituminous dampproofing as specified in Section 07_11_00 - Dampproofing:
    a. Apply dampproofing in accordance with the coating manufacturer's instructions and at a rate of 40 to 60 square feet per gallon per coat.
    b. Mask over at least 1 inch back from joint caulks or sealants and prevent dampproofing from coming in contact with those materials.
8. Backfill handholes and manholes as indicated on the Drawings and as specified in Section 31_00_00 - Earthwork.

D. Site tolerances:
1. Set electrical handholes and manholes plumb and true at locations indicated on the Drawings.
2. Tolerances on placing:
    a. Horizontal location: Within 1 inch.
    b. Vertical elevation: Within 1/2 inch.
    c. Plumb: Within 1/8 inch over 10 feet.

3.04 REPAIR/RESTORATION

A. Repair cracks or blemishes in concrete as described in Section 03_30_01 - Concrete Work or by methods acceptable to the Engineer. Submit proposed repairs for acceptance before commencing work.

3.05 ADJUSTING

A. After final grading is complete, adjust access covers to grade.

3.06 CLEANING

A. Before installation of cables in any duct banks and handholes or manholes, remove concrete spoil, forms, debris, silt, dust, and other foreign material.

3.07 SCHEDULES

A. See Drawings for the “Electrical Handhole and Manhole Schedule”.

END OF SECTION

SECTION 40_05_00.01

COMMON WORK RESULTS FOR GENERAL PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Basic materials and methods for metallic and plastic piping systems.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B1.1 - Unified Inch Screw Threads (UN, UNR, and UNJ Thread Forms).
   2. B18.2.1 - Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series).
   3. B18.2.2 - Nuts for General Applications: Machine Screw Nuts; and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series).
   4. PCC-1 - Pressure Boundary Bolted Flange Joint Assembly.

B. American Water Work Association (AWWA):
   1. C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
   2. C110 - Ductile-Iron and Gray-Iron Fittings.
   3. C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   4. C115 - Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
   5. C151 - Ductile-Iron Pipe, Centrifugally Cast.

C. ASTM International (ASTM):
   1. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   2. A194 - Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   3. A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength.
   4. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
   5. B88 - Standard Specification for Seamless Copper Water Tube.
   6. D395 - Standard Test Methods for Rubber Property—Compression Set.
   7. D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension.

8. D573 - Standard Test Method for Rubber—Deterioration in an Air Oven.
9. D1149 - Standard Test Methods for Rubber Deterioration—Cracking in an Ozone Controlled Environment.
10. D1330 - Standard Specification for Rubber Sheet Gaskets.
11. D2513 - Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing and Fittings.
12. F37 - Standard Test Methods for Sealability of Gasket Materials.
13. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
14. F594 - Standard Specification for Stainless Steel Nuts.
15. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements of Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.

D. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

E. City of Santa Cruz Water System Standard Specifications.

F. City of Santa Cruz Public Works Standards.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning:
   1. Buried pipes: Pipes that are buried in the soil with or without a concrete pipe encasement.
   2. Exposed pipe: Pipes that are located above ground, or located inside a structure, supported by a structure, or cast into a concrete structure.
   3. Pipes adjacent to a wet wall: Pipe centerline within 10 inches of the wet wall.
   4. Underground pipes: Buried pipes - see 1. above.
   5. Underwater pipes: Pipes below the top of walls in basins or tanks containing water.
   6. Wet wall: A wall with water on at least one side.

PART 2 PRODUCTS

2.01 GENERAL

A. Pipes:
   1. Provide new pipe.
   2. Piping provided from manufacturers/distributors' inventory is subject to the following condition:
      a. Provide proof pipe manufactured more than 6 months prior to delivery was stored properly and the material and/or coating was not subjected to ultraviolet (UV) degradation.
   3. Mark each piece of pipe in accordance with applicable standards.

B. Coatings and linings requirements shown in the Pipe Schedule, as modified in the individual pipe Technical Sections, and as specified in Section 09_96_01 - High-Performance Coatings.

2.02 LINK TYPE SEALS

A. Characteristics:
   1. Modular mechanical type, consisting of interlocking neoprene or synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening.
   2. Links to form a continuous rubber belt around the pipe.
   3. Provide a nylon polymer pressure plate with Type 316 stainless steel hardware. Isolate pressure plate from contact with wall sleeve.
   4. Hardware to be Type 316 stainless steel:
      a. Provide anti-galling lubricant for threads.

B. One of the following or equal:
   1. Link-Seal.
   2. Pipe Linx.

2.03 FLANGE BOLTS AND NUTS

A. General:
   1. Washer: Provide for each nut:
      a. Shall be of the same material as the nut.
   2. Nuts: Heavy hex-head.
   3. Cut and finish flange bolts to project:
      a. Face of the bolt shall exceed face of nut by 1/8-inch minimum.
      b. A maximum of 1/4 inch beyond outside face of nut after assembly.
   4. Tap holes for cap screws or stud bolts when used.
   5. Lubricant for stainless steel bolts and nuts:
      a. Chloride-free.
      b. Manufacturers: One of the following or equal:
         1) Huskey, FG-1800 Anti-Seize.
         2) Weicon, Anti-Seize High-Tech.

B. Ductile iron pipe:
   1. On exposed pipes with pressures equal to or less than 150 pounds per square inch gauge (psig):
      a. Bolts: In accordance with ASTM A307, Grade B.
      b. Nuts: In accordance with ASTM A563, Grade A.
      c. Bolts and nuts: Hot-dip galvanized in accordance with ASTM F2329.
   2. On exposed pipes with pressures greater than 150 psig:
      a. Bolts: In accordance with ASTM A193, Grade B7.
      b. Nuts: In accordance with ASTM A194, Grade 2H.
      c. Bolts and nuts: Hot-dip galvanized in accordance with ASTM F2329.
   3. On underwater pipes and pipes adjacent to wet walls:
      a. Bolts: In accordance with ASTM A193, Grade B8M.
      b. Nuts: In accordance with ASTM A194, Grade 8M.
   4. On buried pipes:
      a. Bolts: In accordance with ASTM A307, Grade B.

b. Nuts: In accordance with ASTM A563, Grade A.
c. Encase in 2 layers of loose polyethylene wrap in accordance with AWWA C105.

C. Plastic pipe:
1. On exposed pipes:
a. Bolts: In accordance with ASTM A307, Grade B.
b. Nuts: In accordance with ASTM A563, Grade A.
c. Bolts and nuts: Hot-dip galvanized in accordance with ASTM F2329.
2. On underwater pipes and pipes adjacent to wet walls:
a. Bolts: In accordance with ASTM A193, Grade B8M.
b. Nuts: In accordance with ASTM A194, Grade 8M.

D. Steel pipe:
1. Exposed flange bolts, nuts, and washers:
a. Bolts: ASTM A193, Grade B7 Steel, ASME B1.1 Class 2A Threads, with dimensions in accordance with ASME B18.2.1.
b. Nuts: ASTM A194, Grade 2H Steel, ASME B1.1 Class 2A Fit, with square or heavy hex dimensions in accordance with ASME B18.2.2.
c. Washers: In accordance with ASME PCC-1, Appendix M, Type 4.
d. Bolts and nuts: Hot-dip galvanized in accordance with ASTM F2329.
2. On underwater pipes and pipes adjacent to wet walls:
a. Bolts: ASTM A193, Grade B8M Stainless Steel, ASME B1.1 Class 2A Threads, with dimensions in accordance with ASME B18.2.1.
b. Nuts: ASTM A194, Grade 8M Stainless Steel, ASME B1.1 Class 2A Fit, with square or heavy hex dimensions in accordance with ASME B18.2.2.
c. Washers: In accordance with ASME PCC-1, Appendix M, Type 7.

2.04 MECHANICAL JOINTS BOLTS AND NUTS

A. Bolts, including T-bolts:
1. Type 316 stainless steel in accordance with ASTM F593.

B. Heavy hex nuts:
1. Type 316 stainless steel in accordance with ASTM F594.

2.05 GASKETS

A. General:
1. Suitable for the specific fluids, pressure, and temperature conditions.
2. Capable of being applied on surface of piping with cavities to provide for an improved seal with the internal piping pressure.

B. For flanged joints in ductile iron and steel piping for sewage service:
1. Suitable for pressures equal to and less than 150 pounds per square inch gauge, temperatures equal to and less than 250 degrees Fahrenheit, and raw sewage service.
2. Material:
a. SBR or neoprene elastomer with minimum Shore A hardness value of 70.
b. Reinforcement: Cloth or synthetic fiber.

c. Thickness: Minimum 3/32-inch thick for less than 10-inch pipe; minimum 1/8-inch thick for 10 inch and larger pipe.

3. Manufacturers: One of the following or equal:
   a. Pipe less than 48 inches in diameter:
      1) Garlock, Style 7797.
      2) John Crane, similar product.
   b. Pipe 48 inches in diameter and larger:
      1) Garlock, Style 3760.
      2) John Crane, similar product.

C. For flanged joints in polyvinyl chloride and polyethylene piping:
   1. Suitable for pressures equal to and less than 150 pounds per square inch gauge, with low flange bolt loadings, temperatures equal to and less than 120 degrees Fahrenheit, and polymer, chlorine, caustic solutions, and other chemicals, except chemicals which liberate free fluorine, including fluorochemicals and gaseous fluorine.
   2. Material:
      a. Chemical systems: 0.125-inch thick Viton™ rubber.
      b. Sewer and water: 0.125-inch thick SBR.
   3. Manufacturers: One of the following or equal:
      a. Garlock.
      b. John Crane, similar product.

D. For flanged joints in ductile iron or steel water piping:
   1. Suitable for hot or cold water, pressures equal to and less than 150 pounds per square inch gauge, and temperatures equal to and less than 160 degrees Fahrenheit.
   2. Material:
      a. SBR or neoprene elastomer, compressed, with non-asbestos fiber reinforcement.
   3. Manufacturers: One of the following or equal:
      a. Garlock, Bluegard 3300.
      b. John Crane, similar product.

E. For flanged joints in steel drinking water piping in accordance with NSF 61 requirements:
   1. Material: EPDM elastomer, Sulphur cure:
      a. Temperature range: -40 to 275 degrees Fahrenheit.
      b. Operating pressure: 150 psig.
      c. Durometer, Shore A (within 5): 80.
      d. ASTM D412 tensile strength: 1,500 psi.
      e. ASTM D412 elongation: 185 percent.
      f. ASTM D395 B, compression set, 25 percent deflection, maximum percentage 22 hours at 158 degrees Fahrenheit: 25.
   2. Thickness, minimum:
      a. 3/32-inch for less than 10-inch pipe.
      b. 1/8 inch for 10 inch and larger pipe.
   3. Manufacturers: One of the following or equal:
      a. Garlock, Style 98206.
      b. John Crane.

F. For flanged joints in ductile iron drinking water piping in accordance with NSF 61 requirements:
   1. Application: Full faced type with one or more annular rings molded into the gasket as described in AWWA C110, C111, and C115.
   2. Material: Styrene butadiene copolymer (SBR).
      a. Temperature range: 20 to 150 degrees Fahrenheit.
      b. Operating pressure:
         1) Pipe size 4-inch through 24-inch: 350 psi.
         2) Pipe size 24 inch and greater: 250 psi.
   3. Thickness, minimum: 1/8 inch.
   4. Manufacturers: One of the following or equal:
      a. American Cast Iron Pipe Co., Toruseal Flange Gasket.
      b. U.S. Pipe, Flange-Tyte II.

G. For flanged joints in ductile iron drinking water piping in accordance with NSF 61 requirements:
   1. In accordance with AWWA C110, C111, and C115.
   2. Material: Styrene butadiene copolymer (SBR) in accordance with ASTM D1330 Grade II:
      a. Temperature range: 20 to 150 degrees Fahrenheit.
      b. Operating pressure: 250 psi.
      c. Durometer, Shore A: 70 to 85.
      d. ASTM D412 tensile strength: 700 psi.
      e. ASTM D412 elongation: 150 percent.
      f. ASTM D395 B, compression set, 25 percent deflection, maximum percentage 22 hours at 158 degrees Fahrenheit: 40.
   3. Thickness, minimum: 1/8 inch.
   4. Manufacturers: One of the following or equal:
      a. McWane Ductile.
      b. SIP industries.

H. For mechanical joints or wedge action joint restraints in ductile iron drinking water piping in accordance with NSF 61 requirements:
   1. In accordance with AWWA C110, C111, and C115.
   2. Material: Vulcanized styrene butadiene copolymer (SBR):
      a. Temperature range: 20 to 150 degrees Fahrenheit.
      b. Operating pressure: 250 psi.
      c. Durometer, Shore A (within 5): 75.
      d. ASTM D412 tensile strength: 1,500 psi.
      e. ASTM D412 elongation: 150 percent.
      f. ASTM D395 B, compression set, 25 percent deflection, maximum percentage 22 hours at 158 degrees Fahrenheit: 20.
      g. ASTM D573 minimum aging: 60 percent.
      h. ASTM D1149 resistance to surface ozone: No cracking.
   3. Manufacturers: One of the following or equal:
      a. American Cast Iron Pipe Co.
      b. EBAA Iron, Inc.
      c. Star Pipe Products.

I. For push-on joints in ductile iron drinking water piping in accordance with NSF 61 requirements:
   1. In accordance with AWWA C110, C111, and C115.
   2. Material: Vulcanized styrene butadiene copolymer (SBR).
      a. Temperature range: 20 to 150 degrees Fahrenheit.
      b. Operating pressure: 250 psi.
      c. Durometer, Shore A:
         1) Main body: 50 to 65.
         2) Harder portion (if used): 80 to 85.
      d. ASTM D412 tensile strength:
         1) Main body: 2,000 psi.
         2) Harder portion (if used): 1,200 psi.
      e. ASTM D412 elongation:
         1) Main body: 300 percent.
         2) Harder portion (if used): 125 percent.
      f. ASTM D395 B, compression set, 25 percent deflection, maximum percentage 22 hours at 158 degrees Fahrenheit: 20.
      g. ASTM D573 minimum aging: 60 percent.
      h. ASTM D1149 resistance to surface ozone: No cracking.
   3. Manufacturers: One of the following or equal:
      a. American Cast Iron Pipe Co, Fastite Gasket.
      b. McWane Ductile, Tyton Gasket.
      c. U.S. Pipe.

J. For integrally restrained push-on joints in ductile iron drinking water piping in accordance with NSF 61 requirements:
   1. In accordance with AWWA C110, C111, and C115.
   2. Material: Vulcanized styrene butadiene copolymer (SBR):
      a. Temperature range: 20 to 150 degrees Fahrenheit.
      b. Operating pressure: 250 psi.
      c. Durometer, Shore A:
         1) Main body: 50 to 65.
         2) Harder portion (if used): 80 to 85.
      d. ASTM D412 tensile strength:
         1) Main body: 2,000 psi.
         2) Harder portion (if used): 1,200 psi.
      e. ASTM D412 elongation:
         1) Main body: 300 percent.
         2) Harder portion (if used): 125 percent.
      f. ASTM D395 B, compression set, 25 percent deflection, maximum percentage 22 hours at 158 degrees Fahrenheit: 20.
      g. ASTM D573 minimum aging: 60 percent.
      h. ASTM D1149 resistance to surface ozone: No cracking.
   3. Manufacturers: One of the following or equal:
      a. American Cast Iron Pipe Co, Fast-grip gasket.
      b. U.S. Pipe, Field Lok 350 Gaskets.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Piping drawings:
      a. Except in details, piping is indicated diagrammatically. Not every offset and fitting, or structural difficulty that may be encountered has been indicated on the Drawings. Sizes and locations are indicated on the Drawings.
      b. Perform minor modifications to piping alignment where necessary to avoid structural, mechanical, or other type of obstructions that cannot be removed or changed:
         1) Modifications are intended to be of minor scope, not involving a change to the design concept or a change to the Contract Price or Contract Times.
   2. Piping alternatives:
      a. Provide piping as specified in this Section, unless indicated on the Drawings or specified otherwise.
      b. Alternative pipe ratings:
         1) Piping with greater pressure rating than specified may be substituted in lieu of specified piping without changes to the Contract Price.
         2) Piping of different material may not be substituted in lieu of specified piping.
      c. Valves in piping sections: Capable of withstanding specified test pressures for piping sections and fabricated with ends to fit piping.
      d. Grooved joints: Use couplings, flange adapters, and fittings of the same manufacturer:
         1) Manufacturer's factory trained representative:
            a) Provide on-site training for the Contractor's field personnel.
            b) Periodically visit the jobsite to verify the Contractor is following best recommended practices.
         2) Distributor's representative is not considered qualified to conduct the training or jobsite visits.
      e. Flanged joints: Where one of the joining flanges is raised face type, provide a matching raised face type flange for the other joining flange.
   3. Unless otherwise indicated on the Drawings, piping at pipe joints, fittings, couplings, and equipment shall be installed without rotation, angular deflection, vertical offset, or horizontal offset.

B. Wall and slab penetrations:
   1. Provide sleeves for piping penetrations through aboveground masonry and concrete walls, floors, ceilings, roofs, unless specified or otherwise indicated on the Drawings.
   2. For piping 1 inch in nominal diameter and larger, provide sleeves with minimum inside diameters of 1 inch plus outside diameter of piping. For piping smaller than 1 inch in nominal diameter, provide sleeve of minimum twice the outside diameter of piping:
      a. Arrange sleeves and adjacent joints so piping can be pulled out of sleeves and replaced without disturbing the structure.
      b. Cut ends of sleeves flush with surfaces of concrete, masonry, or plaster.

c. Conceal ends of sleeves with escutcheons where piping runs through floors, walls, or ceilings of finished spaces within buildings.
d. Seal spaces between pipes and sleeves with link-type seals when not otherwise specified or indicated on the Drawings.
e. Seal openings around piping running through interior walls and floors of chlorine rooms and chlorine storage rooms gastight with synthetic rubber sealing compound.

3. Provide flexibility in piping connecting to structures to accommodate movement due to soil settlement and earthquakes. Provide flexibility using details indicated on the Drawings and specifications.
4. Core drilled openings:
   a. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by the Engineer.
   b. Determine location of reinforcing bars or other obstructions with a non-destructive indicator device.
   c. Remove dust and debris from hole using compressed air.

C. Exposed piping:
1. Install in straight runs parallel to the axes of structures, unless otherwise indicated on the Drawings:
   a. Install piping runs plumb and level, unless otherwise indicated on the Drawings:
      1) Slope plumbing drain piping with a minimum of 1/4 inch per foot downward in the direction of flow.
2. Install after installing equipment and after piping and fitting locations have been determined.
3. Route piping to preserve headroom, access space and workspace, and to prevent tripping hazards and clearance problems:
   a. Install piping so it does not interfere with the proper and safe operation of equipment and does not block or interfere with ingress or egress, including hatches.
4. Support piping: As specified in Section 40_05_07.01 - Pipe Supports and Section 40_05_07.03 - Preformed Channel Pipe Support System:
   a. Do not transfer pipe loads and strain to equipment.
5. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, flanged coupling adapters, and other types of joints or means which are compatible with and suitable for the piping system, and necessary to allow ready assembly and disassembly of the piping.
6. Assemble piping without distortion or stresses caused by misalignment:
   a. Match and properly orient flanges, unions, flexible couplings, and other connections.
   b. Do not subject piping to bending or other undue stresses when fitting piping.
   c. Do not correct defective orientation or alignment by distorting flanged joints or subjecting flange bolts to bending or other undue stresses.
   d. Flange bolts, union halves, flexible connectors, and other connection elements shall slip freely into place.
   e. Alter piping assembly to fit when proper fit is not obtained.
   f. Install eccentric reducers or increasers with the top horizontal for pump suction piping.

D. Buried piping:
   1. Bury piping with minimum 3-foot cover without air traps, unless otherwise indicated on the Drawings.
   2. Where 2 similar services run parallel to each other, piping for such services may be laid in the same trench:
      a. Lay piping with sufficient room for assembly and disassembly of joints, for thrust blocks, for other structures, and to meet separation requirements of public health authorities having jurisdiction.
   3. Laying piping:
      a. In finished trenches free from water or debris. Begin at the lowest point with bell ends up slope.
      b. Place piping with top or bottom markings with markings in proper position.
      c. On an unyielding foundation with uniform bearing under the full length of barrels.
      d. Where joints require external grouting, banding, or pointing, provide space under and immediately in front of the bell end of each section laid with sufficient shape and size for grouting, banding, or pointing of joints.
      e. At the end of each day's construction, plug open ends of piping temporarily to prevent entrance of debris or animals.
   4. Concrete encase buried pipe installed under concrete slabs or structures.

E. Venting piping under pressure:
   1. Lay piping under pressure flat or at a continuous slope without air traps, unless otherwise indicated on the Drawings.
   2. Install plug valves as air bleeder cocks at high points in piping:
      a. Provide 1-inch plug valves for water lines and 2-inch plug valves for sewage and sludge lines, unless otherwise indicated on the Drawings.
   3. Provide additional pipe taps with plug cocks and riser pipes along piping as required for venting during initial filling, disinfecting, and sampling.
   4. Before piping is placed into service, close plug valves and install plugs. Protect plugs and plug valves from corrosion as specified in Section 09_96_01 - High-Performance Coatings.

F. Restraining buried piping:
   1. At valves and at fittings where piping changes direction, changes size, and at ends:
      a. When piping is underground, use concrete thrust blocks, mechanical restraints, or push-on restraints.
      b. Determine thrust forces by multiplying the nominal cross-sectional area of the piping by design test pressure of the piping.
   2. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
      a. During testing, provide suitable temporary restraints where piping does not require permanent restraints.
   3. Place concrete thrust blocks against undisturbed soil.
   4. Place concrete so piping joints, fittings, and other appurtenances are accessible for assembly and disassembly.
   5. Provide underground mechanical restraints where specified in Attachment A - Pipe Schedule.

G. Restraining above ground piping:
    1. At valves and fittings where piping changes direction, changes size, and at ends:
        a. When piping is above ground or underwater, use mechanical or structural restraints.
        b. Determine thrust forces by multiplying the nominal cross-sectional area of the piping by design test pressure of the piping.
    2. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
        c. During testing, provide suitable temporary restraints where piping does not require permanent restraints.

H. Connections to existing piping:
    1. Expose existing piping to which connections are to be made with sufficient time to permit, where necessary, field adjustments in line, grade, or fittings:
        a. Protect domestic water/potable water supplies from contamination:
            1) Make connections between domestic water supply and other water systems in accordance with requirements of public health authorities.
            2) Provide devices approved by the owner of the domestic water supply system to prevent flow from other sources into the domestic supply system.
    2. Make connections to existing piping and valves after sections of new piping to be connected have been tested and found satisfactory.
    3. Provide sleeves, flanges, nipples, couplings, adapters, and other fittings needed to install or attach new fittings to existing piping and to make connections to existing piping.
    4. For flanged connections, provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

I. Connections between ferrous and nonferrous metals:
    1. Connect ferrous and nonferrous metal piping, tubing, and fittings with dielectric couplings, especially designed for the prevention of chemical reactions between dissimilar metals.
    2. Nonferrous metals include aluminum, copper, and copper alloys.

J. Flanged connections between dissimilar metals such as ductile iron pipe and steel pipe:
    1. Provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

3.02 CLEANING

A. Piping cleaning:
    1. Upon completion of installation, clean piping interior of foreign matter and debris.
    2. Perform special cleaning when required by the Contract Documents.

B. Conduct pressure and leak test, as specified.

3.03 PIPE SCHEDULE

A. As specified in Attachment A - Pipe Schedule.

END OF SECTION

ATTACHMENT A - PIPE SCHEDULE

PIPE SCHEDULE

Process Abbrev.	Service	Nominal Diameter (inches)	Material	Pressure Class Special Thickness Class Schedule Wall Thickness	Pipe Spec. Section	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Service Condition	Comments
BW	**Backwash**										
	Underground	2	Copper, Type K	-	40_05_17.05 - Copper Water Tube, Type K: ASTM B88	Solder, ASTM B32, B813	150 psig/ HH	None	2 layers PEE		
	Aboveground	2	GSP	SCH 40	Galvanized Steel Pipe, ASME B16.3	THD	150 psig/ HH	None	EPP		
W	**Potable Water**										
	Underground	< 2	Type 316 SST	SCH 80	40_05_23.01 - Stainless Steel Piping and Tubing	THD	150 psig/ HH	N/A	N/A		
	Aboveground	< 2	Type 316 SST	SCH 80	40_05_23.01 - Stainless Steel Piping and Tubing	THD	150 psig/ HH	N/A	N/A		
	Underground	6	DIP	PC 350	40_05_19.01 - Ductile Iron Pipe: AWWA C151	Mech Rest. MJ	150 psig/ HH	CM	2 Layers PEE		
	Aboveground	6	DIP	PC 350	40_05_19.01 - Ductile Iron Pipe: AWWA C151	FL	150 psig/ HH	CM	EPP or FBE (AWWA C116)		Provide clear poly-urethane topcoat

Process Abbrev.	Service	Nominal Diameter (inches)	Material	Pressure Class Special Thickness Class Schedule Wall Thickness	Pipe Spec. Section	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Service Condition	Comments
RAW	**Raw Water**										
	Underground	6	DIP	PC 350	40_05_19.01 - Ductile Iron Pipe: AWWA C151	Mech Rest. MJ	150 psig/ HH	CM	2 Layers PEE		
	Aboveground	6	DIP	PC 350	40_05_19.01 - Ductile Iron Pipe: AWWA C151	FL	150 psig/ HH	CM	EPP or FBE (AWWA C116)		Provide clear poly-urethane topcoat
FL	**Flush**										
	Underground	12 – 14	PVC (C900)	DR 18	40_05_31.14 - Polyvinyl Chloride (PVC) Pipe: Pressure	Mech Rest. MJ	150 psig/ HH	N/A	N/A		
	Aboveground	6	DIP	PC 350	40_05_19.01 - Ductile Iron Pipe: AWWA C151	FL	150 psig/ HH	CM	EPP or FBE (AWWA C116)		Provide clear poly-urethane topcoat
BF	**Backflush**										
	Underground	6	DIP	PC 350	40_05_19.01 - Ductile Iron Pipe: AWWA C151	Mech Rest. MJ	150 psig/ HH	CM	2 Layers PEE		
	Aboveground	6	DIP	PC 350	40_05_19.01 - Ductile Iron Pipe: AWWA C151	FL	150 psig/ HH	CM	EPP or FBE (AWWA C116)		Provide clear poly-urethane topcoat

Process Abbrev.	Service	Nominal Diameter (inches)	Material	Pressure Class Special Thickness Class Schedule Wall Thickness	Pipe Spec. Section	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Service Condition	Comments
TF	**Trickle Flow**										
	Underground	< 2	Copper, Type K	-	40_05_17.05 - Copper Water Tube, Type K: ASTM B88	Solder, ASTM B32, B813	150 psig/ HH	None	2 layers PEE		
	Aboveground	< 2	Type 316 SST	SCH 80	40_05_23.01 - Stainless Steel Piping and Tubing	THD	150 psig/ HH	N/A	N/A		
N	**Nitrogen**										
	Underground	< 1	Type 316 SST	SCH 80	40_05_23.01 - Stainless Steel Piping and Tubing	SCRD	300 psig/ HH	N/A	N/A		Install in PVC carrier per drawings
	Aboveground	< 1	Type 316 SST	SCH 80	40_05_23.01 - Stainless Steel Piping and Tubing	SCRD	300 psig/ HH	N/A	N/A		

Process Abbrev.	Service	Nominal Diameter (inches)	Material	Pressure Class Special Thickness Class Schedule Wall Thickness	Pipe Spec. Section	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Service Condition	Comments

Abbreviations:

1. The following abbreviations used in the column of test method refer to the respective methods as specified in Section 40_05_00.09 - Piping Systems Testing.

AM	Air method
GR	Gravity method
HH	High head method
LH	Low head method
SC	Special case

2. Abbreviations to designate piping include the following:

B&SP	Bell and spigot
BSP	Black Steel Pipe
CE	Ceramic epoxy lining
CI	Cast iron
CISP	Cast iron soil pipe
CL	Class, followed by the designation
CM	Cement mortar
CM	Compression
CTP	Coal tar pitch
DIP	Ductile iron piping
EPP	Epoxy polyurethane coating (EPU-M-1 per Section 09_96_01)
FBE	Fusion bonded epoxy
FL	Flange
FW	Fusion Weld
GA	Gauge, preceded by the designation
GE	Grooved end joint
GL	Glass lined
GSP	Galvanized steel pipe
MJ	Mechanical joint MWAMechanical wedge action
NPS	Nominal pipe size, followed by the number in inches
psi	pounds per square inch
psig	pounds per square inch gauge
PE	Polyethylene
PEE	Polyethylene encasement
PTW	Polyethylene tape wrap
PVC	Polyvinyl Chloride
RPO	Restrained push-on
SCH	Schedule, followed by the designation
SCRD	Screwed-on
SST	Stainless steel
SW	Solvent welded
THD	Threaded
VCP	Vitrified clay piping
WLD	Weld

SECTION 40_05_00.03

PIPE IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Pipe identification including the following:
   1. Pipe identification markers, flow direction arrows, tags, and bands.
   2. Underground warning tape.
   3. Tracer wire.
   4. Witness markers.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. A13.1 - Scheme for the Identification of Piping Systems.

B. City of Santa Cruz Water System Standard Specifications.

C. City of Santa Cruz Public Works Standards.

1.03 SUBMITTALS

A. Submit as specified in Section 01 33 00 - Submittal Procedures.

B. Submit following:
   1. Product data.
   2. Samples.
   3. Manufacturer’s installation instructions.
   4. Submit following as specified in Section 01 77 00 - Contract Closeout:
      a. Operation and Maintenance Data.
      b. Warranty.

PART 2 PRODUCTS

2.01 EXPOSED AND IN-CHASE PIPE IDENTIFICATION

A. For piping with outer diameter greater than or equal to 3/4-inch, provide lettered pipe markers and flow direction arrows:
   1. General requirements:
      a. Pipe markers shall include the following, minimum:
         1) Printed text identifying the pipe fluid:
            a) The text shall be all capital letters matching the text listed in the "Service" column of the Piping Schedule for the corresponding piping system.
         2) An arrow identifying the direction of fluid flow:
            a) The arrow can either be integral to the text marker or provided separately. If provided separately, the arrow must be placed immediately adjacent to each text marker, with the arrow aligned with the text such that the text and arrow are both visible from the same viewpoint.
            b) The arrow color shall match the text color, and the arrow background color shall match the text background color.
      b. Suitable for outdoor application from -40 degrees to 180 degrees Fahrenheit; in accordance with ASME A13.1 requirements.
      c. Lettering:

Outside Pipe Diameter Including Covering	Lettering Height
Less than 0.75 inches	N/A
0.75 to 1.5 inches	1/2-inch
1.5 inches to 2 inches	3/4-inch
2.5 inches to 6 inches	1-1/4 inches
8 inches to 10 inches	2-1/2 inches
Over 10 inches	3-1/2 inches

      d. Marker colors:

Marker Color System ID(1)	Fluid service	Text/arrow color	Background color
1	Potable, raw, and other waters	White	Green
5	Toxic or corrosive fluids	Black	Orange
Notes: (1) See Piping Schedule.			

   2. Self-adhesive type markers:
      a. Manufacturers: One of the following or equal:
         1) Seton, (of Brady Corporation), Opti Code Pipe Markers.
         2) Marking Services, Inc.
      b. Materials:
         1) Self-adhesive vinyl.

3. Snap-on markers:
    a. Manufacturers: One of following or equal:
        1) Brady Snap-On.
        2) Seton (of Brady Corporation) Setmark.

B. For piping with outer diameter less than 3/4-inch, provide identification tags and flow direction arrows:
    1. Manufacturer: One of the following or equal:
        a. Seton (of Brady Corporation).
    2. Tag and chain materials:
        a. Copper piping: Brass.
        b. Ferrous piping: Type 316 stainless steel.
        c. Plastic piping: Stainless steel.
    3. Flow direction arrow colors shall adhere to the same requirements as for piping with outer diameter greater than or equal to 3/4 -inch, as specified in this Section.

C. Pipe bands:
    1. When bands are required by the Piping Schedule for a specific piping system, provide solid-colored 4-inch-wide bands:
        a. Color as specified in the Piping Schedule.
    2. Self-adhesive type.
    3. Suitable for outdoor application from -40 degrees to 180 degrees Fahrenheit.

2.02 BURIED PIPELINE IDENTIFICATION

A. Underground warning tape:
    1. Manufacturer: One of the following or equal:
        a. Seton (of Brady Corporation).
        b. T. Christy Enterprises, Inc.
    2. Material:
        a. Polyethylene tape for prolonged underground use.
        b. Minimum tape thickness: 4 mils.
        c. Overall tape width: 4 inches.
        d. Message: “CAUTION” with the name of the service followed by “LINE BURIED BELOW.” in black lettering on colored background in accordance with approved APWA colors.

Service	**Color**
Potable water	Blue
Reclaimed water, irrigation, and slurry lines	Purple
Sewers and drain lines	Green
Gas, oil, steam, petroleum, chemicals, or other service	Yellow

        e. Aluminum backing or solid aluminum core.

B. Tracer wire:
    1. Manufacturers: One of the following or equal:
        a. Kris-Tech Wire.
        b. Aegion Corrpro.

2. Materials: One of the following or equal:
    a. Solid copper conductor.
    b. Thickness minimum: 10 gauge.
    c. Insulation:
        1) Match insulation color to the color of the pipe being installed.
        2) UF type, direct bury.
        3) 30 mil HMWPE.
3. Splicing kit:
    a. Manufacturers: One of the following or equal:
        1) 3M, Model 82 A1N.
4. Station box:
    a. Lid and collar materials: Cast iron.
    b. Lid type: Locking.
    c. Able to withstand heavy traffic loading.
    d. Manufacturers: One of the following or equal:
        1) CP Test & Valve Products, Inc., Glenn Test Station.
        2) Farwest Corrosion Control.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify satisfactory conditions of substrate for applying identification.

B. Verify that conditions are satisfactory for installation and application of products as specified in Section 01 61 00 - Common Product Requirements.

3.02 PREPARATION

A. Prepare and coat piping with the coating systems defined in the Piping Schedule.

B. Prepare surface in accordance with identification product manufacturer’s instructions.

3.03 EXPOSED AND IN-CHASE PIPING IDENTIFICATION

A. Identify exposed and in-chase piping with flow direction arrows and lettering (for piping with outer diameter greater than or equal to 3/4-inch) or tags (for piping with outer diameter less than 3/4-inch).

B. Provide lettering (or tags for pipes with outer diameter less than 3/4-inch) and flow direction arrows near equipment served, adjacent to valves, both sides of walls and floors where pipe passes through, at each branch or tee, and at intervals of not more than 50 feet in straight runs of pipe:
    1. Label all chemical tank fill pipelines at locations that are visible from chemical fill stations.
    2. Place markers on piping so they are visible from operator’s position in walkway or working platform near piping. Locate markers along horizontal centerline of pipe, unless better visibility is achieved elsewhere.
    3. Do not apply markers, arrows, or tags to piping that is regularly submerged.

C. Where scheduled in the Piping Schedule, space solid-color bands along piping at 10-foot intervals:
    1. Do not apply bands to piping that is regularly submerged.

3.04 BURIED PIPING IDENTIFICATION

A. Underground warning tape:
    1. Non-detectable warning tape:
        a. Place continuous run of warning tape in pipe trench, 12 inches above the pipe.
    2. Detectable warning tape:
        a. Place continuous run of warning tape in pipe trench, 12 inches above the pipe or a greater height if necessary to limit the tape bury depth to 36 inches. Do not bury detectable warning tape deeper than 36 inches.

B. Tracer wire:
    1. Install on all non-metallic pipe.
    2. Install an electrically continuous run of tracer wire along the entire length of the pipe with wire terminations in valve boxes, vaults, or structures.
    3. Install tracer wire on top of the pipe and secure to pipe with tape a minimum of every 10 feet.
    4. Where approved by the Engineer, splice sections of wire together using approved direct bury wire nuts:
        a. Twisting the wires together is not acceptable.

C. Witness markers:
    1. Install over pipe in unpaved open-space areas at intervals not greater than 200 feet.
    2. Place markers at appurtenances located in unpaved areas.
    3. Embed markers at least 18 inches into the soil.

END OF SECTION

SECTION 40_05_00.09

PIPING SYSTEMS TESTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Test requirements for piping systems.

1.02 REFERENCES

A. National Fuel Gas Code (NFGC).

B. American Society of Mechanical Engineers (ASME):
   1. B31.1 - Power Piping.
   2. B31.3 - Process Piping.
   3. B31.8 - Gas Transmission and Distribution Piping Systems.

C. Underwriters Laboratories Inc. (UL).

D. City of Santa Cruz Water System Standard Specifications.

E. City of Santa Cruz Public Works Standards.

1.03 TESTING REQUIREMENTS

A. General requirements:
   1. All new piping shall be pressure tested and disinfected by the Contractor in accordance with City Water Department Standard Specifications.
   2. Testing requirements are stipulated in Laws and Regulations; are included in the Piping Schedule in Section 40_05_00.01 - Common Work Results for General Piping; are specified in the specifications covering the various types of piping; and are specified in this Section.
   3. Requirements in Laws and Regulations supersede other requirements of Contract Documents, except where requirements of Contract Documents are more stringent, including higher test pressures, longer test times, and lower leakage allowances.
   4. Test plumbing piping in accordance with Laws and Regulations, the plumbing code, as specified in Division 01, and UL requirements.
   5. When testing with water, the specified test pressure is considered to be the pressure at the lowest point of the piping section under test:
      a. Lower test pressure as necessary (based on elevation) if testing is performed at higher point of the pipe section.
   6. Disinfect piping in accordance with City Water Department Standard Specifications. City staff will conduct Bac-T samples and test for disinfection. City staff will only perform disinfection testing on Mondays, Tuesdays, and Wednesdays.

B. Furnish necessary personnel, materials, and equipment, including bulkheads, restraints, anchors, temporary connections, pumps, water, pressure gauges, and other means and facilities required to perform tests.

C. Water for testing, cleaning, and disinfecting:
   1. Water for testing, cleaning, and disinfecting will be provided as specified in Section 01 51 05 - Temporary Utilities and Temporary Facilities.

D. Pipes to be tested: Test only those portions of pipes that have been installed as part of this Contract. Test new pipe sections prior to making final connections to existing piping. Furnish and install test plugs, bulkheads, and restraints required to isolate new pipe sections. Do not use existing valves as test plug or bulkhead.

E. Unsuccessful tests:
   1. Where tests are not successful, correct defects or remove defective piping and appurtenances and install piping and appurtenances that comply with the specified requirements.
   2. Repeat testing until tests are successful.

F. Test completion: Drain and leave piping clean after successful testing.

G. Test water disposal: Dispose of clean testing water at to the storm drain after de-chlorination in accordance with requirements of federal, state, county, and city regulations governing disposal of wastes in the location of the Project and disposal site. All requirements and costs associated with notifications and obtaining any discharge permit or approvals shall be responsibility of Contractor.

1.04 SUBMITTALS

A. Submit as specified in Section 01 33 00 - Submittal Procedures.

B. Schedule and notification of tests:
   1. Submit a list of scheduled piping tests by noon of the working day preceding the date of the scheduled tests.
   2. Notification of readiness to test: Immediately before testing, notify Engineer in writing of readiness, not just intention, to test piping.
   3. Have personnel, materials, and equipment specified in place before submitting notification of readiness.

1.05 SEQUENCE

A. Clean piping before pressure or leak tests.

B. Test gravity piping underground, including sanitary sewers, for visible leaks before backfilling and compacting.

C. Underground pressure piping may be tested before or after backfilling when not indicated or specified otherwise.

D. Backfill and compact trench or provide blocking that prevents pipe movement before testing underground piping with a maximum leakage allowance.

E. Test underground piping before encasing piping in concrete or covering piping with slab, structure, or permanent improvement.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 TESTING ALIGNMENT, GRADE, AND DEFLECTION

A. Alignment and grade:
   1. Visually inspect the interior of gravity piping with artificial light, reflected light, or laser beam.
   2. Consider inspection complete when no broken or collapsed piping, no open or poorly made joints, no grade changes that affect the piping capacity, or no other defects are observed.

B. Deflection test:
   1. Pull a mandrel through the clean piping section under test.
   2. Perform the test not sooner than 30 days after installation and not later than 60 days after installation.
   3. Use a 9-rod mandrel with a contact length of not less than the nominal diameter of the pipe within one percent plus or minus.
   4. Consider test complete when the mandrel can be pulled through the piping with reasonable effort by 1 person, without the aid of mechanical equipment.

3.02 AIR TESTING METHOD FOR PRESSURE PIPING

A. Air test piping, indicated with “AM” in the Piping Schedule, with air or another nonflammable or inert gas.

B. Test gas, air, liquefied petroleum gas, liquid chlorine, and chlorine gas piping by the air test method:
   1. Test chlorine piping with dry air or nitrogen having a dew point of minus 40 degrees Fahrenheit or less. Supply temporary air dryers as necessary.

C. Test at pressure as specified in Piping Schedule in Section 40_05_00.01 - Common Work Results for General Piping:
   1. Provide temporary pressure relief valve for piping under test:
      a. Set at the lesser of 110 percent of the test pressure or 50 pounds per square inch gauge over the test pressure.
   2. Air method test pressures shall not exceed 110 percent of the piping maximum allowable working pressure calculated in accordance with the most stringent of ASME B31.1, ASME B31.3, ASME B31.8, or the pipe manufacturer’s stated maximum working pressure.
   3. Gradually increase test pressure to an initial test pressure equal to the lesser of 1/2 the test pressure or 25 pounds per square inch gauge.

4. Perform initial check of joints and fittings for leakage.
5. Gradually increase test pressure in steps no larger than the initial pressure. Check for leakage; at each step increase until test pressure reached.
6. At each step in the pressure, examine and test piping being air tested for leaks with soap solution.
7. Consider examination complete when piping section under test holds the test pressure for 15 minutes without losses.

3.03 TESTING GRAVITY FLOW PIPING

A. Test gravity flow piping indicated with “GR” in the Piping Schedule, as follows:
   1. Unless specified otherwise, subject gravity flow piping to the following tests:
      a. Alignment and grade.
      b. For plastic piping test for deflection.
      c. Visible leaks and pressure with maximum leakage allowance, except for storm drains and culverts.
   2. Inspect piping for visible leaks before backfilling.
   3. Provide temporary restraints when needed to prevent movement of piping.
   4. Pressure test piping with maximum leakage allowance after backfilling.
   5. With the lower end plugged, fill piping slowly with water while allowing air to escape from high points. Keep piping full under a slight head for the water at least 24 hours:
      a. Examine piping for visible leaks. Consider examination complete when no visible leaks are observed.
      b. Maintain piping with water or allow a new water absorption period of 24 hours for the performance of the pressure test with maximum leakage allowance.
      c. After successful completion of the test for visible leaks and after the piping has been restrained and backfilled, subject piping to the test pressure for minimum of 4 hours while accurately measuring the volume of water added to maintain the test pressure:
         1) Consider the test complete when leakage is equal to or less than the following maximum leakage allowances:
            a) For concrete piping with rubber gasket joints: 80 gallons per day per inch of diameter per mile of piping under test:
               (1) Advise manufacturer of concrete piping with rubber gasket joints of more stringent than normal maximum leakage allowance.
            b) For vitrified clay piping: 500 gallons per day per inch of diameter per mile of piping under test.
            c) For other piping: 80 gallons per day per inch diameter per mile of piping under test.

3.04 TESTING HIGH-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure in the Piping Schedule is 20 pounds per square inch gauge or greater, by the high head pressure test method, indicated “HH” in the Piping Schedule.

B. General:
   1. Test connections, hydrants, valves, blowoffs, and closure pieces with the piping.
   2. Do not use installed valves for shutoff when the specified test pressure exceeds the valve's maximum allowable seat differential pressure. Provide blinds or other means to isolate test sections.
   3. Do not include valves, equipment, or piping specialties in test sections if test pressure exceeds the valve, equipment, or piping specialty safe test pressure allowed by the item's manufacturer.
   4. During the performance of the tests, test pressure shall not vary more than plus or minus 5 pounds per square inch gauge with respect to the specified test pressure.
   5. Select the limits of testing to sections of piping. Select sections that have the same piping material and test pressure.
   6. When test results indicate failure of selected sections, limit tests to piping:
      a. Between valves.
      b. Between a valve and the end of the piping.
      c. Less than 500 feet long.
   7. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.

C. Testing procedures:
   1. Fill piping section under test slowly with water while venting air:
      a. Use potable water for all potable waterlines and where noted on the Piping Schedule.
   2. Before pressurizing for the tests, retain water in piping under slight pressure for a water absorption period of minimum 24 hours.
   3. Raise pressure to the specified test pressure and inspect piping visually for leaks:
      a. Consider visible leakage testing complete when no visible leaks are observed.

D. Pressure test with maximum leakage allowance:
   1. Leakage allowance is zero for piping systems using flanged, National Pipe Thread threaded and welded joints.
   2. Pressure test piping after completion of visible leaks test.
   3. For piping systems using joint designs other than flanged, threaded, or welded joints, accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period:
      a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage and no damage to piping and appurtenances has occurred.
      b. Successful completion of the pressure test with maximum leakage allowance shall be achieved when the observed leakage during the test period is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.

c. When leakage is allowed, calculate the allowable leakage by the following formula:

$L = S \times D \times P^{1/2} \times 148{,}000^{-1}$

wherein the terms shall mean:

L = Allowable leakage in gallons per hour.

S = Length of the test section in feet.

D = Nominal diameter of the piping in inches.

P = Average observed test pressure in pounds per square inches gauge, at the lowest point of the test section, corrected for elevation of the pressure gauge.

x = The multiplication symbol.

3.05 TESTING LOW-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure is less than 20 pounds per square inch gauge, by the low head pressure test method, indicated “LH” in the Piping Schedule.

B. General:
   1. Test pressures shall be as scheduled in Section 40_05_00.01 - Common Work Results for General Piping.
   2. During the performance of the tests, test pressure shall not vary more than plus or minus 2 pounds per square inch gauge with respect to the specified test pressure.
   3. Test connections, blowoffs, vents, closure pieces, and joints into structures, including existing bell rings and other appurtenances, with the piping.
   4. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.

C. Visible leaks test:
   1. Subject piping under test to specified pressure measured at the lowest end.
   2. Fill piping section under test slowly with water while venting air:
      a. Use potable water for all potable waterlines and where noted on the Piping Schedule.
   3. Before pressurizing for the tests, retain water in piping under slight pressure for the water absorption period of minimum 24 hours.
   4. Raise pressure to the specified test pressure and inspect piping visually for leaks. Consider testing complete when no visible leaks are observed.

D. Pressure test with maximum leakage allowance:
   1. Pressure test piping after completion of visible leaks test.

2. Accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period:
    a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage of 80 gallons per inch of nominal diameter per mile of piping section under test after 24 hours, and no damage to piping and appurtenances has occurred.
    b. Successful completion of the leakage test shall have been achieved when the observed leakage is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.

E. Optional joint test:
1. When joint testing is allowed by note in the Piping Schedule, the procedure shall be as follows:
    a. Joint testing will be allowed only for low head pressure piping.
    b. Joint testing does not replace and is not in lieu of any testing of the piping system or trust restraints.
2. Joint testing may be performed with water or air.
3. Joint test piping after completion of backfill and compaction to the top of the trench.
4. Joint testing with water:
    a. Measure test pressure at the invert of the pipe. Apply pressure of 4 feet plus the inside diameter of the pipe in water column within 0.20 feet in water column.
    b. Maintain test pressure for 1 minute.
    c. Base the allowable leakage per joint on 80 gallons per inch nominal diameter, per mile of piping, per 24 hours equally distributed to the actual number of joints per mile for the type of piping.
    d. Consider the pressure test to be complete when makeup water added is less than the allowable leakage.
    e. Successful completion of the joint test with water shall have been achieved when the observed leakage is equal or less than the allowable leakage.
5. Joint testing with air:
    a. Apply test pressure of 3 pounds per square inch gauge with a maximum variation of plus 0.20 and minus 0.00 pounds per square inch.
    b. Maintain test pressure for 2 minutes.
    c. Consider the pressure test to be complete when the test pressure does not drop below 2.7 pounds per square inch for the duration of the test.

END OF SECTION

SECTION 40_05_06.01

PIPING SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Piping specialties, including:
      a. Transition fittings.
      b. Pipe saddles.
      c. Tapping sleeves.
      d. Chemical Injector/Diffuser.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.

B. American Water Works Association (AWWA):
   1. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
   2. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.

C. ASTM International (ASTM):
   1. A148 - Standard Specification for Steel Castings, High-Strength, for Structural Purposes.
   2. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   3. A194 - Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   4. A536 - Standard Specification for Ductile Iron Castings.

D. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects, Includes Errata.
   2. 372 - Drinking Water System Components - Lead Content.

E. City of Santa Cruz Water System Standard Specifications.

F. City of Santa Cruz Public Works Standards.

1.03 SUBMITTALS

A. Submit as specified in Section 01 33 00 - Submittal Procedures and Section 01 61 00 - Common Product Requirements.

B. Product data:
   1. For each piping product in this Section as applicable:
      a. Design features.
      b. Load capacities.
      c. Material designations by UNS alloy number or ASTM Specification and Grade.
      d. Data needed to verify compliance with the Specifications.
      e. Catalog data.
      f. Clearly mark Submittal information to show specific items, materials, and accessories or options being furnished.

C. Installation instructions:
   1. Provide manufacturer's installation instructions.

D. Calculations:
   1. Provide calculations in accordance with NSF 372 for materials in contact with drinking water.

E. Manufacturer's Certificate of Installation as specified in Section 01 79 00 - Demonstration and Training:
   1. Provide as specified in this Section.

1.04 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01 61 00 - Common Product Requirements.

B. Materials in contact with drinking waters: In accordance with NSF 61 and NSF 372.

2.02 TRANSITION FITTINGS

A. Manufacturers: One of the following or equal:
   1. Spears.

B. Materials:
   1. Slip socket: Schedule 80 PVC.
   2. Collar: Type 316 stainless steel.
   3. Threaded insert: Type 316 stainless steel.

2.03 PIPE SADDLES

A. For ductile iron pipe:
   1. Double strap brass type.
   2. Manufacturers: One of the following or equal:
      a. A.Y. McDonald, Style 3825.
      b. The Ford Meter Box Company, Style 202B.
      c. Mueller Company, Style BR2B.
   3. Materials:
      a. Pipe saddle body, straps, and nuts: Brass or silicon bronze.
      b. Gaskets: EPDM.

B. For PVC C900 or C905 pipe:
   1. Manufacturers: One of the following or equal:
      a. Romac Industries, Inc., Style 202S.
      b. Smith-Blair, Inc., Style 317.
   2. Materials:
      a. Pipe saddles: Ductile iron with fusion bonded epoxy finish.
      b. Straps, bolts, and nuts: Type 304 stainless steel with Teflon™ coating on nuts.
      c. Gaskets: EPDM.

2.04 TAPPING SLEEVES

A. Manufacturers: One of the following or equal:
   1. Romac Industries, Inc., Style FTS 420.
   2. Smith-Blair, Inc., Style 622.

B. Materials:
   1. Tapping sleeves: Steel construction.
   2. Bolts and nuts: Type 304 stainless steel.
   3. Nuts: Teflon™ coated.
   4. Gaskets: EPDM.
   5. Size of tapped boss: As indicated on the Drawings or specifications.

2.05 CHEMICAL INJECTOR/DIFFUSER

A. Design:
   1. Chemical injector/diffuser:
      a. Injector configuration: Single feed point into center of water main.
      b. Diffuser configuration: Multiple feed points along water main with hole size and spacing of 12 inches.
      c. Operating pressure: 12 inches.
   2. Heavy duty brass corporation stop or stainless steel ball valve:
      a. Thread connection shall be NPT or AWWA inlet.
      b. Corporation stop must include a safety device to prevent accidental withdrawal of Injection/Diffuser solution tube.
   3. Injector/diffuser solution tube sized to match pump discharge line or injection flow rate:
      a. Tube shall extend 1/3- to 1/2-diameter of water main into center of main.

b. Able to safely withdraw or insert injector/diffuser tube into center of water main while under pressure and without having to shut down the main.
c. Ball check valve located on injector/diffuser solution tube.
d. Stainless steel safety chain located on injector/diffuser solution tube.

B. Materials:
1. Injector/Diffuser: Compatible with chemical solution.

C. Manufacturers: The following or equal:
1. Saf-T-Flo.

2.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01 61 00 - Common Product Requirements.

PART 3 EXECUTION

3.01 GENERAL

A. As specified in Section 01 61 00 - Common Product Requirements.

B. Drawings supersede conflicts with this Section.

C. Bellows type expansion joints and vibration control joints:
1. Protect joints against damage during pressure test.

3.02 INSTALLATION

A. Pipe saddles:
1. Coat threads on bolts with anti-gall coating prior to installation.

B. Tapping sleeves:
1. Verify existing pipe material and outer diameter prior to ordering materials.
2. Coat threads on bolts with anti-gall coating prior to installation.

3.03 FIELD QUALITY CONTROL

A. Manufacturer services:
1. Required only for:
a. Transition couplings.
b. Tapping sleeves for large diameter pipe.
2. Provide Manufacturer’s Certificate of Installation.

B. Field testing:
1. As specified in Section 40_05_00.01 - Common Work Results for General Piping.
2. Protect bellows type expansion joints and vibration control joints.

END OF SECTION

SECTION 40_05_06.03

PIPE COUPLINGS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pipe couplings for ductile iron piping.
   2. Pipe couplings for carbon steel piping.
   3. Pipe couplings for stainless steel piping.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American National Standards Institute (ANSI).

B. American Society of Mechanical Engineers (ASME):
   1. B31.1 - Power Piping.
   2. B31.9 - Building Services Piping.

C. American Water Works Association (AWWA):
   1. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   2. C207 - Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In.
   3. C213 - Standard for Fusion-Bonded Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
   4. C219 - Bolted, Sleeve-Type Couplings For Plain-End Pipe.
   5. C606 - Standard for Grooved and Shouldered Joints.

D. ASTM International (ASTM):
   1. A36 - Standard Specification for Carbon Structural Steel.
   2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   3. A193 - Standard Specification for Alloy Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
   4. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
   5. A449 - Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/9 ksi Minimum Tensile Strength, General Use.

6. A536 - Standard Specification for Ductile Iron Castings.
7. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
8. A576 - Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.
9. C425 - Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings.
10. C443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
11. C564 - Standard Specification for Rubber Gasket for Cast Iron Pipe and Fittings.
12. C1173 - Standard Specification for Flexible Transition Couplings for Underground Piping Systems.
13. D1869 - Standard Specification for Rubber Rings for Asbestos-Cement Pipe.
14. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
15. D5926 - Standard Specification for Poly (Vinyl Chloride) (PVC) Gaskets for Drain, Waste, and Vent (DWV), Sewer, Sanitary, and Storm Plumbing Systems.
16. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
17. F594 - Standard Specification for Stainless Steel Nuts.
18. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.

E. NSF International (NSF):
1. 61 - Drinking Water System Components - Health Effects.
2. 372 - Drinking Water System Components - Lead Content.

F. City of Santa Cruz Water System Standard Specifications.

G. City of Santa Cruz Public Works Standards.

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Product data:
1. For each product in this Section as applicable:
   a. Design features.
   b. Load capacities.
   c. Material designations by UNS alloy number or ASTM specification and grade.
   d. Data needed to verify compliance with the Specifications.
   e. Catalog data.
   f. Clearly mark Submittal information to show specific items, materials, and accessories or options being furnished.

C. Calculations:
1. Provide calculations in accordance with NSF 372 for materials in contact with drinking water.

1.04 WARRANTY

A. Provide warranty as specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01 61 00 - Common Product Requirements:
   1. Materials in contact with drinking waters: In accordance with NSF 61 and NSF 372.

B. Known acceptable manufacturers are listed by specific products.

C. Provide references as specified in this Section by specific product.

D. Manufacturer's representatives requirements as specified in Section 01 79 00 - Demonstration and Training and this Section by specific product.

E. Gaskets for flexible couplings and flanged coupling adapters:
   1. Provide gasket materials for piping applications as follows:
      a. Low-pressure and high-pressure air, steam, hot water: EPDM.
      b. All other piping applications: EPDM.

F. Exterior coatings for underground and submerged applications:
   1. Manufacturers: One of the following or equal:
      a. Kop-Coat Co., Inc., Bitumastic Number 50.
      b. Tapecoat Co., Inc., T.C. Mastic.
   2. Thickness: Minimum 0.040 inch.

2.02 PIPE COUPLINGS FOR DUCTILE IRON PIPING

A. Dismantling joints:
   1. Manufacturers: One of the following or equal:
      a. Romac Ind., Inc., Style DJ400.
      b. Smith-Blair, Inc., Series 975.
   2. Materials:
      a. Flanged spool: AWWA C207 steel pipe:
         1) ASTM A53 for sizes 3 inches to 12 inches.
         2) ASTM A36 for sizes 14 inches to 72 inches.
      b. End ring and body:
         1) For sizes 3 inches to 12 inches: Ductile iron in accordance with ASTM A536.
         2) For sizes 14 inches to 72 inches: Steel in accordance with ASTM A36 or A53.
      c. Follower ring: Ductile iron in accordance with ASTM A536.
      d. Bolts and hex nuts:
         1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.

2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.

e. Tie rods: High tensile steel in accordance with ASTM A193 Grade B7.

3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

B. Equipment connection fittings:
1. Manufacturers: The following or equal:
   a. Romac Ind., Inc., Style ECF400.
2. Design:
   a. In accordance with AWWA C219.
   b. Suitable for minimum 150 pounds per square inch working pressure.
   c. Consist of 2 flanged coupling adapters, plain end section of pipe, thrust restraint rods, and associated fittings designed to transmit thrust without transmitting shear to the thrust restraint rods and without compromising provision for accommodating angular and parallel misalignment:
      1) Face to face length adjustment:
         a) For sizes 3 inches to 12 inches: 2 inches.
         b) For sizes 14 inches to 72 inches: 3 inches.
   d. Provide both lateral and angular misalignment adjustment between flanges:
      1) Shall accommodate a minimum of 1/4-inch lateral offset and 2 degrees deflection.
   e. Provide full pressure thrust restraint between flanges:
      1) Thrust rod:
         a) Selected to provide sufficient freedom of movement through all bolt holes to allow unrestricted maximum adjustment of equipment connection fittings.
         b) No transmission of any shear to the thrust rods.
         c) Allows full development of thrust restraint at thrust rod tension take-ups.
         d) Number and diameter selected as recommended by the manufacturer for the working pressure of the coupling.
3. Materials:
   a. Flanged spool: AWWA C207 steel pipe:
      1) ASTM A53 for sizes 3 inches to 12 inches.
      2) ASTM A36 for sizes 14 inches to 72 inches.
   b. End ring and body:
      1) For sizes 3 inches to 12 inches: Ductile iron in accordance with ASTM A536.
      2) For sizes 14 inches to 72 inches: Steel in accordance with ASTM A36 or A53.
   c. Bolts and hex nuts:
      1) Aboveground: Type 316 stainless steel bolts in accordance with ASTM F593.
   d. Tie rods: Type 316 stainless steel in accordance with ASTM A193 B8M.
   e. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
   f. Harness lugs: ASTM A36 steel.

g. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

C. Flanged coupling adapters: 12-inch size and smaller:
   1. Manufacturers: One of the following or equal:
      a. Dresser, Inc., Style 227.
      b. Romac Ind., Inc., Style FCA501.
      c. Smith-Blair, Inc., Series 912.
   2. Materials:
      a. Flanged body: Ductile iron in accordance with ASTM A536.
      b. Follower ring: Ductile iron in accordance with ASTM A536.
      c. Bolts and hex nuts:
         1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
         2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
   3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
   4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

D. Flanged coupling adapters: Greater than 12-inch size:
   1. Manufacturers: One of the following or equal:
      a. Dresser, Inc., Style 128-W.
      b. Romac Ind., Inc., Style FC400.
      c. Smith-Blair, Inc., Series 913.
   2. Materials:
      a. Flange and flanged body: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
      b. Follower ring: Low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
      c. Bolts and hex nuts:
         1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
         2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
   3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
   4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

E. Flexible couplings:
   1. Manufacturers: One of the following or equal:
      a. Dresser, Inc., Style 253.
      b. Romac Ind., Inc., Style 501.
      c. Smith-Blair, Inc., Series 441.
   2. Materials:
      a. Center rings: Ductile iron in accordance with ASTM A536.
      b. Follower rings: Ductile iron in accordance with ASTM A536.

c. Bolts and hex nuts:
    1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
    2) Buried and underwater: Type 316 stainless steel in accordance with ASTM F593.
3. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
4. Center sleeve dimensions: Provide center sleeves with lengths in accordance with following table:

Nominal Pipe Size	Sleeve Length
3 inch and smaller	Manufacturer's standard
4 inch through 8 inch	7 inches
10 inch through 14 inch	12 inches
Greater than 16 inch	Use steel flexible coupling per pipe couplings for steel piping

F. Flexible couplings (gravity flow):
1. Manufacturers: The following or equal:
    a. Fernco Flexible Coupling.
2. Materials:
    a. In accordance with ASTM D5926, ASTM C1173, and applicable portions of ASTM C443, C425, C564, and D1869.
3. Requirements:
    a. In underground and underwater installations, couplings shall be corrosion resistant or coated with a fusion applied epoxy coating in accordance with AWWA C213.
    b. Bolts and hardware shall be stainless steel 18-8 Type 316 epoxy coated alloy hardware.

G. Restrained flange coupling adapter:
1. Manufacturers: One of the following or equal:
    a. Romac Ind., Inc., Style RFCA.
    b. Star Pipe Products, 3200 StarFlange™.
2. Materials:
    a. Flange and flanged body: Ductile iron in accordance with ASTM A536.
    b. Follower ring: Lug type restraint system:
        1) Follower ring: Ductile iron in accordance with ASTM A536.
        2) Restraining lugs: Ductile iron in accordance with ASTM A536:
            a) Designed to contact the pipe and apply forces evenly.
        3) Restraining bolts:
            a) Ductile iron in accordance with ASTM A536.
            b) Bolt heads shall be designed to twist off when the proper torque has been applied.
    c. Bolts and hex nuts:
        1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
        2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.

3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
5. Angular deflection: Restrained flange coupling adapter must allow angular deflection after assembly.

PART 3 EXECUTION

3.01 INSTALLATION

A. In underground and underwater installations, coat the exterior of coupling with a protective coating in accordance with the manufacturer's instructions.

B. Joints and flexible connections shall be installed centered with no angular deflection unless otherwise indicated on the Drawings.

C. Flexible couplings and flange coupling adapters: Install with gap between pipe ends in accordance with the following table unless a greater gap is indicated on the Drawings. Maximum gap tolerance shall be within 1/8 inch:
1. Install flexible coupling with pipe gap located in middle of center sleeve.
2. Install flanged coupling adapter with end of plain end pipe in middle of flanged coupling body.

Center Ring Length	Gap Dimension and Tolerance
4 inch through 6 inch	3/8 inch
7 inch	5/8 inch
10 inch and greater	7/8 inch

D. Provide harnesses (tie-downs) for flexible couplings unless otherwise indicated on the Drawings with a written note:
1. Design harnesses (tie-downs) for the test pressures as specified in the Piping Schedule in Section 40_05_00.01 - Common Work Results for General Piping.

E. Grooved joint couplings:
1. Grooved ends: Clean and free from indentations, projections, and roll marks in the area from pipe end to groove.
2. Gaskets: Elastomer grade suitable for the intended service and molded and produced by the coupling manufacturer.

F. Bolted, split-sleeve couplings:
1. Inspect each coupling to insure that there are no damaged portions of the coupling:
   a. Pay particular attention to the sealing pad/sealing plate area.
   b. Before installation, thoroughly clean each coupling of any foreign substance which may have collected thereon and shall be kept clean at all times.
2. Wrenches:
   a. Conform to manufacturer instructions.

b. Bolts and studs shall be tightened so as to secure a uniform gasket compression between the coupling and the body of the pipe with all bolts or studs tightened approximately the same amount.
c. Final tightening shall be done by hand (no air impact wrenches) and is complete when the coupling is in uniform contact with the outside surface of the pipe all around the circumference of the pipe.

3. No joint shall be misfit in any plane.
4. On fixed ends of bolted, split-sleeve couplings, shoulders shall bear on restraint rings all around with no visible gap.
5. Ends of piping where couplers are installed shall be smooth and free of defects:
   a. Remove weld splatter and grind smooth.
   b. Grind pipe seam welds flush with pipe wall and smooth.

END OF SECTION

SECTION 40_05_06.10

STRAINERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Strainers.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A420 - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Low-Temperature Service.

B. Society of Automotive Engineers (SAE).

1.03 SUBMITTALS

A. Submit as specified in Section 01 33 00 - Submittal Procedures.

B. Product data: As specified in Section 40_05_00.01 - Common Work Results for General Piping.

PART 2 PRODUCTS

2.01 Y-TYPE STRAINERS

A. Y-type strainers less than 4 inches in diameter:
   1. Materials:
      a. Bodies: Cast iron or semi-steel.
      b. Ends: Flanged or threaded.
      c. Screen: Brass or Type 304 stainless steel.
   2. Suitable for maximum pressure of 250 pounds per square inch gauge.
   3. Screens: Perforations: 1/32 inch.
   4. Manufacturers: The following or equal:
      a. Armstrong, Y-Type Strainer.

B. Y-type strainers less than 3 inches in diameter for chemical service:
   1. Materials:
      a. Bodies: PVC.
      b. Ends: Socket end true unions.
      c. Screen: PVC.
      d. Seal material: FKM.
   2. Suitable for a minimum pressure of 90 pounds per square inch gauge.
   3. Screens: Perforations: 1/16 inch.
   4. Manufacturers: One of the following or equal.
      a. Asahi American.
      b. Hayward Flow Control.
      c. Spears Manufacturing Co.

2.02 H-TYPE STRAINERS

A. H-type strainers 6 inches or larger in diameter:
   1. Materials:
      a. Bodies: Ductile iron with fusion bonded epoxy coating.
      b. Cover and seal: Buna-N.
      c. Strainer: Type 316 stainless steel.
      d. Cover fasteners: Type 316 stainless steel.
      e. Ends: Flanged.
   2. Suitable for maximum pressure of 250 pounds per square inch gauge.
   3. Screens: Perforations: 1/32 inch.
   4. Manufacturers: The following or equal:
      a. Cla-Val, Model X43H H-Style Strainer.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with the manufacturer’s recommendations.

3.02 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training and this Section.

B. Manufacturer services for mechanically cleaned strainers:
   1. Provide certificates:
      a. Manufacturer’s Certificate of Installation and Functionality Compliance.
   2. Manufacturer’s Representative onsite requirements:
      a. Installation: 1 trip, 1 day minimum.
      b. Functional Testing: 1 trip, 1 day minimum each.
   3. Training:
      a. Maintenance: 1 hour per session, 1 session.
      b. Operation: 1 hour per session, 1 session.
   4. Process operational period:
      a. As required by Owner or Contractor to resolve functional problems observed during operational testing.

C. Functional testing:
    1. Mechanically cleaned strainers only:
        a. Test witnessing: Witnessed.
        b. Conduct Level 1 General Equipment Performance Test.

END OF SECTION

SECTION 40_05_06.55

PIPING INSULATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Insulation for piping and related systems that are not plumbing systems.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

B. American Water Works Association (AWWA):
   1. C151 - Ductile-Iron Pipe, Centrifugally Cast.

C. ASTM International (ASTM):
   1. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
   2. B88 - Standard Specification for Seamless Copper Water Tube.
   3. C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
   4. C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
   5. C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
   6. C547 - Standard Specification for Mineral Fiber Pipe Insulation.
   7. C552 - Standard Specification for Cellular Glass Thermal Insulation.
   8. C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
   9. C929 - Standard Practice for Handling, Transporting, Shipping, Storage, Receiving, and Application of Thermal Insulation Materials for Use in Contact with Austenitic Stainless Steel.
   10. C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
   11. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
   12. D2310 - Standard Classification of Machine-Made “Fiberglass” (Glass-Fiber-Reinforced-Thermosetting-Resin) Pipe.
   13. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
   14. E96 - Standard Test Methods for Water Vapor Transmission of Materials.

D. California Energy Commission:
   1. Title 24 - Building Energy Efficiency Standards.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning:
   1. Buried: Piping that is installed below buildings, foundations, or finish grade, either in soil or encased in concrete in soil.
   2. Concealed: Piping above suspended ceilings and within walls, partitions, shafts, or service spaces and spaces not normally exposed to view but not buried.
   3. Exterior: Piping that is installed outside a building or within a pipe trench or tunnel.
   4. Flame spread and smoke density: Burning characteristics determined in accordance with ASTM E84.
   5. Interior: Piping that is installed inside a building.
   6. K-factor: Thermal conductivity determined in accordance with ASTM C177 or ASTM C518.
   7. Mineral fiber: Fibers manufactured of glass, rock, or slag processed from a molten state, with or without a binder.
   8. Water vapor permeance: Water vapor transmission determined in accordance with ASTM E96 and expressed in units of perm-inch.

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures and Section 01 61 00 - Common Product Requirements.

B. Product data:
   1. Insulation properties: Include K-factor, thickness, density, operating temperature limits, tensile strength, compressive strength, moisture absorption, flame spread, and smoke developed in accordance with ASTM E84 and corrosivity to stainless steel piping in accordance with ASTM C795.
   2. Jacket properties: Include covering material, cover thickness, tensile strength, tear strength, permeability in accordance with ASTM E96, flame spread, and smoke developed in accordance with ASTM E84, closure type or devices, and accessories.
   3. Insulating blankets: Include materials, performance characteristics, method of attaching to equipment, listing of locations where insulating blankets will be installed.
   4. Manufacturer’s application instructions: Include assembly and application drawings and detailed instructions.

1.05 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01 61 00 - Common Product Requirements with additional requirements in Section 46_05_10 - Common Work Results for Mechanical Equipment.

B. In accordance with California Energy Commission Title 24.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.

B. Provide insulation thickness in inches in accordance with the following table. Insulation thickness shown is nominal. Manufacturing tolerance of 15 percent variation is permissible.

Table 1. Required Insulation Thicknesses (inches)

Service Temperature Range[(1)]	Nominal Pipe Diameters				
	1 inch and Less	1.25 to 2 inches	2.5 to 4 inches	5 to 10 inches	Over 10 inches
Above 200 degrees Fahrenheit	2.0	2.5	3.0	3.5	3.5
100 to 200 degrees Fahrenheit	1.5	1.5	1.5	2.0	2.5
40 to 100 degrees Fahrenheit	0.5	1.0	1.0	1.5	2.0
Below 40 degrees Fahrenheit	1.0	1.0	1.5	2.0	2.0
Heat Traced Pipes	1.0	1.0	1.0	1.5	2.0
Aeration Air Pipes	0.5	0.5	1.0	1.0	1.0

Notes:
(1) Default to 40 to 100 degrees Fahrenheit unless noted otherwise or indicated on the Drawings.

2.03 PIPE INSULATION

A. Insulation types: Provide in accordance with the insulation types listed and scheduled.

B. Type 1:
1. Material: Closed cell elastomeric insulation.
2. Minimum temperature range: -40 degrees Fahrenheit to 220 degrees Fahrenheit.
3. K-factor at 75 degrees Fahrenheit: Not more than 0.27 Btu-inch/hour-square feet-degrees Fahrenheit.
4. Fire ratings:
   a. Flame spread: 25 or less.
   b. Smoke density: 50 or less for insulation thicknesses up to 1.5 inches.

5. Joints: Seal with the manufacturer's recommended contact adhesive to form a continuous water barrier.
6. Manufacturers: One of the following or equal:
    a. Aeroflex USA Inc., Aerocel® AC.
    b. Armacell, AP Armaflex.

2.04 INSULATION JACKETS

A. Type 2:
    1. Material: Ultraviolet-resistant polyvinyl chloride jacketing, 20 mil minimum thickness.
    2. Fire rating: 25 maximum flame spread, smoke developed 50 or less.
    3. Color: White.
    4. Overlap: 1 inch minimum at joints and fittings.
    5. Joint seal: PVC solvent welded or adhesive as recommended by the manufacturer.
    6. Fittings: Factory made with full thickness insulation.
    7. Manufacturers: One of the following or equal:
        a. Johns Manville, Zeston® 2000 PVC.
        b. Proto Corp., LoSMOKE PVC.
        c. Speedline® Corp., Smoke-Safe™ PVC.

2.05 RELATED MATERIALS

A. Cover adhesive: Premium adhesive as recommended by the insulation cover supplier for heavy-duty service in corrosive, wet environments. Standard-duty adhesives are not permitted.

2.06 REMOVABLE INSULATING BLANKETS

A. In piping systems specified to be insulated, use removable insulating blankets for valves, meters, strainers, filters, catalytic converters, engine exhaust silencers, pumps, and other in-line piping appurtenances and equipment requiring periodic servicing, regardless of pipe size.

B. Size limits: Use removable insulating blankets for equipment and piping appurtenances 3 inches in nominal size and larger:
    1. For equipment and piping appurtenances less than 3 inches that do not require periodic servicing, insulate with molded sections of insulation or by field cutting insulation to conform to the shape of the component and to fit tightly around the component.

C. Manufacturers: One of the following or equal:
    1. Accessible Products, Thermazip 2000 Jacket.
    2. Owens Corning, Temp-Mat.
    3. Thermal Energy Products, Inc., Energy Wrap.

D. Low temperature insulating blankets rated up to 800 degrees Fahrenheit:
    1. For service temperatures up to 800 degrees Fahrenheit.
    2. Insulation: Fiberglass fiber, K-factor 0.27 at 75 degrees Fahrenheit.

3. Cover: 17-ounce fabric with both sides covered with silicone-impregnated glass cloth suitable for temperatures up to 800 degrees Fahrenheit.
4. Cover fasteners: Use one of the following systems:
    a. Grommets in the blanket and stainless steel wire.
    b. 1-inch-wide straps with stainless steel rectangular ring buckles and Velcro on strap tail.

E. High temperature insulating blankets rated up to 1,400 degrees Fahrenheit:
1. Rated for sustained service temperatures up to 1,400 degrees Fahrenheit.
2. Insulation: Ceramic fiber, K-factor 0.50 at 600 degrees Fahrenheit, insulation material suitable for up to 2,300 degrees Fahrenheit, thickness to match adjacent piping insulation specified thickness.
3. Cover: 17-ounce silicone impregnated fiberglass cloth suitable for temperatures up to 1,400 degrees Fahrenheit.
4. Cover fasteners: Use one of the following systems:
    a. Grommets in the blanket and stainless steel wire.
    b. 1-inch-wide straps with stainless steel rectangular ring buckles and Velcro on strap tail.

2.07 SHIPPING, SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

A. As specified in Section 01 61 00 - Common Product Requirements.

PART 3 EXECUTION

3.01 GENERAL

A. As specified in Section 01 61 00 - Common Product Requirements.

B. Handle and store insulation for use on stainless steel in accordance with ASTM C929.

3.02 PREPARATION

A. Pressure test piping and complete application of coating system before applying insulation.

B. When piping is to be heat traced, install and functionally test heat tracing before installation of insulation.

C. Before beginning installation of piping insulation, verify that the Engineer has accepted piping tests, pipe coating applications, and heat tracing tests.

3.03 INSULATION SCHEDULE

A. As indicated on the following table:

Pipe Material	Location	Insulation Type	Jacket Type	Vapor Barrier
Copper	Exposed	1	2	Not required.
Stainless Steel	Exposed	1	2	Not required.
Galvanized	Exposed	1	2	Not required.

3.04 INSTALLATION

A. Install insulation and jacket materials in accordance with the manufacturer's instructions.

B. Apply insulation in a smooth, clean manner with tight and finished smooth joints. Fit insulation tightly against surfaces:
   1. Insulate each continuous run of pipe with full-length sections of insulation with a single piece cut to length to complete the run of pipe.
   2. Do not use cut pieces or scraps to complete the installation.

C. Butt longitudinal and circumferential insulation joints firmly together.

D. Maintain the integrity of vapor barrier jacketing. Do not use staples to hold vapor barrier overlaps in place.

E. Apply sealant or cement when previous applications of adhesives and cement have thoroughly dried.

F. Apply insulation to permit expansion or contraction of pipelines without damage to insulation or jacketing.

G. Fittings:
   1. Insulate fittings by covering with mitered sections of insulation or utilize factory-made prefabricated fitting shapes.
   2. Terminate preformed pipe jackets or covering at sufficient distance from flanges to permit removal of bolts.
   3. Overlap flange and flanged fitting insulation on adjacent pipe covering by at least 2 inches.

H. Valves:
   1. Insulate valves 3 inches in nominal size and larger with removable insulating blankets.
   2. Size blanket to extend up to packing gland only so that replacement of packing does not require removal of insulating blanket.

I. Provide continuous insulation through and over pipe supports and provide protection saddles at supports.

J. Extend insulation against insulation end protection shields or covers so that insulation voids do not exist and provide watertight end seals and covers where insulation terminates.

K. Insulate pipeline strainers to permit removal of strainer basket without disturbing insulation on strainer body.

L. Provide continuous pipe insulation and covering through sleeves or openings in walls and floors. When buried pipe enters a building through a below grade wall or slab penetration, begin insulation system on interior side of penetration.

M. Apply pre-molded pipe insulation with extended legs when used on pipe traced with either tubing or electric cable type.

N. Thermally isolate insulation closure locations (end caps, transitions, etc.) Type 1 or Type 2 jacket installation on piping with potential reach temperatures greater than 150 degrees Fahrenheit.

O. Apply piping identification on jackets as specified in Section 40_05_00.03 - Pipe Identification.

END OF SECTION

SECTION 40_05_07.01

PIPE SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Supports for pipe, fittings, valves, and appurtenances.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   2. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   3. A967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.

B. Manufacturers Standardization Society (MSS):
   1. SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.

1.03 SUBMITTALS

A. Submit as specified in Section 01 33 00 - Submittal Procedures.

B. Product data:
   1. Design features.
   2. Load capacities.
   3. Material designations by UNS alloy number or ASTM Specification and Grade.
   4. Data needed to verify compliance with the Specifications.
   5. Catalog data.
   6. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.

C. Submit sealed and signed calculations for all pipe supports. Calculations shall meet the requirements as specified in Division 01 and technical sections.

1.04 WARRANTY

A. Provide warranty as specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01 61 00 - Common Product Requirements.

2.02 MATERIALS

A. General:
   1. Hot dip galvanized:
      a. Fabricate as specified in Section 05_50_00 - Metal Fabrications.
      b. Hot dip after fabrication of support in accordance with ASTM A123.
      c. Repair galvanized surface as specified in Section 05_50_00 - Metal Fabrications.
   2. Stainless steel:
      a. Fabricate as specified in Section 05_50_00 - Metal Fabrications.
      b. Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.
      c. At the shop, perform pickling and passivation on all surfaces inside and out in accordance with ASTM A380 or ASTM A967.
      d. Field welding is prohibited unless specifically allowed by the Owner. All field welds shall be passivated.

B. Outdoor areas: Areas exposed to the natural outdoor environment:
   1. Type 316 Stainless Steel or painted Hot Dip Galvanized.

C. Indoor areas: Areas exposed to an indoor environment including galleries and tunnels:
   1. Type 316 Stainless Steel or painted Hot Dip Galvanized.

D. Submerged, 3 feet or less above water level in a structure, or inside a water bearing structure:
   1. Type 304L Stainless Steel.

E. Stainless steel piping system:
   1. Type 316 Stainless Steel.

F. Chemical containment areas and chemical piping:
   1. Type 316 Stainless Steel.

G. Fasteners:
   1. As specified in Section 05_50_00 - Metal Fabrications.

2.03 PIPE SUPPORTS

A. Hanger rods: Sized to match suspended pipe hanger, or as indicated on the Drawings:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Bergen-Power, Figure 133.
         2) Nibco-Tolco, Figure 103.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 140.
         2) Bergen-Power, Figure 133.
         3) Cooper B-Line Systems, Inc., Figure B3205.

B. Hanger rods, continuously threaded: Sized to match suspended pipe hanger, or as indicated on the Drawings:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Bergen-Power, Figure 94.
         2) FM Stainless Fasteners.
      b. For steel and ductile iron piping:
         1) Anvil International, Figure 146.
         2) Bergen-Power, Figure 94.

C. Eye bolts:
   1. For stainless steel piping:
      a. Type 316 stainless steel welded and rated equal to full load capacity of rod.
   2. For all other piping, unless indicated on the Drawings:
      a. Welded and rated equal to full load capacity of rod.

D. Welded eyebolt rod:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) FM Stainless Fasteners.
         2) Nibco-Tolco, Figure 101.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 278.
         2) Bergen-Power, Figure 93.
         3) Cooper B-Line Systems, Inc., Figure B3210.

E. Adjustable ring hangers: MSS SP-58, Type 7 or Type 9 (system dependent):
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Bergen-Power, Figure 100SS.
         2) Nibco-Tolco, Figure 1C.I.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 69.
         2) Cooper B-Line Systems, Inc., Figure B3172.

F. Adjustable clevis hangers: MSS SP-58, Type 1:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Cooper B-Line Systems, Inc., Figure B3100 or B3102.
         2) FM Stainless Fasteners, Figure 60.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 260 or Figure 590.
         2) Bergen-Power, Figure 100.
         3) Cooper B-Line Systems, Inc., Figure B3100 or B3102.

G. Adjustable clevis hangers for insulated pipe: Oversize:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 1A.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 300.
         2) Bergen-Power, Figure 100EL.
         3) Cooper B-Line Systems, Inc. Figure B3108.

H. Single rod hangers for steam pipe: MSS SP-58, Type 43; malleable iron or steel yoke and roller hangers; swivel to allow rotation of yoke on rod:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Cooper B-Line Systems, Inc., Figure B3110.
         2) FM Fasteners, Figure 81.
         3) Nibco-Tolco, Figure 324.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 181.
         2) Cooper B-Line Systems, Inc., Figure B3110.

I. Double rod hangers for steam pipe: MSS SP-58, Type 41:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) FM Stainless Fasteners, Figure 71.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 171.
         2) Cooper B-Line Systems, Inc., Figure B3114.

J. Brackets: MSS SP-58, Type 32 with back plate; rated for 1,500 pounds:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Cooper B-Line Systems, Inc., Figure B3066.
         2) FM Stainless Fasteners, Figure 98.
         3) Nibco-Tolco, Figure 30M.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 195.
         2) Cooper B-Line Systems, Inc., Figure B3066.

K. Standard U-bolt: MSS SP-58, Type 24:
    1. Manufacturers: One of the following or equal:
        a. For stainless steel piping:
            1) Cooper B-Line Systems, Inc., Figure B3188.
            2) FM Stainless Fasteners, Figure 37.
            3) Nibco-Tolco, Figure 110.
        b. For all other piping, unless indicated on the Drawings:
            1) Anvil International, Figure 137.
            2) Bergen-Power, Figure 283.
            3) Cooper B-Line Systems, Inc., Figure B3188.

L. Riser clamps : MSS SP-58, Type 8:
    1. Manufacturers: One of the following or equal:
        a. For stainless steel piping:
            1) Cooper B-Line Systems, Inc., Figure B3373.
            2) FM Stainless Fasteners, Figure 61.
        b. For all other piping, unless indicated on the Drawings:
            1) Anvil International, Figure 261.
            2) Bergen-Power, Figure 126.
            3) Cooper B-Line Systems, Inc., Figure B3373.

M. Pipe clamps: MSS SP-58, Type 4:
    1. Manufacturers: One of the following or equal:
        a. For stainless steel piping:
            1) Cooper B-Line Systems, Inc., Figure 3140.
            2) Nibco-Tolco, Figure 4.
        b. For all other piping, unless indicated on the Drawings:
            1) Anvil International, Figure 212.
            2) Bergen-Power, Figure 175.
            3) Cooper B-Line Systems, Inc., Figure B3140.

N. Adjustable offset pipe clamp:
    1. Manufacturers: One of the following or equal:
        a. For stainless steel piping:
            1) Cooper B-Line Systems, Inc., Figure B3149.
            2) FM Stainless Fasteners, Figure 63.
            3) Nibco-Tolco, Figure 4.
        b. For all other piping, unless indicated on the Drawings:
            1) Anvil International, Figure 100.
            2) Cooper B-Line Systems, Inc., Figure B3149.

O. Offset pipe clamp:
    1. Manufacturers: One of the following or equal:
        a. For stainless steel piping:
            1) Cooper B-Line Systems, Inc., Figure 3148.
            2) Nibco-Tolco, Figure 8.
        b. For all other piping, unless indicated on the Drawings:
            1) Anvil International, Figure 103.
            2) Cooper B-Line Systems, Inc., Figure B3148.

P. Floor stand or stanchion saddles: MSS SP-58, Type 37. Provided with U-bolt hold down yokes:
    1. Manufacturers: One of the following or equal:
        a. For stainless steel piping:
            1) FM Stainless Fasteners, Figure 59.
            2) Nibco-Tolco, Figure 318.
        b. For all other piping, unless indicated on the Drawings:
            1) Anvil International, Figure 259.
            2) Bergen-Power, Figure 125.
            3) Cooper B-Line Systems, Inc., Figure B3090.
        c. Threaded pipe stand support stanchion. Match pipe support material:
            1) Anvil International, Figure 63T.
            2) Bergen-Power, Figure 138.
            3) Cooper B-Line Systems Inc., Figure B3088ST.

Q. Spring hangers:
    1. Manufacturers: One of the following or equal:
        a. For stainless steel piping:
            1) Bergen-Power, Figure 920.
        b. For all other piping, unless indicated on the Drawings:
            1) Anvil International, Figure B-268, Type G.
            2) Bergen-Power, Figure 920.

R. One hole pipe clamps:
    1. Manufacturers: One of the following or equal:
        a. For stainless steel piping: Engineer knows of no product.
        b. For all other piping:
            1) Anvil International, Figure 126.
            2) Carpenter & Paterson, Figure 237S.

S. Welded beam attachment: MSS SP-58, Type 22:
    1. Manufacturers: One of the following or equal:
        a. For stainless steel piping:
            1) Cooper B-Line Systems, Inc., Figure 3083.
            2) Nibco-Tolco, Figure 304.
        b. For all other piping, unless indicated on the Drawings:
            1) Anvil International, Figure 66.
            2) Bergen-Power, Figure 113A or 113B.
            3) Cooper B-Line Systems, Inc., Figure B3083.

T. Heavy pipe clamp: MSS SP-58, Type 4:
    1. Manufacturers: One of the following or equal:
        a. For stainless steel piping:
            1) Nibco-Tolco, Figure 4H.
        b. For all other piping, unless otherwise indicated on the Drawings:
            1) Anvil International, Figure 216.
            2) Bergen-Power, Figure 298.

U. PTFE pipe slide assembly: MSS SP-58, Type 35 with lateral and vertical restraint:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 426.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 257, Type 3.
         2) Cooper B-Line Systems, Inc., Figure B3893.

V. Anchor bolts, concrete anchors, concrete inserts, powder-actuated fasteners, and sleeve anchors: As specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.

PART 3 EXECUTION

3.01 INSTALLATION

A. Support, suspend, or anchor exposed pipe, fittings, valves, and appurtenances to prevent sagging, overstressing, or movement of piping; and to prevent thrusts or loads on or against connected pumps, blowers, and other equipment.

B. Field verify support location, orientation, and configuration to eliminate interferences prior to fabrication of supports.

C. Carefully determine locations of inserts. Anchor to formwork prior to placing concrete.

D. Use flush shells only where indicated on the Drawings.

E. Do not use anchors relying on deformation of lead alloy.

F. Do not use powder-actuated fasteners for securing metallic conduit or steel pipe larger than 1 inch to concrete, masonry, or wood.

G. Suspend pipe hangers from hanger rods and secure with double nuts.

H. Install continuously threaded hanger rods only where indicated on the Drawings.

I. Use adjustable ring hangers or adjustable clevis hangers for 4-inch and smaller diameter pipe.

J. Use adjustable clevis hangers for pipe larger than 4 inches in diameter.

K. Secure pipes with double nutted U-bolts or suspend pipes from hanger rods and hangers:
   1. For stainless steel piping, use stainless steel U-bolts.
   2. For all other piping, use galvanized U-bolts.

L. Support spacing:
   1. Support 2-inch and smaller piping on horizontal and vertical runs at maximum 5 feet on center, unless otherwise specified.
   2. Support larger than 2-inch piping on horizontal and vertical runs at maximum 10 feet on center, unless otherwise specified.

3. Support exposed polyvinyl chloride and other plastic pipes at maximum 5 feet on center, regardless of size.
4. Support tubing, PVC pipe 1-inch and smaller, copper pipe and tubing, fiber-reinforced plastic pipe or duct, and rubber hose and tubing at intervals close enough to prevent sagging greater than 1/4-inch between supports.
5. Do not suspend or support valves, pipe and fittings from another pipe or conduit.

M. Install supports at:
1. Any change in direction.
2. Both sides of flexible pipe connections.
3. Base of risers.
4. Floor penetrations.
5. Connections to pumps, blowers, and other equipment.
6. Valves and appurtenances.

N. Securely anchor plastic pipe, valves, and headers to prevent movement during operation of valves.

O. Anchor plastic pipe between expansion loops and direction changes to prevent axial movement through anchors.

P. Provide elbows or tees supported from floors with base fittings where indicated on the Drawings.

Q. Support base fittings with metal supports or, when indicated on the Drawings, support on concrete piers.

R. Do not use chains, plumbers' straps, wire, or similar devices for permanently suspending, supporting, or restraining pipes.

S. Support plumbing drainage and vents in accordance with the California Plumbing Code as specified in Division 01.

T. Supports, clamps, brackets, and portions of support system bearing against copper pipe: Copper plated, copper throughout, or isolated with neoprene or polyvinyl chloride tape.

U. Where pipe is insulated, install over-sized supports and hangers.

V. Install thermal pipe shield in accordance with MSS SP-58, Type 40 on pipe supports for insulated pipes.

W. Install riser clamps at floor penetrations and where indicated on the Drawings.

X. Coat support system components as specified in Section 09_96_01 - High-Performance Coatings.

END OF SECTION

SECTION 40_05_07.03

PREFORMED CHANNEL PIPE SUPPORT SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Preformed channel pipe support system consisting of preformed channels, fittings, straps, and fasteners engineered to support piping.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Institute of Steel Construction (AISC).

B. American Iron and Steel Institute (AISI).

C. Manufacturer's Standardization Society (MSS):
   1. SP-58 - Pipe Hangers and Supports - Materials, Design, and Manufacture.

1.03 SUBMITTALS

A. Submit as specified in Section 01 33 00 - Submittal Procedures.

B. Product data.

1.04 QUALITY ASSURANCE

A. Design preformed channel pipe support system for loads in accordance with applicable provisions of:
   1. AISC Manual of Steel Construction.
   2. AISI Cold-Formed Steel Design Manual.

B. Product standards:
   1. Pipe support materials: In accordance with MSS SP-58.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Fabricate preformed channel pipe support system using, as a minimum, parts specified below and meeting the requirements specified under Design Criteria.
   1. Manufacturers: One of the following or equal:
      a. Unistrut, Series P1000 or P1001; P5500 or P5501.
      b. Allied Support Systems, Power Strut, Figure PS-200 or PS-200 2TS; PS-150 or PS-150 2TS.
      c. Cooper Ind., B-Line, Channel Type B22 or B22A; B12 or B12A.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Design responsibility:
   1. The manufacturer of the preformed channel pipe support system is responsible for the design of the support system.
   2. Prepare design calculations utilizing the design criteria included in these Specifications.
   3. Prepare detailed shop drawings illustrating the layout of the support system and identifying the components of the support system.

B. Design criteria:
   1. Include live, dead, and seismic loads associated with piping, valves, and appurtenances. Consider the content of the pipes in load calculations.
   2. Minimum gauge thickness: 12-gauge.
   3. Allowable stress of channels:
      a. Steel channels: The lesser of 25,000 pounds per square inch, or 0.66 times yield stress of steel.
      b. Stainless steel channels: 0.66 times the yield stress of the stainless steel alloy.
   4. Maximum deflection: 1/240 of span.
   5. Allowable column loads: As recommended by manufacturer in published instruction for column's unsupported height and "K" value for calculating effective column length of not less than 1.0.
   6. Future loads:
      a. Support systems indicated on the Drawings and in the required in the specifications may include spaces intended to accommodate future pipes.
      b. Assume such spaces are occupied by 6-inch diameter ductile iron pipes. Only the number of pipes that would physically fit into the space need be considered.
      c. Include the weight of the pipe contents in determining future loads. Assume pipe contents are water.
   7. Seismic design criteria: As specified in technical sections and as indicated on the Drawings.
   8. Spacing of supports: As required to comply with design requirements but not more than 5 feet.

C. Supports below the top of walls of water bearing structures: Use Type 316 stainless steel for support system components:
    1. Supports in other locations: Use hot-dipped galvanized components unless other materials are specifically indicated on the Drawings.

2.03 MATERIALS

A. General:
    1. Hot dip galvanized:
        a. Fabricate as specified in Section 05_50_00 - Metal Fabrications.
        b. Hot dip after fabrication of support in accordance with ASTM A123.
        c. Repair galvanized surface as specified in Section 05_50_00 - Metal Fabrications.
    2. Stainless steel:
        a. Fabricate as specified in Section 05_50_00 - Metal Fabrications.
        b. Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.
        c. At the shop, perform pickling and passivation on all surfaces inside and out in accordance with ASTM A380 or ASTM A967.
        d. Field welding is prohibited unless specifically allowed by the Owner. All field welds shall be passivated.

B. Outdoor areas: Areas exposed to the natural outdoor environment:
    1. Type 316 Stainless Steel or painted Hot Dip Galvanized.

C. Indoor areas: Areas exposed to an indoor environment including galleries and tunnels:
    1. Type 316 Stainless Steel or painted Hot Dip Galvanized.

D. Submerged, 3 feet or less above water level in a structure, or inside a water bearing structure:
    1. Type 316 Stainless Steel.

E. Stainless steel piping system:
    1. Type 316 Stainless Steel.

F. Chemical containment areas and chemical piping:
    1. Type 316 Stainless Steel.

G. Fasteners:
    1. As specified in Section 05_50_00 - Metal Fabrications.

2.04 ACCESSORIES

A. Preformed channel concrete inserts: Minimum 12 inches long:
    1. Manufacturers: One of the following or equal:
        a. Unistrut, Series P-3200.
        b. Allied Support Systems, Figure 282.
        c. Cooper Ind., B-Line Series B32I.

B. 90-degree angle fittings:
   1. Manufacturers: One of the following or equal:
      a. Unistrut, P1026.
      b. Allied Support Systems, Power Strut, P603.

C. Pipe straps:
   1. For pipes 8 inches in diameter and smaller: Use 2-piece universal strap with slotted hex head screw and nut:
      a. Manufacturers: One of the following or equal:
         1) Unistrut, Series P1109 through P1126.
         2) Allied Support Systems, PS1100.
         3) Cooper Ind., B-Line Series B2000.
   2. For pipes greater than 8 inches in diameter: Unless different material is otherwise indicated on the Drawings use 1-piece 1-inch wide by 1/8-inch-thick steel strap, hot-dip galvanized after fabrication.
   3. For stainless steel pipes: Use type of strap required for the pipe sizes specified above but use Type 316 stainless steel materials.

D. Prefabricated double channel bracket:
   1. Manufacturers: One of the following or equal:
      a. Unistrut, P2542-P2546.
      b. Cooper Ind., B-Line Series B297.

E. Touch-up paint for galvanized surfaces:
   1. Manufacturers: The following or equal:
      a. Galvinox, Galvo-Weld.

F. Touch-up paint for painted surfaces: Same formulation as factory paint.

G. Cushion strip:
   1. For solvent welded plastic pipes in elevated temperatures, use a thermoplastic elastomer, cushion wrap designed for use from -50 degrees Fahrenheit to 275 degrees Fahrenheit. Contractor to add a cushion strip at each pipe support strap that meets these criteria:
      a. Manufacturers: One of the following or equal:
         1) Anvil, AS 3795.
         2) Unistrut, P2600 Unicushion.

2.05 FABRICATION

A. Hot dip galvanize support system components after fabrication to required length and shape.

B. Do not galvanize or paint stainless steel components.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install preformed channel concrete inserts for vertical support, quantity based on manufacturer's structural design calculations.

B. Fasten preformed channel pipe supports to existing walls using Z-fittings and concrete anchors as indicated on the Drawings.

C. Fasten preformed channel pipe supports to preformed channel concrete inserts embedded in ceiling using U-shaped fittings.

D. Suspend threaded rods from concrete inserts embedded in ceiling. Support preformed channel pipe supports with threaded rods.

E. Touchup cut or damaged galvanized surfaces.

F. Prevent contact between pipes and support components of dissimilar metals. Utilize rubber coated, plastic coated, or vinyl coated components, stainless steel components, or wrap pipe with PVC or polyethylene tape.

G. Install support as near as possible to concentrated loads.

H. Install support within 2 feet of horizontal and vertical changes in pipe alignment.

I. Adjust supports or install shims to obtain specified slope or elevation.

END OF SECTION

SECTION 40_05_17.05

COPPER WATER TUBE: SEAMLESS, ASTM B88

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Copper water tube-seamless, ASTM B88.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
   2. B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

B. ASTM International (ASTM):
   1. A536 - Standard Specification for Ductile Iron Castings.
   2. B32 - Standard Specification for Solder Metal.
   3. B88 - Standard Specification for Seamless Copper Water Tube.
   4. B813 - Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube.
   5. B828 - Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fitting.

C. International Association of Plumbing and Mechanical Officials (IAPMO):
   1. IS 3 - Installation Standard for Copper Plumbing Tube, Pipe and Fittings.

1.03 SUBMITTALS

A. Submit as specified in Section 01 33 00 - Submittal Procedures.

B. Product data: As specified in Section 40_05_00.01 - Common Work Results for General Piping.

PART 2 PRODUCTS

2.01 MATERIALS

A. Seamless copper water tube:
   1. Type: ASTM B88:
      a. Exposed copper piping or tubing: Type L hard-drawn, rigid.
      b. Copper tubing buried in the ground or in plastic conduit: Type K soft-annealed.
   2. Fittings: Solder type forged or wrought copper:
      a. Manufacturers: One of the following or equal:
         1) Hoke, Gyrolok.
         2) Crawford Fitting Co., Swagelok.
         3) Parker.
   3. Solder: ASTM B32, Alloy Grade Sb5.
   4. Flux: ASTM B813.
   5. Grooved end fittings: ASME B16.22 wrought copper or ASME B16.18 bronze castings with copper tube dimensioned grooved ends (flaring of tube and fitting ends to IPS dimensions is not permitted):
      a. Manufacturers:
         1) Victaulic Company.
   6. Grooved mechanical couplings:
      a. “Installation Ready” stab-on coupling designed for direct ‘stab’ installation onto roll grooved copper tube without prior field disassembly and no loose parts.
      b. Housings shall be ductile iron, cast with offsetting, angle-pattern bolt pads coated with copper-colored enamel.
      c. Gasket shall be Grade “EHP” EPDM suitable for water temperatures up to 250 degrees Fahrenheit, and plated steel bolts and nuts.
      d. Victaulic Style 607 QuickVic™.
   7. Grooved joint flange adapters:
      a. ASTM A 536 ductile iron casting coated with copper-colored enamel, flat faced, designed for connecting directly to ANSI Class 125 and 150 flanged components.
      b. Victaulic Style 641.
   8. Dielectric insulating unions or waterway fittings:
      a. Manufacturers: One of the following or equal:
         1) Mueller Co.
         2) Watts.
         3) Victaulic Co. Style 47.
   9. Special thread to tube adapters:
      a. Manufacturers: One of the following or equal:
         1) Crawford Fitting Co., Swagelok.
         2) Hoke, Gyrolok.
         3) Parker.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Support copper piping and tubing as specified in Section 40_05_07.01 - Pipe Supports and Section 40_05_07.03 - Preformed Channel Pipe Support System.
   2. Clean copper lines with high-pressure air after first disconnecting piping at instruments, filters, pressure reducers, valve operators, and other special devices.
   3. Install copper pipe in accordance with IAPMO IS 3.

B. Installation of copper piping:
   1. Connect copper pipe connected to ferrous pipe or valves, or other non-copper items, by means of dielectric insulating unions or fittings.
   2. Where connections are made to meters or other devices having iron pipe size threaded fittings, provide special thread to tube adapters.
   3. Grooved joint piping systems shall be installed in accordance with the manufacturer's (Victaulic) guidelines and recommendations:
      a. Grooved couplings and fittings shall be the products of a single manufacturer.
      b. Grooving tools shall be of the same manufacturer as the grooved components.
      c. Gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified.
      d. Gaskets shall be molded and produced by Victaulic.
      e. Grooved end shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove for proper gasket sealing.
      f. A Victaulic factory-trained field representative shall provide on-site training for Contractor's field personnel in the proper use of grooving tools and installation of grooved piping products.
      g. Factory-trained representative shall periodically review the product installation.
   4. Remove and replace any improperly installed products.

C. Installation of copper tubing:
   1. In accordance with ASTM B828 and IAPMO IS 3.
   2. Straight runs, supported at intervals close enough to avoid sagging.
   3. Make cuts square with a tubing cutter or with a 32-tooth hacksaw:
      a. Provide a sizing tool to correct distortions.
   4. Ream the inside of the tubing and remove burrs from the outside, holding the end of the tubing downward and preventing chips and fillings from entering the tubing.
   5. Perform flaring with a flare block and yoke type screw feed flaring tool:
      a. After removing the tubing from the flare block, inspect both surfaces of the flare for splits, cracks, or other imperfections.
      b. Where there are imperfections, cut off the imperfect flare, and prepare a new flare.

3.02 FIELD QUALITY CONTROL

A. Test copper lines in the same manner as the piping system to which they connect.

END OF SECTION

SECTION 40_05_19.01

DUCTILE IRON PIPE: AWWA C151

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Ductile iron pipe, joints, connections, fittings, and pipe linings and coatings.

B. As specified in Section 40_05_00.01 - Common Work Results for General Piping.

C. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

B. American Water Works Association (AWWA):
   1. C104 - Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
   2. C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
   3. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
   4. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   5. C116 - Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings.
   6. C150 - Standard for Thickness Design of Ductile-Iron Pipe.
   7. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.
   8. C153 - Ductile-Iron Compact Fittings.
   9. C210 - Liquid-Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
   10. C222 - Polyurethane Coatings and Linings for Steel Water Pipe and Fittings.
   11. C600 - Installation of Ductile Iron Water Mains and Their Appurtenances.
   12. C606 - Standard for Grooved and Shouldered Joints.

C. American Welding Society (AWS):
   1. D11.2 - Guide for Welding Iron Castings.

D. ASTM International (ASTM):
   1. A536 - Standard Specifications for Ductile Iron Castings.
   2. B1000 - Standard Practices for Casting Preparation and Test Procedure of Porcelain Enamel-Lined Pipe, Fittings, and Valves for Use in the Municipal Wastewater, Sewage, and Water Treatment Industry.

3. C33 - Standard Specification for Concrete Aggregates.
4. C150 - Standard Specification for Portland Cement.
5. C283 - Standard Test Methods for Resistance of Porcelain Enameled Utensils to Boiling Acid.
6. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
7. D4541 - Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.

E. Ductile Iron Pipe Research Association (DIPRA):
1. Thrust Restraint Design Manual.

F. International Organization for Standardization (ISO):
1. 8179 - Ductile iron pipe, fittings, accessories and their joints - External zinc-based coating - Part 1: Metallic zinc with finishing layer.

G. National Association of Pipe Fabricators, Inc. (NAPF):
1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.

H. NSF International (NSF):
1. 61 - Drinking Water System Components - Health Effects.

I. Society for Protective Coatings (SSPC):
1. SP 5 - White Metal Blast Cleaning.
2. SP 10 - Near White Wet Blast.
3. SP 11 - Bare Metal Power Tool Cleaning.
4. PA 2 - Measurement of Dry Coating Thickness with Magnetic Gages.
5. QP 1 - Industrial Contractor Qualification.

J. City of Santa Cruz Water System Standard Specifications.

K. City of Santa Cruz Public Works Standards.

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Product data.

C. Manufacturer’s qualifications:
1. Manufacturer qualifications and list of projects using the specified material: 5 years minimum.

D. Manufacturer’s Quality Assurance Manual:
1. Submit manufacturer’s coating and lining application quality assurance manual to the Engineer prior to beginning coating application:
a. Strict conformance to the requirements of the manual will be required.
b. Deviation from the requirements of the manual will be grounds for the Engineer to reject the applied coating.

E. Shop Drawings:
   1. Detailed layout drawings showing alignment of pipes, location of valves, fittings, and appurtenances, types of joints, and connections to pipelines or structures.
   2. Thrust restraint systems.
   3. Photographs, drawings, and descriptions of fittings, gaskets, couplings, grooving of pipe and fittings.

F. Calculations:
   1. Thrust restraint system design.

G. Manufacturer's Certificate of Source Testing for ceramic epoxy, glass lined, plural component polyurethane, and zinc materials:
   1. Certify successful performance of holiday detection tests on 100 percent of lining in accordance with ASTM B1000.
   2. Identify each test piece by mark designation and show the actual test results during the final inspection by the manufacturer prior to shipment.
   3. Zinc coating: Regular measurements in accordance with ISO 8179 Part 4.4.
   4. Include the coating manufacturer's technical representative's reports.

1.04 QUALITY ASSURANCE

A. Ductile iron pipe shall be supplied by a single manufacturer.

B. Hydrostatically test each joint of ductile iron pipe in accordance with AWWA C151.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Block piping and associated fittings for shipment to prevent damage to coatings and linings.

B. Carefully handle piping and associated fittings during loading, unloading, and installation:
   1. Do not drop piping material from cars or trucks.
   2. Lower piping by mechanical means.
   3. Do not drop or pound pipe to fit grade.

C. Handle pipe from the outside if lined with ceramic epoxy, glass or plural component polyurethane:
   1. No forks, chains, straps, hooks, or other lifting device shall be placed inside the pipe or fittings for lifting, positioning, or laying.

D. Protect gaskets and polyethylene encasement from long-term exposure to sunlight.

E. Store piping, fittings, and other accessories such that they do not accumulate and hold rainwater, dirt, and debris.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Ductile iron piping:
   1. Manufacturers: One of the following or equal:
      a. American Cast Iron Pipe Co.
      b. McWane Ductile.
      c. SIP Industries.
      d. U.S. Pipe.

2.02 THRUST RESTRAINT SYSTEM DESIGN

A. Length of pipe that must be restrained on each side of the focus of a thrust load as specified in the Pipe Schedule.

B. Design pressure as specified in the Pipe Schedule.

C. Laying condition: Type 5 in accordance with AWWA C150.

D. Soil type: Clay 2.

E. Unit friction resistance for polyethylene encasement of pipe: DIPRA factor multiplied by a safety factor of 1.5.

2.03 CONCRETE THRUST BLOCK RESTRAINT

A. Joint thrust restraint system designed by the Contractor.

B. Thrust restrain system shall meet the minimum requirements of City of Santa Cruz Water Department Standard Detail 19.

2.04 DUCTILE IRON JOINTS AND CONNECTIONS

A. General:
   1. Pressure class or special thickness class as indicated in the Piping Schedule provided in Section 40_05_00.01 - Common Work Results for General Piping.
   2. In accordance with AWWA C150 and AWWA C151.
   3. Joints:
      a. Flanged.
      b. Grooved.
      c. Mechanical.
      d. Push-on rubber gasket.
      e. Integrally restrained mechanical.
      f. Integrally restrained push-on.
      g. Push-on joint restraint harness.
   4. Connections:
      a. Tapping saddle.
      b. Tapping sleeve.
      c. Welded outlet.
   5. Fittings.

B. Joints:
   1. Flanged joints:
      a. Screw-on flanges:
         1) Comply with the diameter, thickness, drilling, and other characteristics in accordance with ASME B16.1.
         2) Ductile iron.
         3) Long hub, threaded, and specially designed for ductile iron pipe.
         4) After attaching to pipe, machine flange face to make pipe end and flange even and perpendicular to the axis of the pipe.
      b. Bolt holes on flanges: 2-holed and aligned at both ends of pipe.
      c. Cap screw or stud bolt holes: Tapped.
      d. Bolts and nuts:
         1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
      e. Gaskets:
         1) Standard styrene butadiene copolymer (SBR) unless specified otherwise in Section 40_05_00.01 - Common Work Results for General Piping.
   2. Grooved joints:
      a. In accordance with AWWA C606, as complemented and modified below, radius-cut type.
      b. Couplings:
         1) Rigid type, cast from ductile iron in accordance with ASTM A536, Grade 65-45-12.
      c. Bolts and nuts:
         1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
      d. Gaskets:
         1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
      e. Fittings:
         1) In accordance with AWWA C606, rigid radius-cut groove.
         2) Center-to-center dimensions: In accordance with AWWA C110.
         3) Wall thickness and other characteristics: In accordance with AWWA C606.
      f. Flanged unit connections:
         1) Flanged to grooved joint adapters or a long enough spool with one end flanged and the other end grooved to prevent interference with the operation of adjacent valves, pumps, or other items.
   3. Mechanical joints:
      a. In accordance with AWWA C111.
      b. Gaskets:
         1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
      c. Bolts and nuts, including T-bolts:
         1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.

4. Push-on rubber gasket joints:
    a. In accordance with AWWA C111.
    b. Gaskets:
        1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
    c. Coatings:
        1) Provide manufacturer applied coating system.
        2) Manufacturers: One of the following or equal:
            a) EBAA Iron Inc., Mega-Bond polyester powder applied by an electrostatic spray process.
            b) Sigma Corp., Corrsafe™ Electro-deposition coating.
            c) Star Pipe Products, Star-Bond™ TGIC polyester powder coating applied by an electrostatic spray process.
    d. Working pressure:
        1) Shall include a minimum safety factor of 2:1.
        2) Sizes 3- through 16-inch: 350 pounds per square inch.
        3) Sizes 18- through 48-inch: 250 pounds per square inch.
    e. Restraint shall allow post assembly angular deflection that is a minimum of 50 percent of the angular deflection allowed by the mechanical joint.
    f. Restraint must be in accordance with applicable requirements of AWWA C110 and AWWA C111 for mechanical joints.

C. Connections:
    1. Tapping saddle as specified in Owner standard specification:
        a. Per City of Santa Cruz Water Department Standard Detail 1.
    2. Tapping sleeve as specified in Owner standard specification:
        a. If Owner does not have a standard specification, provide tapping sleeves as specified in Section 40_05_06.01 - Piping Specialties.
    3. Welded outlet:
        a. Not allowed without Engineer approval.

D. Fittings:
    1. Ductile iron in accordance with AWWA C110 or AWWA C153.
    2. Joint type:
        a. Same as that of the associated piping as specified in Section 40_05_00.01 - Common Work Results for General Piping.
    3. Plain end-to-flanged joint connectors using setscrews are not acceptable.

2.05 ASPHALT VARNISH

A. Coating:
    1. Factory apply.

B. Compatible with materials as specified in Section 09_96_01 - High-Performance Coatings.

2.06 CEMENT MORTAR

A. Line pipe with cement mortar in accordance with AWWA C104 and as specified in this Section.

B. Cement:
   1. Cement: In accordance with ASTM C150, Type II.

C. Water:
   1. In accordance with AWWA C104 and as specified in this Section.

D. Sand and aggregate:
   1. In accordance with AWWA C104.
   2. Provide silica sand or other aggregate that is not subject to leaching in accordance with ASTM C33.

E. Lining:
   1. Minimum thickness: Standard in accordance with AWWA C104.
   2. Apply cement mortar on clean bare metal surfaces.
   3. Extend to faces of flanges, ends of spigots, and shoulders of hubs.
   4. Line special pieces or fittings by mechanical, pneumatic, or hand placement:
      a. Extend to faces of flanges and ends of spigots.
      b. Less than 12 inches in width: Coat with epoxy bonding agent prior to applying cement mortar.
      c. Larger than 12 inches in width: Reinforced with 2-inch by 4-inch No. 13 gauge welded steel wire mesh prior to applying cement mortar.
   5. Provide plastic end caps of sufficient thickness and strength to resist shipping, handling, and storage stresses.
   6. Repair damage to the cement mortar lining, including disbondment, or cracking caused by improper curing, shipping, handling, or installation in accordance with AWWA C104 and approved by the Engineer:
      a. Reinforce coating with 2 layers spirally wound steel wire positioned approximately in center of mortar coating positioned approximately at the third points of mortar coating:
         1) No. 12 gauge spaced at maximum 1-inch centers.
         2) No. 14 gauge steel wire at maximum 1/2-inch centers.

2.07 POLYETHYLENE ENCASEMENT

A. General:
   1. Polyethylene encasement shall be supplied by the pipe manufacturer.

B. Materials: Supply one of the following polyethylene encasements:
   1. 2 layers of linear low-density polyethylene (LLDPE) film, minimum thickness of 8 mils in accordance with AWWA C105.
   2. Single layer of high-density, cross-laminated polyethylene (HDCLPE) film, minimum thickness of 4 mils in accordance with AWWA C105.
   3. Single layer of V-Bio® enhanced polyethylene encasement (3 layers of coextruded LLDPE film with anti-microbial additive and volatile corrosion inhibitor infused on the inside surface), meeting all requirements of AWWA C105.

2.08 PLURAL COMPONENT EPOXY

A. Coat pipe with plural component, 100 percent solids, non-extended in accordance with AWWA C210 and as specified in this Section.

B. Surface preparation:
   1. In accordance with SSPC-SP 10 or SSPC-SP 11.
   2. In accordance with AWWA C210 and as specified in this Section:
      a. Steel pipe: SSPC-SP 5, 3.00 mil profile, minimum, or in accordance with the manufacturer's requirements, whichever is greater.

C. Primer: In accordance with the coating manufacturer's requirements.

D. High build epoxy coating:
   1. 2 component, high build polyamide or polyamine cured epoxy coating, suitable for direct burial or immersion, dries to touch in 2 or more hours, suitable for immersion or burial after full cure of coating.
   2. Manufacturers: One of the following or equal:
      a. Carboline.
      b. ICI Devoe.
      c. Sherwin Williams.
      d. Warren Environmental.

E. Fast cure epoxy coating:
   1. 2 component, 100 percent solids by volume, fast cure epoxy coating suitable for direct burial or immersion, dry to touch in less than 1 hour at 72 degrees Fahrenheit, capable of curing while immersed or buried.
   2. Manufacturers: One of the following or equal:
      a. North American Denso, Protal 7125 or Protal 7200.
      b. Tapecoat Inc., TC 7010.

F. Application:
   1. Apply coating using plural component spray equipment by a manufacturer certified coating applicator.
   2. Perform coating application in an environmentally controlled shop area that meets or exceeds the written environmental application requirements of the coating manufacturer:
      a. It is not acceptable to apply coating in outdoor conditions without adequate environmental shelter, environmental controls, and/or dehumidification.
   3. In potable water applications, provide epoxy lining suitable for potable water contact in accordance with NSF 61, unless otherwise approved by the Engineer.
   4. Concrete embedded pipe penetrations: Extend epoxy coating a minimum of 6 inches outside of interior and exterior surfaces of concrete walls or floors.
   5. Concrete penetrations minimum dry film thickness: 12 mils.
   6. Apply heat shrink sleeves to buried transitions from epoxy to tape wrap or extruded polyolefin coating systems:
      a. Backfill as soon as practical to limit exposure to direct sun or heat and potential thermal creep of sleeve.

G. Self-priming, plural component, 100 percent solids, suitable for burial or immersion, and in accordance with AWWA C210 and the following, whichever is more stringent:
   1. Non-NSF certified: Ceramic fill.
   2. NSF certified: Poly amine epoxy or poly amide epoxy.

3. Shop applied coating thickness:
    a. Minimum: 1 coat, 35 mils total dry film thickness.
4. Shop applied lining thickness:
    a. Minimum: 1 coat, 35 mils total dry film thickness.

H. Adhesion test procedures:
1. Use self-aligning pneumatic pull off equipment and test procedures in accordance with ASTM D4541, Method E, using Delfesko Positest AT-A, except as modified in this Section:
    a. Perform at an applied load rate of 100 pounds per square inch per second, plus or minus 10 pounds per square inch.
    b. Use automatic adhesion test equipment.
    c. Perform tests to coating or glue failure or maximum test load, whichever is happens first.
    d. In accordance with ASTM D4541 using standard 20 millimeter dollies.
    e. Base adhesion testing on 3 tests:
        1) Conduct the tests by the same person, test equipment, and test procedure.
        2) Complete the tests within a 30-minute period.
    f. Conduct adhesion tests within an area not to exceed 6 inches by 6 inches.
    g. Score coatings with more than 10 percent elongation or 25 mils thick around dolly to metal substrate using manual methods and tools, normal to the pipe surface, and in a manner that does not stress or overheat the coating.
2. Attach dollies for adhesion testing to the coating surface using a 2 part epoxy or cyanoacrylate glue and cured for a minimum of 12 hours before testing or until full cure, whichever is greater:
    a. Pipe fabricator and coating manufacturer determine glue type for the pipe diameter, temperatures, and environmental conditions.
3. Perform adhesion testing at temperatures between 55 and 90 degrees Fahrenheit or at temperatures in accordance with the coating manufacturer's requirements:
    a. Testing up to 115 degrees Fahrenheit or below 55 degrees Fahrenheit will be permitted if tests can demonstrate no statistically detectable effect on test results and in accordance with the coating manufacturer's requirements and the Engineer's approval.
4. Epoxy coating and lining adhesion criteria:
    a. Coating is acceptable if first dolly pull test exceeds 1,750 pounds per square inch, minimum.
    b. If first dolly pull is less than 1,750 pounds per square inch, perform 2 additional tests with acceptance based on "Best of 3" evaluation method as defined in this Section.
5. Pipe lot performance criteria:
    a. Minimum median value for coating or lining adhesion tests: 2,000 pounds per square inch.
    b. Classify failing pipe lots as rejected until 100 percent of the pipe within the pipe lot has been tested for adhesion:
        1) Reject each pipe that fails the coating adhesion criteria.
6. Adhesion test evaluation and records:
    a. Definition: "Best of 3" evaluation method is when 2 of 3 test values meet the adhesion criteria.

b. Consider adhesion tests as valid and suitable for acceptance or rejection of the coating, except where retesting is required.
c. Adhesion test failure:
    1) Adhesive or substrate failure:
        a) Definition: A percentage of separation of the coating from the steel substrate or between distinct coating layers.
    2) Cohesive test failure:
        a) Definition: A percentage of failure within the coating, resulting in coating remaining both on the steel substrate and test dolly.
d. Retest coating adhesion tests:
    1) When any test is glue failure at 25 percent or more of dolly surface area and the test value is less than the Acceptance Criteria or the Minimum Criteria.
    2) Within the same 6-inch by 6-inch test area as the original adhesion testing.
    3) Retest disputed adhesion tests:
        a) City's Representative will witness dolly attachment and adhesion retesting.
e. Adhesion tests will be conducted on pipe coating and lining independently and will be accepted or rejected independently.
f. Maintain adhesion test records in an electronic spreadsheet that includes the following information:
    1) Pipe identification.
    2) Pipe coating date.
    3) Adhesion test date.
    4) Surface tested (interior or exterior).
    5) Surface temperature at time of test.
    6) Coating thickness.
    7) Tensile force applied.
    8) Applied load rate per second.
    9) Mode of failure.
    10) Percentage of failure types, previously defined, relative to dolly surface area.
    11) Dolly size and attachment glue used.
    12) If different coatings are tested, include coating manufacturer and product number.

7. Adhesion test repairs:
    a. Fabricator or Contractor to complete adhesion repairs as specified this Section.
    b. Randomly select repair patches on epoxy or polyurethane coating for adhesion testing in a manner as described in this Section and at the discretion of the coating inspector.

l. Long term adhesion test:
1. Acceptance criteria:
    a. Not more than 10 percent loss of adhesion over duration of test.
    b. Differential based on the highest average adhesion result to the lowest average adhesion result.
2. Test durations, cumulative:
    a. 1 day.
    b. 7 days.

c. 3 weeks.
d. 2 months.

3. Sample preparation:
   a. SSPC-SP 5, 3.00 mil profile, minimum.
   b. Test area minimum: 18 inches by 18 inches.
   c. Curved steel plate:
      1) Minimum radius of 15 inches.
      2) Inclined between 30 and 45 degrees.
4. Test procedure:
   a. Expose samples to ambient, outdoor conditions, and facing in a southern direction for maximum UV exposure for the full duration of the test.
5. Adhesion test results:
   a. Based on 8 pulls per test period with the 3 lowest pulls discarded.
   b. Based an average of the 5 highest pulls and identify the values used.
6. Record adhesion pulls and their failure mode.
7. Repair sample after adhesion tests to prevent water from causing any effects on subsequent adhesion tests.

2.09 FUSION BONDED EPOXY

A. Where specified in the Pipe Schedule, coat the exterior of the pipe and fittings with fusion bonded epoxy per AWWA C116. Provide UV-resistant polyurethane topcoat for outdoor installations.

2.10 PLURAL COMPONENT POLYURETHANE

A. Coat exposed pipe with plural component, polyurethane coating system (referred to as a polyurethane system) applied in accordance with AWWA C222 and as specified in this Section.

B. Manufacturers: One of the following or equal:
   1. Chemline, Chemthane 2265.
   2. Lifelast, Equivalent product.

C. Surface preparation:
   1. In accordance with AWWA C222 and as specified in this Section.
   2. In accordance with SSPC-SP 5, 3.00 mil profile, minimum, or in accordance with the manufacturer’s requirements, whichever is greater.

D. Adhesion test procedures:
   1. Use self-aligning pneumatic pull off equipment and test procedures in accordance with ASTM D4541, Method E, using Delfesko Positest AT-A, except as modified in this Section:
      a. Perform at an applied load rate of 100 pounds per square inch per second, plus or minus 10 pounds per square inch.
      b. Use automatic adhesion test equipment.
      c. Perform tests to coating or glue failure or maximum test load, whichever happens first.
      d. In accordance with ASTM D4541 using standard 20 millimeter dollies.

e. Base adhesion testing on 3 tests:
    1) Conduct the tests by the same person, test equipment, and test procedure.
    2) Complete the tests within a 30-minute period.
f. Conduct adhesion tests within an area not to exceed 6 inches by 6 inches.
g. Score coatings with more than 10 percent elongation or 25 mils thick around dolly to metal substrate using manual methods and tools, normal to the pipe surface, and in a manner that does not stress or overheat the coating.

2. Attach dollies for adhesion testing to the coating surface using a 2 part epoxy or cyanoacrylate glue and cured for a minimum of 12 hours before testing or until full cure, whichever is greater:
    a. Pipe fabricator and coating manufacturer determine glue type for the pipe diameter, temperatures, and environmental conditions.
3. Perform adhesion testing at temperatures between 55 and 90 degrees Fahrenheit or at temperatures in accordance with the coating manufacturer's requirements:
    a. Testing up to 115 degrees Fahrenheit or below 55 degrees Fahrenheit will be permitted if tests can demonstrate no statistically detectable effect on test results and in accordance with the coating manufacturer's requirements and the Engineer's approval.
4. Epoxy coating and lining adhesion criteria:
    a. Coating is acceptable if first dolly pull test exceeds 1,750 pounds per square inch, minimum.
    b. If first dolly pull is less than 1,750 pounds per square inch, perform 2 additional tests with acceptance based on "Best of 3" evaluation method as defined in this Section.
5. Pipe lot performance criteria:
    a. Minimum median value for coating or lining adhesion tests: 2,000 pounds per square inch.
    b. Classify failing pipe lots as rejected until 100 percent of the pipe within the pipe lot has been tested for adhesion:
        1) Reject each pipe that fails the coating adhesion criteria.
6. Adhesion test evaluation and records:
    a. Definition: "Best of 3" evaluation method is when 2 of 3 test values meet the adhesion criteria.
    b. Consider adhesion tests as valid and suitable for acceptance or rejection of the coating, except where retesting is required.
    c. Adhesion test failure:
        1) Adhesive or substrate failure:
            a) Definition: A percentage of separation of the coating from the steel substrate or between distinct coating layers.
        2) Cohesive test failure:
            a) Definition: A percentage of failure within the coating, resulting in coating remaining both on the steel substrate and test dolly.
    d. Retest coating adhesion tests:
        1) When any test is glue failure at 25 percent or more of dolly surface area and the test value is less than the Acceptance Criteria or the Minimum Criteria.

2) Within the same 6-inch by 6-inch test area as the original adhesion testing.
3) Retest disputed adhesion tests:
a) City's Representative will witness dolly attachment and adhesion retesting.

e. Adhesion tests will be conducted on pipe coating and lining independently and will be accepted or rejected independently.

f. Maintain adhesion test records in an electronic spreadsheet that includes the following information:
1) Pipe identification.
2) Pipe coating date.
3) Adhesion test date.
4) Surface tested (interior or exterior).
5) Surface temperature at time of test.
6) Coating thickness.
7) Tensile force applied.
8) Applied load rate per second.
9) Mode of failure.
10) Percentage of failure types, previously defined, relative to dolly surface area.
11) Dolly size and attachment glue used.
12) If different coatings are tested, include coating manufacturer and product number.

7. Adhesion test repairs:
a. Fabricator or Contractor to complete adhesion repairs as specified this Section.
b. Randomly select repair patches on epoxy or polyurethane coating for adhesion testing in a manner as described in this Section and at the discretion of the coating inspector.

E. Long term adhesion test:
1. Acceptance criteria:
a. Not more than 10 percent loss of adhesion over duration of test.
b. Differential based on the highest average adhesion result to the lowest average adhesion result.
2. Test durations, cumulative:
a. 1 day.
b. 7 days.
c. 3 weeks.
d. 2 months.
3. Sample preparation:
a. SSPC-SP 5, 3.00 mil profile, minimum.
b. Test area minimum: 18 inches by 18 inches.
c. Curved steel plate:
1) Minimum radius of 15 inches.
2) Inclined between 30 and 45 degrees.
4. Test procedure:
a. Expose samples to ambient, outdoor conditions, and facing in a southern direction for maximum UV exposure for the full duration of the test.

5. Adhesion test results:
    a. Based on 8 pulls per test period with the 3 lowest pulls discarded.
    b. Based an average of the 5 highest pulls and identify the values used.
6. Record adhesion pulls and their failure mode.
7. Repair sample after adhesion tests to prevent water from causing any effects on subsequent adhesion tests.

2.11 SEAL COAT

A. Asphaltic seal coat:
    1. Apply over cement mortar linings and to outside surface of pipes that will not receive another coating.
    2. Apply in accordance with AWWA C151.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
    1. Install ductile iron piping in accordance with AWWA C600, or as modified in Section 40_05_00.01 - Common Work Results for General Piping.
    2. For underground piping, the trenching, backfill, and compaction:
        a. Inspect coating prior to backfill.
        b. As specified in Section 31_23_35 - Trenching.

B. Joints:
    1. Install types of joints as specified in the piping schedule provided in Section 40_05_00.01 - Common Work Results for General Piping.
    2. Mechanical joints are not acceptable in above ground applications.
    3. Field closure for restrained push-on pipe:
        a. Locate field closures in areas where thrust calculations demonstrate restraint is not required.
    4. Grooved joints:
        a. Install piping with grooved joints where specified in the piping schedule as specified in Section 40_05_00.01 - Common Work Results for General Piping.
        b. Assemble grooved joints in accordance with the manufacturer’s published instructions.
        c. Support grooved-end pipe in accordance with the manufacturer’s published instructions:
            1) Install at least 1 support between consecutive couplings.

C. Connection:
1. Tapping ductile iron pipe:
a. Direct tapping of ductile iron pipe may be performed but is limited to the following conditions:
1) Maximum allowable tap diameter by pipe diameter and pressure class:

Pipe Size (inches)	Pressure Class				
	150	200	250	300	350
	Maximum Allowable Direct Tap Size (inches)				
3	-	-	-	-	3/4
4	-	-	-	-	3/4
6	-	-	-	-	1
8	-	-	-	-	1
10	-	-	-	-	1
12	-	-	-	-	1-1/4
14	-	-	1-1/4	1-1/2	1-1/2
16	-	-	1-1/2	2	2
18	-	-	2	2	2
20	-	-	2	2	2
24	-	2	2	2	2

b. Maximum allowable tap diameter for pipelines greater than 24 inches is 2 inches.
c. 2 layers of 3-mil thread sealant are required to minimize the torque required to effect a watertight connection.
2. When direct tapping of ductile iron pipe is not possible due to limited wall thickness, a saddle tap shall be used.

3.02 DEFECTS IN COATINGS EXCEPT TAPE WRAP AND CEMENT MORTAR COATING

A. Engineer will identify defective coating to be field repaired in accordance with the applicable AWWA standard:
1. Pipe joints exceeding the following defect maximum will be rejected:
a. Minor defects:
1) No more than 1.5 per 100 square feet of surface area.
2) 2 or more minor repairs within an 8-inch diameter circle will be considered a single repair.
3) Repairs for adhesion testing will not be included in the total number of repairs.
4) Repair in accordance with the manufacturer’s requirements.
b. Major defects:
1) No more than 3 major repairs on each pipe joint.
2) No more than 30 percent repairs on the pipe surface area with defects.
2. Minor repairs:
a. Less than 8 inches in the greatest dimension.
b. Repair in accordance with the manufacturer’s requirements.

3. Major repairs:
    a. Exceed 8 inches in the greatest dimension.
    b. Repair in accordance with the manufacturer's requirements.

3.03 PLURAL COMPONENT EPOXY

A. Joints:
    1. Field applied coating shall be of the same density, smoothness, and thickness as shop applied coating.
    2. Comply with same application requirements as shop applied coating or lining:
        a. Provide heating and/or dehumidification equipment as required to meet the environmental conditions necessary for proper coating application.

3.04 PLURAL COMPONENT POLYURETHANE

A. Joints:
    1. Field applied coating or lining shall be of the same density, smoothness, and thickness as shop applied coating or lining.
    2. Comply with same application requirements as shop applied coating or lining:
        a. Provide heating and/or dehumidification equipment as required to meet the environmental conditions necessary for proper coating application.

3.05 POLYETHYLENE ENCASEMENT

A. Wrap buried ductile iron pipe and fittings in a single layer of V-Bio polyethylene wrap in accordance with AWWA C105 and as specified in this Section.

B. Wrap polyethylene encasement to be continuous and terminated neatly at connections to below grade equipment or structures.

C. At wall penetrations, extend encasement to the wall and neatly terminate.

D. At slab penetrations, extend encasement to 2 inches below the top of slab and neatly terminate.

E. When rising vertically in unimproved areas, extend encasement on pipe 6 inches above existing grade and neatly terminate.

F. Repair tears and make joints with 2 layers of plastic tape.

G. Work shall be inspected prior to backfilling of pipe and associated items.

3.06 CORROSION PROTECTION REQUIREMENTS

A. Install flange insulating kits and dielectric fitting as indicated on the Drawings.

3.07 FIELD QUALITY CONTROL

A. Testing ductile iron piping:
    1. Test as specified in Section 40_05_00.01 - Common Work Results for General Piping and Section 40_05_00.09 - Piping Systems Testing.

B. Repair damaged cement mortar lining to match quality, thickness, and bonding of original lining in accordance with AWWA C104:
   1. When lining cannot be repaired or repairs are defective, replace defective piping with undamaged piping.

C. Verify that interior surfaces of ceramic epoxy and glass lined pipe and fittings have continuous coverage:
   1. Test random samples, as directed by the Engineer, in accordance with ASTM B1000.
   2. Discard lined piping and fittings found to have pinholes, crazing, or fish scales, which expose the metal substrate.

END OF SECTION

SECTION 40_05_23.01

STAINLESS STEEL PIPE AND TUBING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Stainless steel piping and tubing.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.
   3. B16.11 - Forged Fittings, Socket-Welding and Threaded.
   4. B31.3 - Process Piping.
   5. B36.19 - Stainless Steel Pipe.

B. ASTM International (ASTM):
   1. A182 - Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High Temperature Service.
   2. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   3. A194 - Standard Specification for Carbon and Alloy Steel Nuts and Bolts for High Pressure or High Temperature Service, or Both.
   4. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   5. A269 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
   6. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   7. A312 - Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
   8. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
   9. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.

10. A403 - Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.
11. A743 - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
12. A744 - Standard Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service.
13. A774 - Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Services at Low and Moderate Temperatures.
14. A778 - Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.
15. A789 - Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service.
16. A790 - Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe.
17. A928 - Standard Specification for Ferritic/Austenitic (Duplex) Stainless Steel Pipe Electric Fusion Welded with Addition of Filler Metal.
18. A967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.
19. B622 - Standard Specification for Seamless Nickel and Nickel-Cobalt Alloy Pipe and Tube.
20. B912 - Standard Specification for Passivation of Stainless Steels Using Electropolishing.
21. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

C. American Welding Society (AWS):
   1. D1.6 - Structural Welding Code - Stainless Steel.

D. NSF International (NSF):
   1. Standard 61 - Drinking Water System Components - Health Effects.

1.03 SUBMITTALS

A. Submit as specified in Section 01 33 00 - Submittal Procedures.

B. Product data: As specified in Section 40_05_00.01 - Common Work Results for General Piping.

C. Shop Drawings:
   1. Detailed layout drawings:
      a. Dimensions and alignment of pipes.
      b. Location of valves, fittings, and appurtenances.
      c. Location of field joints.
      d. Location of pipe hangars and supports.
      e. Connections to equipment and structures.
      f. Location and details of shop welds.
   2. Thickness and dimensions of fittings and gaskets.
   3. Photographs, drawings, and descriptions of pipe, fittings, welding procedures, and pickling and passivating procedures.
   4. Material specifications for pipe, gaskets, fittings, and couplings.

5. Data on joint types and components used in the system including stub ends, backing flanges, flanged joints, grooved joint couplings and screwed joints.

D. Field welding references:
   1. Welder and weld operator qualification certificates and welding procedures.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Piping layout: Lay out and fabricate piping systems with piping sections as long as possible, while still allowing shipment, so that joints are minimized:
   1. Piping design indicated on the Drawings illustrates piping layout and configuration and does not indicate the location of every joint and flexible coupling that may be needed to connect piping sections fabricated in the shop.
   2. Where joints and couplings are specifically indicated on the Drawings, design and shop-fabricate piping sections utilizing the joint or coupling illustrated at the locations shown.
   3. Add joints and flexible couplings in a manner that achieves intent of maximizing size of individual piping sections.

B. Shop fabrication: Fabricate piping sections in the shop and pickle and passivate at point of manufacture.

C. Field assembly:
   1. Field welding is prohibited.
   2. Assemble shop-fabricated piping in the field using the joints designed into the piping layout or by using flexible couplings.

2.02 STAINLESS STEEL PIPE

A. General:
   1. Pipe sizes specified in the Specifications and indicated on the Drawings are nominal.

B. Wall thickness:
   1. As specified in Section 40_05_00.01 - Common Work Results for General Piping.
   2. Piping 3 inches in nominal diameter and greater:
      a. For general service applications with pressures less than 250 pounds per square inch gauge, pipe diameter 24-inches or less, minimum wall thickness corresponding to Schedule 10S.
      b. For pressures exceeding 250 pounds per square inch gauge, minimum wall thickness corresponding to Schedule 40S.
   3. Piping less than 3 inches in nominal diameter:
      a. Piping with threaded or grooved joints:
         1) Minimum wall thickness corresponding to Schedule 40S.
      b. Piping with Vic-Press joints:
         1) Minimum wall thickness corresponding to Schedule 10S.

4. Piping with threaded or grooved joints:
   a. For general service applications with pressures less than 250 pounds per square inch gauge, minimum wall thickness corresponding to Schedule 40S.
   b. For pressures exceeding 250 pounds per square inch gauge, minimum wall thickness corresponding to Schedule 80S.

C. Piping material and manufacturing:
   1. Comply with the requirements outlined in the following table:

Service	Stainless Steel Grade	Pipe Manufacturing Process
For low chloride water service with chloride concentrates below 200 parts per million and/or free chlorine less than 2 parts per million at ambient temperatures.		
Piping 3 inches in nominal diameter and larger	Type 304L stainless steel in accordance with ASTM A240	In accordance with ASTM A778
Piping less than 3 inches in nominal diameter	Type 304L stainless steel in accordance with ASTM A240	In accordance with ASTM A312
PREN: Pitting Resistance Equivalency Number PREN = Cr% + (3.3 x Mo%) + (16 x N%)		

UNS #	Alloy	Cr%	Mo%	N%	Other	PREN
N10276	C-276	14.5-16	15-17	-	W 3-4.5	64
S32750	Alloy 2507	24-26	6-8	0.24-0.32	-	48
S32654	654SMO	24-25	7-8	-	-	47
N06625	Alloy 625	20-23	8-10	-	Cb 3.25-4.15	46
N08366	AL6XN	20-22	6-7	-	-	40
N06985	Alloy G	21-23.5	5.5-7.5	-	-	39
S32760	Zeron 100	24-26	3-4	0.2-0.3	W 0.5-1.0	37
S32205	Alloy 2205	22-23	3-3.5	0.14-0.20	-	34
N08904	904L	19-23	4-5	-	-	32
S31726	317LNM	17-20	4-5	0.1-0.2	-	32
N08825	Alloy 825	19-23.5	2.5-3.5	-	-	27
S32101	LDX-2101	21.5	0.3	0.22	-	26
S31603	316L	16-18	2-3	-	-	23
S30403	304L	18-20	-	-	-	18

   2. Location of material fabrication.
   3. Chemical analysis certificates.

D. Fittings for piping 3 inches in nominal diameter and greater:
   1. Material: In accordance with ASTM A240 stainless steel, grade to match the pipe.
   2. Manufacturing standard: In accordance with ASTM A774.
   3. Wall thickness of fitting: In accordance with ASME B36.19 for the schedule of pipe specified.
   4. End configuration: As needed to comply with specified type of joint.
   5. Dimensional standards:
      a. Fittings with weld ends: In accordance with ASME B16.11.
      b. Fittings with flanged ends: In accordance with ASME B16.5, Class 150.

E. Fittings for piping less than 3 inches in diameter:
   1. Material: In accordance with ASTM A240 stainless steel, grade to match the pipe.
   2. Manufacturing standard: In accordance with ASTM A403, Class WP.
   3. Wall thickness and dimensions of fitting: In accordance with ASME B16.11 and as required for the schedule of pipe specified.
   4. End configuration: As needed to comply with specified type of joint.
   5. Forgings in accordance with ASTM A182, or barstock in accordance with ASTM A276. Match forging or barstock material to the piping materials.

F. Piping joints:
   1. Joint types, piping greater than 2 inches in diameter, general:
      a. Where type of joint is specifically indicated on the Drawings or specified, design and shop-fabricate piping sections utilizing type of joint illustrated or scheduled.
      b. Where type of joint is not specifically indicated on the Drawings or as specified in Section 40_05_00.01 - Common Work Results for General Piping, Piping Schedule, design and shop-fabricate piping sections utilizing any of the following joint types:
         1) Piping stub ends with backing flanges.
         2) Welded joints.
         3) Flanged joints.
         4) Grooved joints.
      c. Joints at valves and pipe appurtenances:
         1) Provide flanged valves and flanged pipe appurtenances in stainless steel piping systems with flanged ends.
         2) Design and fabricate piping sections to make connections with flanged valves and pipe appurtenances using piping stub ends with backing flanges, flanged coupling adapters or flanged joints:
            a) Flexible couplings and flanged coupling adapters: Provide stainless steel construction with materials matching the piping system and in accordance with requirements as specified in Section 40_05_06.03 - Pipe Couplings.
   2. Joints in piping 2 inches in diameter and smaller: Flanged, grooved, or screwed with Teflon™ tape thread lubricant, as scheduled or as specified in Section 40_05_00.01 - Common Work Results for General Piping.
   3. Welded joints:
      a. Piping 12 inches and larger in diameter: Automatically weld joints using gas tungsten-arc procedures.
      b. Piping 4 inches through 12 inches in diameter: Double butt welded joints.

c. Piping less than 4 inches in diameter: Single butt-welded joints.
d. Mark each weld with a symbol that identifies the welder.

4. Flanged joints: Conforming to the requirements in accordance with ASME B16.5, Class 150.
5. Piping stub ends and backing flanges for pipe 3 inches and larger:
   a. Piping stub ends: Cast stainless steel to match the pipe material with machined gasket and wetted surfaces of stub ends free of crevices, pits, cracks and protrusions:
      1) Manufacturers: The following or equal:
         a) Alaskan Copper Works, Figure SK-38.
   b. Backing flanges: Forged or plate stainless steel (type to match pipe material) with drilled bolt patterns in accordance with ASME B16.1, Class 125 or ASME B16.5, Class 150, 300 or 600, as scheduled:
      1) Manufacturers: The following or equal:
         a) Alaskan Copper Works, Figure SK-39 (tube) or SK-39P (pipe).
6. Flanges for Schedule 40S and Schedule 80S pipe:
   a. Provide forged stainless steel (type matching piping system) welding neck flanges or slip-on flanges in accordance with ASME B16.5 Class 150.
   b. Material: In accordance with ASTM A182.
7. Grooved joints:
   a. Pressure less than 500 pounds per square inch:
      1) Cut grooves from Schedule 40 or higher.
   b. Heavier schedule pipe sections used for cut groove ends:
      1) Tapered inside diameter to transition from the inside diameter of the lighter schedule pipe.
   c. Butt welds connecting pipes of different schedules that leave an abrupt change in inside diameter are not allowed.
   d. Couplings:
      1) Rigid type, cast from ductile iron, Victaulic Style 07 or equal.

G. Gaskets:
1. EPDM, nitrile, or other materials compatible with the process fluid:
   a. Drinking water applications: NSF Standard 61 compliant materials only.

H. Bolts for flanges and stub end/backing flanges:
1. Bolts and nuts: Type 316 stainless steel in accordance with ASTM A193 heavy hex head:
   a. Bolt length such that after installation, end of bolt projects 1/8-inch to 3/8-inch beyond outer face of nut.
   b. Nuts: In accordance with ASTM A194 heavy hex pattern.

I. Fabrication of pipe sections:
1. Welding: Weld in accordance with ASME B31.3.
2. Weld seams:
   a. Full penetration welds, free of oxidation, crevices, pits and cracks, and without undercuts.
   b. Provide weld crowns of 1/16 inch with tolerance of plus 1/16 inch and minus 1/32 inch.

c. Where internal weld seams are not accessible, use gas tungsten-arc procedures with internal gas purge.
d. Where internal weld seams are accessible, weld seams inside and outside using manual shielded metal-arc procedures.

J. Cleaning (pickling) and passivation:
1. Following shop fabrication of pipe sections, straight spools, fittings, and other piping components, clean (pickle) and passivate fabricated pieces.
2. Clean (pickle) and passivate in accordance with ASTM A380 or ASTM A967:
a. If degreasing is required before cleaning to remove scale or iron oxide, cleaning (pickling) treatments with citric acid are permissible:
1) However, these treatments must be followed by inorganic cleaners such as nitric acid/hydrofluoric acid.
b. Passivation treatments with citric acid are not allowed.
3. Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.

2.03 STAINLESS STEEL TUBING

A. Stainless steel tubing:
1. Seamless tubing made of Type 316L stainless steel and in accordance with ASTM A269, wall thickness not less than 0.035 inch.

B. Fittings: Swage ferrule design:
1. Components made of:
a. Type 316 stainless steel.
2. Double acting ferrule design, providing both a primary seal and a secondary bearing force.
3. Flare type fittings are not acceptable.
4. Manufacturers: One of the following, or equal:
a. Crawford Fitting Co., Swagelok.
b. Hoke, Gyrolok.
c. Parker, CPI.

C. Valves for use with stainless steel tubing:
1. Ball type valves with swage ends to match tubing diameter.
2. Constructed from:
a. Type 316 stainless steel with TFE seats.
3. Manufacturers: The following or equal:
a. Crawford Fitting Co., Swagelok.

2.04 SOURCE QUALITY CONTROL

A. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.

B. Provide written certification that the pipe as supplied are in accordance with ASTM A778. Supplemental testing is not required.

C. Provide written certification that the fittings as supplied are in accordance with ASTM A774:
   1. Supplementary testing is not required.

D. Thoroughly clean any equipment before use in cleaning or fabrication of stainless steel.

E. Storage: Segregate location of stainless steel piping from fabrication of any other piping materials.

F. Shipment to site:
   1. Protect flanges and pipe ends by encapsulating in dense foam.
   2. Securely strap all elements to pallets with nylon straps. Use of metallic straps is prohibited.
   3. Cap ends of tube, piping, pipe spools, fittings, and valves with non-metallic plugs.
   4. Load pallets so no tube, piping, pipe spools, fittings, or valves bear the weight of pallets above.
   5. Notify Engineer when deliveries arrive so Engineer may inspect the shipping conditions.
   6. Engineer may reject material due to improper shipping methods or damage during shipment.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install piping in such a manner as not to impart strain to connected equipment.

B. Slope horizontal lines so that they can be drained completely.

C. Provide valve drains at low points in piping systems.

D. Install eccentric reducers where necessary to facilitate draining of piping system.

E. Provide access for inspection and flushing of piping systems to remove sediment, deposits, and debris.

3.02 FIELD ASSEMBLY OF SHOP-FABRICATED PIPING SECTIONS

A. Join shop-fabricated piping sections together using backing flanges, flexible couplings, flanged coupling adapters, grooved couplings, or flanges.

3.03 FIELD QUALITY CONTROL

A. Test piping to pressure and by method as specified in Section 40_05_00.01 - Common Work Results for General Piping:
   1. If pressure testing is accomplished with water:
      a. Use only potable quality water.
      b. Piping: Thoroughly drained and dried or place immediately into service.

B. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.

3.04 PROTECTION

A. Preserve appearance and finish of stainless steel piping by providing suitable protection during handling and installation and until final acceptance of the Work:
   1. Use handling methods and equipment to prevent damage to the coating, include the use of wide canvas slings and wide padded skids.
   2. Do not use bare cables, chains, hooks, metal bars, or narrow skids.
   3. Store stainless steel piping and fittings away from any other piping or metals. Storage in contact with ground or outside without projection from bad weather is prohibited.
   4. Protect stainless steel piping and fittings from carbon steel projections (when grinding carbon steel assemblies in proximity) and carbon steel contamination (do not contact stainless steel with carbon steel wire brush or other carbon steel tool).

END OF SECTION

SECTION 40_05_24.01

STEEL PIPE: EXPOSED

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Steel piping, joints, fittings, and fabricated steel piping fittings and specials.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

B. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   2. B16.3 - Malleable-Iron Threaded Fittings: Classes 150 and 300.
   3. B16.5 - Pipe Flanges and Flanged Fittings.
   4. B16.9 - Factory-Made Wrought Buttwelding Fittings.
   5. B16.12 - Cast Iron Threaded Drainage Fittings.

C. American Water Works Association (AWWA):
   1. C200 - Steel Water Pipe 6 Inches and Larger.
   2. C205 - Cement-Mortar Protective Lining and Coating for Steel Water Pipe: 4 inches and Larger-Shop Applied.
   3. C206 - Field Welding of Steel Water Pipe.
   4. C207 - Standard for Steel Pipe Flanges for Waterworks Service-Sizes 4 inches Through 144 inches.
   5. C208 - Standard for Dimensions for Fabricated Steel Water Pipe Fittings.
   6. C210 - Liquid-Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
   7. C222 - Polyurethane Coatings and Linings for Steel Water Pipe and Fittings.
   8. C606 - Standard for Grooved and Shouldered Joints.
   9. M11 - Steel Pipe: A Guide for Design and Installation.

D. ASTM International (ASTM):
   1. A47 - Standard Specification for Ferritic Malleable Iron Casting.
   2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

3. A105 - Standard Specification for Carbon Steel Forgings for Piping Applications.
4. A106 - Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
5. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
6. A536 - Standard Specification for Ductile Iron Castings.
7. C33 - Standard Specification for Concrete Aggregates.
8. C150 - Standard Specification for Portland Cement.
9. C205 - Standard Specification for Processing Additions for Use in the Manufacture of Hydraulic Cements.
10. D297 - Standard Test Methods for Rubber Products-Chemical Analysis.
11. D395 - Standard Test Methods for Rubber Property-Compression Set.
12. D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension.
13. D471 - Standard Test Methods for Rubber Property-Effect of Liquids.
14. D573 - Standard Test Methods for Rubber -Deterioration in an Air Oven.
15. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
16. D2240 - Standard Test Method for Rubber Property-Durometer Hardness.
17. D4541 - Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
18. E165 - Standard Practice for Liquid Penetrant Testing for General Industry.

E. NSF International (NSF):
1. 61 - Drinking Water System Components - Health Effects.

F. Society for Protective Coatings (SSPC):
1. SP 5 - White Metal Blast Cleaning.
2. SP 10 - Near White Wet Blast.
3. SP 11 - Bare Metal Power Tool Cleaning.
4. QP 1 - Industrial Contractor Qualification.

1.03 SUBMITTALS

A. Submit as specified in Section 01 33 00 - Submittal Procedures.

B. Product data: As specified in Section 40_05_00.01 - Common Work Results for General Piping.

C. Manufacturer’s qualifications:
1. Manufacturer qualifications and list of projects using the specified material: 5 years minimum.

D. Manufacturer’s Quality Assurance Manual:
1. Submit manufacturer’s coating and lining application quality assurance manual to Engineer prior to beginning coating application:
   a. Strict conformance to the requirements of the manual will be required.
   b. Deviation from the requirements of the manual will be grounds for the Engineer to reject the applied coating.

E. Shop drawings:
   1. Details of fittings and specials showing thickness and dimensions of plates.
   2. Details of welds and materials.
   3. Listing of proposed services and locations for use of grooved joint type piping.
   4. Tabulated layout schedules for cement-mortar lined and coated steel pipe.
   5. Grooved joint piping fittings, gaskets, and couplings.
   6. Grooving of pipe and fittings.

F. Calculations:
   1. Submit calculations prepared and stamped by a professional engineer licensed in the State of California. The calculations shall be based on the requirements defined in this Section.
   2. Design calculations: Wall thicknesses for external loading, special loading, internal pressure, and other necessary design cases.

G. Certificates of Compliance: Cement-mortar lined and coated steel pipe.

H. Mill certificates.

I. Test reports: Rubber gaskets.

1.04 QUALITY ASSURANCE

A. Applicable standards:
   1. Steel pipe larger than 12 inches diameter shall conform to the following standards, as complemented and modified in this Section:
      a. Steel pipe: AWWA C200.
      b. Fittings and specials: AWWA C208.
      c. Reinforcement of fittings and specials: AWWA M11.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Design requirements:
   1. Design criteria for pipe and pipe fittings: In accordance with AWWA M11 with the following modifications:
      a. Wall thickness: Thicker of the thickness specified in Section 40_05_00.01 - Common Work Results for General Piping Pipe Schedule, and the following thickness:
         1) For pipes smaller than 26 inches in diameter: Minimum 1/4 inch.
         2) For pipes 26 inches and larger but less than 38 inches in diameter: Minimum 5/16 inch.
         3) For pipes 38 inches and larger in diameter and including 72 inches in diameter: Minimum 3/8 inch.
      b. Inside diameter of unlined pipe: Nominal.
      c. Inside diameter of lined pipe: As measured from face to face of liner, but not less than nominal.

d. Deflection of underground pipe inside diameter: Maximum 2 percent under trench load of H-20 live load in accordance with AASHTO specifications.
e. Working stress of steel: Maximum 50 percent of yield stress.
f. Contractor shall develop and submit calculations to determine the steel pipe and fitting wall thickness and design requirements according to the requirements of this specification.

2.02 MATERIALS

A. Steel pipe:
1. Type, pipe 6 inches and smaller: ASTM A53, black or galvanized, seamless or straight seam electric resistance welded. Minimum Schedule 40.
2. Type, from 6 to 12 inches: ASTM A53, black or galvanized pipe, seamless or straight seam electric resistance welded. Minimum Schedule 20.
3. Type, larger than 12 inches: AWWA C200, without butt strap, riveted, or swaged joints; wall thickness as specified or as indicated on the Drawings.
4. Type, 24 inches and larger, with grooved type couplings and wall thickness less than 1/2-inch: Provided with stub ends, sized as follows, for grooves.
   a. Thickness: As recommended by coupling manufacturer, but not less than 1/2-inch.
   b. Length: Width of coupling plus 1 inch, but not less than 6 inches.
5. Type for liquid or gaseous dry chlorine: ASTM A106, Grade A, Schedule 80, assembled with 300 pounds per square inch malleable iron fittings and ammonia type flanges.

B. Steel pipe fittings:
1. Screwed fittings:
   a. Malleable iron: ASME B16.3, 150 pounds; galvanized in accordance with ASTM A153 where used with galvanized pipe.
   b. Cast iron drainage: ASME B16.12, galvanized in accordance with ASTM A153 where used with galvanized pipe.
2. Flanged fittings:
   a. Type for 12-inch and smaller pipe: ASME B16.1, cast iron or ductile iron, 125 pounds; or ASME B16.5, steel, 150 pounds, galvanized in accordance with ASTM A153 where used with galvanized pipe.
   b. Type for larger than 12-inch pipe: ASME B16.5, steel, 150 pounds; galvanized in accordance with ASTM A153 where used with galvanized pipe; or AWWA C207 and AWWA C208, fabricated from flanges and steel pipe, respectively.
   c. Companion flanges for 4 inches and smaller pipe: ASME B16.1, cast iron or ductile iron, 125 pounds; ASME B16.5, steel, 150 pounds, slip-on or welding neck; or ammonia type for use on chlorine liquid or gas piping.
   d. Companion flanges for larger than 4 inch to and including 12-inch pipe: ASME B16.5, slip-on or welding neck type.
   e. Companion flanges for larger than 12-inch pipe: ASME B16.5, steel, 150 pounds; galvanized in accordance with ASTM A153 where used with galvanized pipe; or AWWA C207, steel plate or raised hub type.
   f. Weld flanges to pipe or fittings before applying lining.
   g. Machine flanges or provide tapered filler for changes in grade or to slope lines for drainage.

h. Flange bolts: As specified in Section 40_05_00.01 - Common Work Results for General Piping.
i. Gaskets: As specified in Section 40_05_00.01 - Common Work Results for General Piping.

3. Welding fittings:
   a. Welding fittings for piping 8 inches and less in nominal diameter: Butt-welding fittings in accordance with ASME B16.9, standard wall, or standard weight.
   b. Welding fittings for piping larger than 8 inches in nominal diameter: Butt-welding fittings in accordance with ASME B16.9, or, at the option of the Contractor, made up out of sections of pipe welded together, except where smooth bends are indicated for air lines.
   c. Fittings made up of sections of pipe welded together shall be made of pipe of at least the same wall thickness as the pipe with which used, and bends shall be miter bends, fabricated in accordance with AWWA C208 and as supplemented by AWWA M11. Welding of these made-up fittings shall be in accordance with AWWA C206:
      1) Design and fabricate outlets and 4 branch fittings in accordance with AWWA M11.
      2) Bends may be welded to adjacent pipe sections:
         a) Bends shall be manufactured of the following number of pieces:
            (1) Bends from 0 to 30 degrees angle, 2 pieces.
            (2) Bends from 30 to 45 degrees angle, 3 pieces.
            (3) Bends from 45 to 67-1/2 degrees angle, 4 pieces.
            (4) Bends from 67-1/2 to 90 degrees angle, 5 pieces.

4. Grooved joint fittings:
   a. Fittings for grooved joint steel piping: Rigid-grooved type, and as follows:
      1) Grooves: Cut; rolled grooves are not acceptable.
      2) Couplings: Cast in 2 or more segments of ductile iron in accordance with ASTM A536, Grade 65-45-12 or malleable iron in accordance with ASTM A47, Grade 32510.
      3) Bolts and nuts: As specified in Section 40_05_00.01 - Common Work Results for General Piping.
      4) Gaskets: Composition water sealing designed so that the internal piping pressure serves to increase the seal's watertightness:
         a) Gaskets for water service and oil-free air systems at temperatures less than 230 degrees Fahrenheit shall be made of ethylene propylene diene monomers (EPDM) in accordance with ASTM D2000 Line Call Out 2CA615A25B24.
         b) Gaskets for use with cement-mortar lined steel piping shall be captured between the ends of the pipe to protect exposed metal from corrosion and shall be made of nitrile in accordance with ASTM D2000, Line Call Out 2CA615A25B24.
      5) Perform grooving of the pipe wall only on standard or heavier schedule weight pipe:
         a) For pipe with wall thickness less than standard weight, weld a shouldered end on the pipe in accordance with AWWA C606.
         b) Fabricated pipe, pipe in accordance with AWWA C200, shall have shouldered ends welded onto the pipe.
         c) Shoulder: Type B or D in accordance with AWWA C606.

6) Couplings and grooving:
a) Manufacturers: One of the following or equal:
(1) Gustin-Bacon Piping Products.
(2) Victaulic Co.

b. Fittings for grooved joint piping: Ductile iron in accordance with ASTM A536, Grade 65-45-12, or malleable iron in accordance with ASTM A47, Grade 32510, and as follows:
1) Where cast fittings are not made, standard fittings including large diameter elbows shall be made of forged steel in accordance with ASTM A105, Grade B with 0.375-inch wall thickness, or shall be standard segmentally welded fittings fabricated of Schedule 40 carbon steel pipe:
a) Grooves:
(1) Manufacturers: One of the following or equal:
(a) Gustin-Bacon Piping Products.
(b) Victaulic Co.
2) Fittings for grooved joint piping shall be furnished by the manufacturer of the grooved joint material.
3) Fittings for grooved joint piping shall be for rigid-grooved type joints.
4) Connection to flanged units shall be by means of flange to grooved joint adapters:
a) Where the flanged to grooved joint adapters interfere with the operation of adjacent valves, pumps, or other items, the connection shall be by means of a spool with one end flanged and the other grooved, long enough to prevent interference with adjacent valves, pumps, or other items.

C. Steel pipe lining and coating:
1. General:
a. Except where otherwise specified in the Specifications or indicated on the Drawings, lining and coating for steel pipe shall be as specified in Section 40_05_00.01 - Common Work Results for General Piping.

D. Fabricated steel piping fittings and specials:
1. General: Specified in this Section are the design and fabrication of fabricated steel piping fittings and specials, which include elbows, branches, nozzles, manifolds, headers, heads, collars, stiffeners, reinforcements, and other steel fabrications relating to steel piping, but shall not include steel pipe.
2. Design:
a. Contractor shall design and detail fittings and specials:
1) Design: In accordance with the recommended procedures in AWWA Manual M11, as complemented and modified in this Section.
2) Nozzles: Reinforced in accordance with recommended practice in AWWA M11, Steel Pipe Manual.
3) Design reinforcing for fittings and specials for the specified test pressure.
4) Fittings shall conform in dimension to AWWA C208, complemented with the provisions specified in this Section.
5) The working stress for steel used for fabrication of pipe shall not exceed 50 percent of the yield stress.

b. The thickness of pipe, large elbows, and headers, except header nozzles, shall be the thicker of:
    1) The thickness designed in accordance with the design methods specified in this Section.
    2) The thickness indicated on the Drawings or specified in Section 40_05_00.01 - Common Work Results for General Piping Pipe Schedule, or as required by the Contractor's calculations.
    3) The following thicknesses:
        a) For pipes smaller than 26 inches in diameter: Minimum 1/4 inch.
        b) For pipes 26 inches and larger but less than 38 inches in diameter: Minimum 5/16 inch.
        c) For pipes 38 inches and larger in diameter and including 72 inches in diameter: Minimum 3/8 inch.
c. Elbows shall be of the number of pieces as specified in this Section, and thickness of material shall conform to thickness of pipe or manifold shells specified.
d. Ends of fittings to be welded to pipe shall be beveled for welding.

3. Fabrication:
    a. Shop fabricate steel piping fittings and specials in units as long as practicable for safe hauling and installation. Minimize number of field welds.
    b. Fabricate fittings and specials to uniform lengths with proper end clearance for the specified types of joint or attachment.
    c. Fabricate fittings and specials to allow field assembly without cutting or special work.
    d. Where specified in the Piping Schedule in Section 40_05_00.01 - Common Work Results for General Piping or indicated on the Drawings, the inside of fabricated steel manifolds and other fittings and specials shall receive a cement-mortar lining in accordance with AWWA C205:
        1) Reinforce lining for piping 24 inches in diameter and larger with wire fabric.
    e. Do not weld flanges to nozzles until the nozzles and reinforcements are completely welded to the header:
        1) Accurately space and align flanges so that when connections have been made there will be no stress on the header, piping, or equipment. Properly locate and align equipment.
4. Dished heads:
    a. Dished heads on 84 inch diameter and smaller manifolds: 1 piece (seamless) spherically dished (torispherical) heads:
        1) Larger heads may be seamed.
    b. Dish radius: Same dimension as the outside diameter of the head measured at skirt.
    c. Skirt face length: Not less than 3 inches.
    d. Design heads in accordance with recommended practice in AWWA M11, Steel Pipe Manual.
5. Testing: No shop testing will be required for manifolds or piping connected thereto.

E. AWWA C200 steel pipe and fittings design and fabrication:
   1. General:
      a. Applicable standards: AWWA C200 steel pipe shall conform to the standards specified in General of this Section.
      b. Identification marks: Provide identification marks in accordance with AWWA C200. These marks shall be stenciled or otherwise shown at the top of the piping items exterior, including the following information:
         1) Name or trademark of the manufacturer.
         2) Date of manufacture of the item.
         3) Internal diameter in inches.
         4) Number of the item, sequential from initial to end station.
      c. Diameter designation: The pipe diameter specified in the Specifications and indicated on the Drawings shall be the clear inside diameter after application of the cement-mortar lining with a tolerance of plus 0 inch and minus 1/4 inch.
   2. Design:
      a. Pipe and fittings shall be designed by Contractor.
      b. Design: In accordance with the recommended procedures in AWWA Manual M11, as complemented and modified in this Section.
      c. Thicknesses of pipe, fittings and specials shall be the thicker of:
         1) The thickness designed in accordance with the design methods specified in this Section.
         2) The thickness indicated on the Drawings or specified in Section 40_05_00.01 - Common Work Results for General Piping Pipe Schedule.
         3) The following thicknesses:
            a) For pipes smaller than 26 inches in diameter: Minimum 1/4 inch.
            b) For pipes 26 inches and larger but less than 38 inches in diameter: Minimum 5/16 inch.
            c) For pipes 38 inches and larger in diameter and including 72 inches in diameter: Minimum 3/8 inch.
      d. The working stress for steel used for fabrication of pipe shall not exceed 50 percent of the yield stress.
      e. Break longitudinal and girth seams for straight seam pipe shall be no greater in number than would be required for the fabrication of pipe with 96-inch by 120-inch steel plates:
         1) Break longitudinal seams at the girth seams.
      f. Calculate earth loads using the following formula:

$$W = 192 \times H \times B$$

         wherein the various terms shall have the following meaning:

         W: Earth load, pounds per linear foot of pipe.
         H: Height of fill over the pipe, feet.
         B: Outside diameter of the pipe, feet.
         x: Mathematical symbol for multiplication.

      g. Add AASHTO's H-20 loading to earth loads.

h. Design pipe, fittings and specials for a deflection, under external loads, not to exceed 2 percent of the diameter:
    1) Stiffness computations shall not consider the effect of the cement-mortar lining and coating.
    2) Calculate deflection using the Spangler formula and the following values:
        a) Bedding constant K = 0.100.
        b) Modulus of soil reaction E' = 700 pounds per square inch.
        c) Deflection lag constant D_1 = 1.00.

i. Where piping is designated to be flanged or welded in order to restrain thrust, the design of the cylinder and flange or welded joint shall take into account the effect of stresses caused by thrust loads.

3. Materials:
    a. Coatings and linings: As required in Section 40_05_00.01 - Common Work Results for General Piping.
    b. Gaskets shall be as specified in Section 40_05_00.01 - Common Work Results for General Piping and meet the following requirements:
        1) Minimum tensile strength, tested in accordance with ASTM D412, between 2,000 and 2,700 pounds per square inch.
        2) Minimum elongation, tested in accordance with ASTM D412, between 350 and 400 percent.
        3) Shore A durometer hardness, tested in accordance with ASTM D2240, between 50 and 65.
        4) Specific gravity, tested in accordance with ASTM D297, between 0.90 and 1.50.
        5) Maximum compression set, tested in accordance with Method B of ASTM D395, 20 percent.
        6) Maximum tension strength loss, tested in accordance with ASTM D573 at 96 hours, 70 degrees Centigrade, in air, 20 percent.
        7) Maximum elongation loss, tested in accordance with ASTM D573 at 96 hours, 70 degrees Centigrade, in air, 20 percent.
        8) Maximum absorption, tested in accordance with ASTM D471 at 48 hours, 70 degrees Centigrade, in air, 5 percent.

4. Joints and connections:
    a. Joints:
        1) Except as otherwise specified or indicated on the Drawings, provide lap welded or bell and spigot type joints with rubber gaskets for pipelines 54 inches and smaller.
        2) Butt-strap joints shall be used only where required for closures or where indicated on the Drawings.
        3) The joints furnished shall have the same or higher-pressure rating as the abutting pipe.
    b. Connections:
        1) Connections to existing systems shall be made using a flange isolation joint.
        2) If an existing pipeline or facility does not include a flange at or near the connection point:
            a) An isolation flange shall be placed in the first length of pipe.
            b) A butt-strap joint shall be used to connect the first length of pipe to the existing pipeline.
    c. Bell and spigot joint rings: Rolled Carnegie shape M-3516.

d. Lap welded joints:
    1) Double fillet weld lap welded joints shall be welded on the inside and outside of the joint.
    2) Lap joints prepared for electric field welding shall be in accordance with AWWA C206.
    3) Joint forming:
        a) Joint geometry and joint field weld will be such that no part of any field weld will be closer than 1 inch to the nearest point of tangency to the bell radius.
        b) Bell ends shall be formed by an expanding press or by being moved axially over a die in such a manner as to stretch the steel plate beyond its elastic limit to form a truly round bell of suitable diameter and shape.
    4) Faying surfaces of the bell and spigot shall be essentially parallel, but in no case shall the bell slope vary more than 2 degrees from the longitudinal axis of the pipe.
e. Butt-strap joints: Butt-strap joints where used or required, shall be:
    1) A minimum of 10 inches wide.
    2) The same thickness as the pipe wall.
    3) Provide for a minimum of 2-inch lap at each pipe joint.
    4) Double fillet weld each side of joint on the inside and outside of the joint.
f. Flanges: AWWA C207, Class D, steel ring, and as follows:
    1) Match pipe flanges to the valve flanges:
        a) At flanged joints connecting to valves, provide a steel pipe section without rod reinforcing and not less than 24 inches in length.
        b) Apply cement-mortar lining and coating to the steel pipe section.
    2) Flange bolts: As specified in Section 40_05_00.01 - Common Work Results for General Piping.
    3) Gaskets: As specified in Section 40_05_00.01 - Common Work Results for General Piping.

5. Fabrication:
    a. Shop coat of primer: Flanges and portions of pipe not covered with cement-mortar shall be given a shop coating of primer.
    b. Bend radii of fittings: Not less than 2.5 times the nominal diameter in accordance with AWWA C208.

2.03 COATING AND LINING - GENERAL

A. Coating and lining shall be as indicated on the Drawings or as specified in Section 40_05_00.01 - Common Work Results for General Piping.

B. Extend pipe coatings for underground piping 6-inches above finished grade or 3 inches above finished floor, and neatly terminate.

C. As specified in Section 01 61 00 - Common Product Requirements.

D. Prepare, install, and repair in accordance with manufacturer’s requirements.

E. Contractor is responsible for:
   1. That coating selected is suitable for the application conditions anticipated, such as temperature, humidity, etc.
   2. Managing the project schedule to allow adequate cure time before backfill or immersion based on surface temperatures at the time of application.

2.04 CEMENT MORTAR

A. Line pipe with cement mortar in accordance with AWWA C205 and as specified in this Section):
   1. Cement:
      a. Cement: In accordance with ASTM C150, Type II or V.
   2. Water:
      a. In accordance with AWWA C205 and as specified in this Section.
   3. Sand and aggregate:
      a. In accordance with AWWA C205.
      b. Provide silica sand or other aggregate that is not subject to leaching in accordance with ASTM C33.

B. Lining:
   1. Line special pieces or fittings by mechanical, pneumatic, or hand placement.
      a. Extend to faces of flanges and ends of spigots.
      b. Less than 12 inches in width: Coat with epoxy bonding agent prior to applying cement mortar.
      c. Larger than 12 inches in width: Reinforced with 2-inch by 4-inch No. 13 gauge welded steel wire mesh prior to applying cement mortar.
   2. Provide plastic end caps of sufficient thickness and strength to resist shipping, handling, and storage stresses.
   3. Repair damage to the cement mortar lining, including disbondment, or cracking caused by improper curing, shipping, handling, or installation in accordance with AWWA C205 and approved by the Engineer:
      a. Reinforce coating with 2 layers spirally wound steel wire positioned approximately in center of mortar coating positioned approximately at the third points of mortar coating:
         1) No. 12 gauge spaced at maximum 1-inch centers.
         2) No. 14 gauge steel wire at maximum 1/2-inch centers.

2.05 PLURAL COMPONENT EPOXY

A. Coat exposed pipe with plural component, 100 percent solids, non-extended in accordance with AWWA C210 and as specified in this Section.

B. Surface preparation:
   1. In accordance with SSPC-SP 10 or SSPC-SP 11.
   2. In accordance with AWWA C210 and as specified in this Section:
      a. Steel pipe: SSPC-SP 5, 3.00 mil profile, minimum, or in accordance with manufacturer’s requirements, whichever is greater.

C. Primer: In accordance with coating manufacturer’s requirements.

D. High build epoxy coating:
   1. 2 component, high build polyamide or polyamine cured epoxy coating, suitable for direct burial or immersion, dries to touch in 2 or more hours, suitable for immersion or burial after full cure of coating.
   2. Manufacturers: One of the following or equal:
      a. Carboline.
      b. ICI Devoe.
      c. Sherwin Williams.
      d. Warren Environmental.

E. Fast cure epoxy coating:
   1. 2 component, 100 percent solids by volume, fast cure epoxy coating suitable for direct burial or immersion, dry to touch in less than 1 hour at 72 degrees Fahrenheit, capable of curing while immersed or buried.
   2. Manufacturers: One of the following or equal:
      a. North American Denso, Protal 7125 or Protal 7200.
      b. Tapecoat Inc., TC 7010.

F. Application:
   1. Apply coating using plural component spray equipment by a manufacturer certified coating applicator.
   2. Perform coating application in an environmentally controlled shop area that meets or exceeds the written environmental application requirements of the coating manufacturer:
      a. It is not acceptable to apply coating in outdoor conditions without adequate environmental shelter, environmental controls, and/or dehumidification.
   3. In potable water applications, provide epoxy lining suitable for potable water contact in accordance with NSF 61, unless otherwise approved by Engineer.
   4. Concrete embedded pipe penetrations: Extend epoxy coating a minimum of 6 inches outside of interior and exterior surfaces of concrete walls or floors.
   5. Concrete penetrations minimum dry film thickness: 12 mils.
   6. Apply heat shrink sleeves to buried transitions from epoxy to tape wrap or extruded polyolefin coating systems:
      a. Backfill as soon as practical to limit exposure to direct sun or heat and potential thermal creep of sleeve.

G. Self-priming, plural component, 100 percent solids, suitable for burial or immersion, and in accordance with AWWA C210 and the following, whichever is more stringent:
   1. Non-NSF certified: Ceramic fill.
   2. NSF certified: Poly amine epoxy or poly amide epoxy.
   3. Shop applied coating thickness:
      a. Minimum: 1 coat, 35 mils total dry film thickness.
   4. Shop applied lining thickness:
      a. Minimum: 1 coat, 35 mils total dry film thickness.

H. Adhesion test procedures:
   1. Use self-aligning pneumatic pull off equipment and test procedures in accordance with ASTM D4541, Method E, using Delfesko Positest AT-A except as modified in this Section:
      a. Perform at an applied load rate of 100 pounds per square inch per second, plus or minus 10 pounds per square inch.
      b. Use automatic adhesion test equipment.
      c. Perform tests to coating or glue failure or maximum test load, whichever happens first.
      d. In accordance with ASTM D4541 using standard 20-millimeter dollies.
      e. Base adhesion testing on 3 tests:
         1) Conduct the tests by the same person, test equipment, and test procedure.
         2) Complete the tests within a 30-minute period.
      f. Conduct adhesion tests within an area not to exceed 6 inches by 6-inches.
      g. Score coatings with more than 10 percent elongation or 25 mils thick around dolly to metal substrate using manual methods and tools, normal to the pipe surface, and in a manner that does not stress or overheat the coating.
   2. Attach dollies for adhesion testing to the coating surface using a 2-part epoxy or cyanoacrylate glue and cured for a minimum of 12 hours before testing or until full cure, whichever is greater:
      a. Pipe fabricator and coating manufacturer determine glue type for the pipe diameter, temperatures, and environmental conditions.
   3. Perform adhesion testing at temperatures between 55 and 90 degrees Fahrenheit or at temperatures in accordance with coating manufacturer's requirements:
      a. Testing up to 115 degrees Fahrenheit or below 55 degrees Fahrenheit will be permitted if tests can demonstrate no statistically detectable effect on test results and in accordance with coating manufacturer's requirements and Engineer's approval.
   4. Epoxy coating and lining adhesion criteria:
      a. Coating is acceptable if first dolly pull test exceeds 1,750 pounds per square inch, minimum.
      b. If first dolly pull is less than 1,750 pounds per square inch, perform 2 additional tests with acceptance based on "Best of 3" evaluation method as defined in this Section.
   5. Pipe lot performance criteria:
      a. Minimum median value for coating or lining adhesion tests: 2,000 pounds per square inch.
      b. Classify failing pipe lots as rejected until 100 percent of the pipe within the pipe lot has been tested for adhesion:
         1) Reject each pipe that fails the coating adhesion criteria.
   6. Adhesion test evaluation and records:
      a. Definition: "Best of 3" evaluation method is when 2 of 3 test values meet the adhesion criteria.
      b. Consider adhesion tests as valid and suitable for acceptance or rejection of the coating, except where retesting is required.

c. Adhesion test failure:
    1) Adhesive or substrate failure:
        a) Definition: A percentage of separation of the coating from the steel substrate or between distinct coating layers.
    2) Cohesive test failure:
        a) Definition: A percentage of failure within the coating, resulting in coating remaining both on the steel substrate and test dolly.
d. Retest coating adhesion tests:
    1) When any test is glue failure at 25 percent or more of dolly surface area and the test value is less than the Acceptance Criteria or the Minimum Criteria.
    2) Within the same 6-inch by 6-inch test area as the original adhesion testing.
    3) Retest disputed adhesion tests:
        a) City's Representative will witness dolly attachment and adhesion retesting.
e. Adhesion tests will be conducted on pipe coating and lining independently and will be accepted or rejected independently.
f. Maintain adhesion test records in an electronic spreadsheet that includes the following information:
    1) Pipe identification.
    2) Pipe coating date.
    3) Adhesion test date.
    4) Surface tested (interior or exterior).
    5) Surface temperature at time of test.
    6) Coating thickness.
    7) Tensile force applied.
    8) Applied load rate per second.
    9) Mode of failure.
    10) Percentage of failure types, previously defined, relative to dolly surface area.
    11) Dolly size and attachment glue used.
    12) If different coatings are tested, include coating manufacturer and product number.

7. Adhesion test repairs:
    a. Fabricator or contractor to complete adhesion repairs as specified this Section.
    b. Randomly select repair patches on epoxy or polyurethane coating for adhesion testing in a manner as described in this Section and at the discretion of the coating inspector.

l. Long term adhesion test:
1. Acceptance criteria:
    a. Not more than 10 percent loss of adhesion over duration of test.
    b. Differential based on the highest average adhesion result to the lowest average adhesion result.
2. Test durations, cumulative:
    a. 1 day.
    b. 7 days.
    c. 3 weeks.
    d. 2 months.

3. Sample preparation:
    a. SSPC-SP 5, 3.00 mils profile, minimum.
    b. Test area minimum: 18-inches by 18-inches.
    c. Curved steel plate:
        1) Minimum radius of 15-inches.
        2) Inclined between 30 and 45 degrees.
4. Test procedure:
    a. Expose samples to ambient, outdoor conditions, and facing in a southern direction for maximum UV exposure for the full duration of the test.
5. Adhesion test results:
    a. Based on 8 pulls per test period with the 3 lowest pulls discarded.
    b. Based an average of the 5 highest pulls and identify the values used.
6. Record adhesion pulls and their failure mode.
7. Repair sample after adhesion tests to prevent water from causing any effects on subsequent adhesion tests.

2.06 PLURAL COMPONENT POLYURETHANE

A. Coat exposed pipe with plural component, polyurethane coating system (referred to as a polyurethane system) applied in accordance with AWWA C222 and as specified in this Section.

B. Manufacturers: One of the following or equal:
    1. Chemline, Chemthane 2265.
    2. Lifelast, Equivalent product.

C. Surface preparation:
    1. In accordance with AWWA C222 and as specified in this Section.
    2. In accordance with SSPC-SP 5, 3.00 mil profile, minimum, or in accordance with manufacturer’s requirements, whichever is greater.

D. Adhesion test procedures:
    1. Use self-aligning pneumatic pull off equipment and test procedures in accordance with ASTM D4541, Method E, using Delfesko Positest AT-A except as modified in this Section:
        a. Perform at an applied load rate of 100 pounds per square inch per second, plus or minus 10 pounds per square inch.
        b. Use automatic adhesion test equipment.
        c. Perform tests to coating or glue failure or maximum test load, whichever happens first.
        d. In accordance with ASTM D4541 using standard 20-millimeter dollies.
        e. Base adhesion testing on 3 tests:
            1) Conduct the tests by the same person, test equipment, and test procedure.
            2) Complete the tests within a 30-minute period.
        f. Conduct adhesion tests within an area not to exceed 6 inches by 6 inches.
        g. Score coatings with more than 10 percent elongation or 25 mils thick around dolly to metal substrate using manual methods and tools, normal to the pipe surface, and in a manner that does not stress or overheat the coating.

2. Attach dollies for adhesion testing to the coating surface using a 2-part epoxy or cyanoacrylate glue and cured for a minimum of 12 hours before testing or until full cure, whichever is greater:
    a. Pipe fabricator and coating manufacturer determine glue type for the pipe diameter, temperatures, and environmental conditions.
3. Perform adhesion testing at temperatures between 55 and 90 degrees Fahrenheit or at temperatures in accordance with coating manufacturer's requirements:
    a. Testing up to 115 degrees Fahrenheit or below 55 degrees Fahrenheit will be permitted if tests can demonstrate no statistically detectable effect on test results and in accordance with coating manufacturer's requirements and Engineer's approval.
4. Epoxy coating and lining adhesion criteria:
    a. Coating is acceptable if first dolly pull test exceeds 1,750 pounds per square inch, minimum.
    b. If first dolly pull is less than 1,750 pounds per square inch, perform 2 additional tests with acceptance based on "Best of 3" evaluation method as defined in this Section.
5. Pipe lot performance criteria:
    a. Minimum median value for coating or lining adhesion tests: 2,000 pounds per square inch.
    b. Classify failing pipe lots as rejected until 100 percent of the pipe within the pipe lot has been tested for adhesion:
        1) Reject each pipe that fails the coating adhesion criteria.
6. Adhesion test evaluation and records:
    a. Definition: "Best of 3" evaluation method is when 2 of 3 test values meet the adhesion criteria.
    b. Consider adhesion tests as valid and suitable for acceptance or rejection of the coating, except where retesting is required.
    c. Adhesion test failure:
        1) Adhesive or substrate failure.
            a) Definition: A percentage of separation of the coating from the steel substrate or between distinct coating layers.
        2) Cohesive test failure:
            a) Definition: A percentage of failure within the coating, resulting in coating remaining both on the steel substrate and test dolly.
    d. Retest coating adhesion tests:
        1) When any test is glue failure at 25 percent or more of dolly surface area and the test value is less than the Acceptance Criteria or the Minimum Criteria.
        2) Within the same 6-inch by 6-inch test area as the original adhesion testing.
        3) Retest disputed adhesion tests:
            a) City's Representative will witness dolly attachment and adhesion retesting.
    e. Adhesion tests will be conducted on pipe coating and lining independently and will be accepted or rejected independently.
    f. Maintain adhesion test records in an electronic spreadsheet that includes the following information:
        1) Pipe identification.
        2) Pipe coating date.

3) Adhesion test date.
4) Surface tested (interior or exterior).
5) Surface temperature at time of test.
6) Coating thickness.
7) Tensile force applied.
8) Applied load rate per second.
9) Mode of failure.
10) Percentage of failure types, previously defined, relative to dolly surface area.
11) Dolly size and attachment glue used.
12) If different coatings are tested, include coating manufacturer and product number.

7. Adhesion test repairs:
   a. Fabricator or contractor to complete adhesion repairs as specified this Section.
   b. Randomly select repair patches on epoxy or polyurethane coating for adhesion testing in a manner as described in this Section and at the discretion of the coating inspector.

E. Long term adhesion test:
1. Acceptance criteria:
   a. Not more than 10 percent loss of adhesion over duration of test.
   b. Differential based on the highest average adhesion result to the lowest average adhesion result.
2. Test durations, cumulative:
   a. 1 day.
   b. 7 days.
   c. 3 weeks.
   d. 2 months.
3. Sample preparation:
   a. SSPC-SP 5, 3.00 mils profile, minimum.
   b. Test area minimum: 18-inches by 18-inches.
   c. Curved steel plate.
      1) Minimum radius of 15-inches.
      2) Inclined between 30 and 45 degrees.
4. Test procedure:
   a. Expose samples to ambient, outdoor conditions, and facing in a southern direction for maximum UV exposure for the full duration of the test.
5. Adhesion test results:
   a. Based on 8 pulls per test period with the 3 lowest pulls discarded.
   b. Based an average of the 5 highest pulls and identify the values used.
6. Record adhesion pulls and their failure mode.
7. Repair sample after adhesion tests to prevent water from causing any effects on subsequent adhesion tests.

PART 3 EXECUTION

3.01 INSTALLATION

A. Joints:
   1. Steel pipe joints shall be screwed, welded, flanged, grooved, or made with flexible joints. The type of joint for piping is specified in the Piping Schedule in Section 40_05_00.01 - Common Work Results for General Piping.
   2. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, and other types of joints or means necessary to allow ready assembly and disassembly of the piping.
   3. Unless otherwise indicated on the Drawings or specified in the Piping Schedule in Section 40_05_00.01 - Common Work Results for General Piping, pipe joints shall be as follows:
      a. Pipe smaller than 2 inches in nominal diameter shall have screwed joints or flexible couplings.
      b. Pipe 2 inches to 4 inches in nominal diameter shall have screwed joints, flanged joints, welded joints, or joints made with flexible couplings.
      c. Pipe larger than 4 inches in nominal diameter shall have flanged joints, welded joints, or joints made with flexible couplings.

B. Screwed joints:
   1. Perform threading with clean, sharp dies:
      a. Wavy, rough, or otherwise defective pipe threads are not acceptable.
   2. Make screwed joints tight and clean with an application of Teflon™ tape or approved paste compound applied to the male threads only, except as follows:
      a. Make up liquid and dry chlorine lines, and liquefied petroleum gas lines, with litharge and glycerin.
   3. Provide railroad type unions with bronze-to-iron seat, galvanized where used with galvanized pipe:
      a. Flanged joints may be used instead of unions.

C. Flanged joints:
   1. In flanged joints, flanges shall come together at the proper orientation with no air gaps between the flanges after the gaskets are in place.
   2. Attach slip-on flanges to pipe by 2 fillet welds, in accordance with AWWA C207.
   3. Secure welding neck flanges with full penetration butt welds without backing rings:
      a. After welding in place, the faces of flanges shall be perpendicular to the axis of the pipe, or, in the case of fittings, at the proper angle to each other, and bolt holes shall be in proper alignment.

D. Welded joints:
   1. Welded joints shall be electric welded in accordance with AWWA C206.
   2. Welders shall be qualified pursuant to the provisions of AWWA C206:
      a. Welders' testing shall be at the Contractor's expense, including cost of test nipples, welding rods, and equipment.
   3. Do not weld galvanized pipe.

E. Grooved joints:
   1. Piping with grooved joints shall be installed where indicated on the Drawings and may be installed in place of flanged piping and screwed piping, except that grooved joint piping shall not be used in the following installations:
      a. In underground and underwater installations.
      b. In piping subject to test pressures of 150 pounds per square inch gauge, or more.
      c. In steam and gas piping.
      d. In sludge and scum piping designed to be steam cleaned.
   2. Assemble in accordance with manufacturer's published instructions.
   3. Support grooved-end pipe in accordance with manufacturer's recommendations. In addition, provide at least 1 support between consecutive couplings.

3.02 DEFECTS IN COATINGS EXCEPT CEMENT MORTAR

A. Engineer will identify defective coating to be field repaired in accordance with the applicable AWWA standard:
   1. Pipe joints exceeding the following defect maximum will be rejected:
      a. Minor defects:
         1) No more than 1.5 per 100 square feet of surface area.
         2) 2 or more minor repairs within an 8-inches diameter circle will be considered a single repair.
         3) Repairs for adhesion testing will not be included in the total number of repairs.
         4) Repair in accordance with manufacturer's requirements.
      b. Major defects:
         1) No more than 3 major repairs on each pipe joint.
         2) No more than 30 percent repairs on the pipe surface area with defects.
   2. Minor repairs:
      a. Repairs less than 8 inches in the greatest dimension.
      b. Repair in accordance with manufacturer's requirements.
   3. Major repairs:
      a. Repairs that exceed 8 inches in the greatest dimension.
      b. Repair in accordance with manufacturer's requirements.

3.03 CEMENT MORTAR

A. Lining:
   1. Field applied interior joint lining:
      a. Field applied lining shall be of the same density, smoothness, and thickness as shop applied lining.
      b. After the backfill has been completed to final grade, fill interior joint recess with tightly packed cement mortar:
         1) Trowel flush with the interior surface with no indentation or projection of the mortar exceeding 1/16-inch.
         2) Remove excess cement mortar.

3.04 PLURAL COMPONENT EPOXY

A. Joints:
   1. Field applied coating or lining shall be of the same density, smoothness, and thickness as shop applied coating or lining.
   2. Comply with same application requirements as shop applied coating or lining.
      a. Provide heating and/or dehumidification equipment as required to meet the environmental conditions necessary for proper coating application.

3.05 PLURAL COMPONENT POLYURETHANE

A. Joints:
   1. Field applied coating or lining shall be of the same density, smoothness, and thickness as shop applied coating or lining.
   2. Comply with same application requirements as shop applied coating or lining.
      a. Provide heating and/or dehumidification equipment as required to meet the environmental conditions necessary for proper coating application.

3.06 FIELD QUALITY CONTROL

A. Field test fabricated steel manifolds with the pipe to which they connect.

B. Weld testing:
   1. Liquid penetrant testing:
      a. As soon as possible after welding of pipeline joints, all fillet welds shall be tested by the liquid penetrant inspection procedure in accordance with ASTM E165 under Method “B” and “Leak Testing”.
      b. Chip out defects, rebell, and retest:
         1) Upon retest, the repaired area shall show no leaks or other defects.

END OF SECTION

SECTION 40_05_31.01

PLASTIC PIPING AND TUBING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Plastic pipe, tubing, and fittings for systems that are not plumbing systems.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.12 - Cast Iron Threaded Drainage Fittings.

B. ASTM International (ASTM):
   1. D1248 - Standard Specification for Polyethylene Plastics Extrusion Materials For Wire and Cable.
   2. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
   3. D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.
   4. D1869 - Standard Specification for Rubber Rings for Asbestos-Cement Pipe.
   5. D2412 - Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
   6. D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
   7. D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
   8. D2513 - Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings.
   9. D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
   10. D2665 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
   11. D2855 - Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets.
   12. D3034 - Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
   13. D3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
   14. D3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
   15. D3350 - Standard Specification for Polyethylene Plastic Pipes and Fittings Materials.
   16. D4101 - Standard Specification for Polypropylene Injection and Extrusion Materials.

17. F437 – Standard Specification for Threaded Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
18. F439 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
19. F441 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
20. F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
21. F493 - Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
22. F645 - Standard Guide for Selection, Design and Installation of Thermoplastic Water-Pressure Piping Systems.
23. F679 - Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
24. F714 - Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.

C. NSF International (NSF).

D. Plastics Pipe Institute (PPI):
   1. TR 31 - Underground Installation of Polyolefin Piping.

1.03 ABBREVIATIONS

A. ABS: Acrylonitrile-butadiene-styrene.

B. CPVC: Chlorinated polyvinyl chloride.

C. DR: Dimension ratio.

D. DWV: Drain, waste, and vent.

E. HDPE: High-density polyethylene.

F. ID: Inside diameter of piping or tubing.

G. NPS: Nominal pipe size followed by the size designation.

H. NS: Nominal size of piping or tubing.

I. PE: Polyethylene.

J. PP: Polypropylene.

K. PVC: Polyvinyl chloride.

L. SDR: Standard dimension ratio; the outside diameter divided by the pipe wall thickness.

1.04 SUBMITTALS

A. Submit as specified in Section 01 33 00 - Submittal Procedures.

B. Product data: As specified in Section 40_05_00.01 - Common Work Results for General Piping.

C. Shop Drawings:
   1. Describe materials, pipe, fittings, gaskets, and solvent cement.
   2. Installation instructions.

1.05 QUALITY ASSURANCE

A. Plastic pipe in potable water applications: Provide pipe and tubing bearing NSF seal.

B. Fusion machine technician qualifications: 1 year of experience in the installation of similar PE piping systems from the same manufacturer.

C. Mark plastic pipe with nominal size, type, class, schedule, or pressure rating, manufacturer and all markings required in accordance with ASTM and AWWA standards.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect piping materials from sunlight, scoring, and distortion.

B. Do not allow surface temperatures on pipe and fittings to exceed 120 degrees Fahrenheit.

C. Store and handle PE pipe and fittings as recommended by manufacturer in published instructions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.

B. Fittings: Same material as the pipe and of equal or greater pressure rating, except that fittings used in drain, waste, and vent piping systems need not be pressure rated.

C. Unions 2-1/2 inches and smaller: Socket end screwed unions. Make unions 3 inches and larger of socket flanges with 1/8-inch full-face soft EPDM gasket.

2.02 PVC PIPING, SCHEDULE TYPE

A. Materials:
   1. PVC Pipe: Designation PVC 1120 in accordance with ASTM D1785 and appendices:
      a. Pipe and fittings: Extruded from Type I, Grade 1, Class 12454 material in accordance with ASTM D1784.
      b. PVC Pipe: Schedule 80 unless otherwise indicated on the Drawings.

2. Fittings:
    a. Supplied by pipe manufacturer.
    b. Pressure fittings: In accordance with ASTM D2466 or ASTM D2467.
    c. DWV fittings: In accordance with ASTM D2665.
3. Solvent cement: In accordance with ASTM D2564:
    a. Chemical service: For CPVC or PVC pipe in chemical service, provide the following primer and cement, or equal:
        1) Primer: IPS Corp., Type P70.
        2) Cement: IPS Corp., Type 724 cement or another cement certified by the manufacturer for chemical service.

2.03 PVC HOSE

A. Application: Orthophosphate hose at tank inlet connection.

B. Material and size: Clear PVC polyester yarn braid reinforced hose tubing with a smooth interior. Rated for NSF 51 and NSF 61, and 125 psi:
    1. For NS 1 inch, OD of 1.28 inch minimum.

C. Fittings: Compression fittings, Fit-Line or equal.

D. Manufacturer, one of the following or equal:
    1. Nylobrade by NewAge.

2.04 PFA TUBING

A. Application: Orthophosphate tubing.

B. Small bore PFA tubing: Flexible virgin perfluoroalkoxy tubing, ASTM D 3307 Type II, Natural color, OD copper tubing size, rated for NSF 61:
    1. Plastic tubing ID as follows:
        a. For NS 1/4-inch, ID of 0.125 inch.
        b. For NS 5/16-inch, ID of 0.1875 inch.
        c. For NS 3/8-inch, ID of 0.25 inch.
        d. For NS 1/2-inch, ID of 0.375 inch.
        e. For NS 3/4-inch, ID of 0.625 inch.
        f. For NS 1 inch, ID of 0.875 inch.
        g. For NS 1-1/8-inch, ID of 1 inch.

C. Fittings: Compression fittings, Fit-Line; or equal.

D. Supplied in 1,000-foot coiled lengths.

E. Manufacturer, one of the following or equal:
    1. Altalflo Altafluor 400 PFA, heavy wall.
    2. Parker Hannifin Corp., 104 Series Heavy Wall.

2.05 CHLORINATED POLYVINYL CHLORIDE (CPVC) PIPE

A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.

B. Pipe:
   1. In accordance with ASTM F441 and Appendix, CPVC 4120.
   2. Extruded from Corzan CPVC Type IV, Grade 1, Class 24448 for sizes 8 inch and below and Class 23447 for sizes 8 inch and above material in accordance with ASTM D1784.
   3. Schedule 80, unless otherwise indicated on the Drawings or specified in the Piping Schedule in Section 40_05_00.01 - Common Work Results for General Piping.
   4. Manufacturers: One of the following or equal:
      a. IPEX USA, LLC.
      b. GF Harvel.
      c. Chemtrol (fittings only).

C. Fittings:
   1. In accordance with ASTM F437 and ASTM F439 for pressure fittings, as appropriate to the service and pressure requirement.
   2. Same material as the pipe and of equal or greater pressure rating.
   3. Supplied by pipe manufacturer.

D. Solvent cement:
   1. In accordance with ASTM F493.
   2. Manufacturers: The following or equal:
      a. IPS Corp.
   3. Certified by the manufacturer for the service of the pipe.
   4. Primer: As recommended by the solvent cement manufacturer.
   5. In potable water applications: Provide solvent cement listed by NSF 61 for potable water applications.

E. Unions 4 inches and smaller:
   1. Socket end screwed unions.

F. Unions 6 inches and larger:
   1. Socket flanges with 1/8-inch full-face soft gasket:
      a. Gasket material: As indicated on the Piping Schedule.

2.06 SOURCE QUALITY CONTROL

A. PVC piping, Schedule Type:
   1. Mark pipe and fittings in accordance with ASTM D1785.

B. CPVC piping:
   1. Mark pipe and fittings in accordance with ASTM F441.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Where not otherwise specified, install piping in accordance with ASTM F645, or manufacturer's published instructions for installation of piping, as applicable to the particular type of piping.
   2. Provide molded transition fittings for transitions from plastic to metal or IPS pipe. Do not thread plastic pipe.
   3. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.
   4. Provide serrated nipples for transition from plastic pipe to rubber hose.

B. Installation of PVC piping, Schedule Type:
   1. Solvent weld joints in accordance with ASTM D2855:
      a. For PVC pipe in chemical service use IPS Corp., Type 724 cement in accordance with manufacturer's instructions.
   2. Install piping in accordance with manufacturer's published instructions.

C. Installation of PVC gravity sewer piping:
   1. Install piping in accordance with manufacturer's published instructions, as modified and complemented in this Section.
   2. Install pipe and fittings not later than 4 months after their manufacture.
   3. Provide for contraction and expansion at joints with a gasket ring.
   4. Provide plugs or caps for stubs and branch pipes left unconnected to laterals.
   5. Lubricate and assemble joints in accordance with the pipe manufacturer's published instructions.
   6. Make connections to manholes with a manhole gasket that prevents infiltration and exfiltration through the penetrations:
      a. Provide opening for connection large enough to allow subsequent grouting around the manhole gasket.
      b. Grout around the manhole gasket and seal the opening.

D. Installation of PFA Tubing:
   1. Install in accordance with manufacturer's printed instructions, in continuous runs wherever possible, and with long radius bends (i.e. minimum 4-inch radius).

3.02 FIELD QUALITY CONTROL

A. Leakage test for PVC piping, Class Type:
   1. Polyvinyl chloride (PVC) piping, Class Type: Subject to visible leaks test and to pressure test with maximum leakage allowance, as specified in Section 40_05_00.09 - Piping Systems Testing.

2. Pressure test with maximum leakage allowance: Perform test after backfilling:
   a. Pressure: 125 pounds per square inch, gauge.
   b. Maximum leakage allowance as follows, wherein the value for leakage is in gallons per 100 joints per hour:

NPS, Inches	1-1/2	2	2-1/2	3	4	6	8	10	12
Leakage	0.41	0.52	0.63	0.76	0.98	1.45	1.88	2.35	2.80

B. Mandrel tests for PVC gravity sewer and HDPE piping:
   1. Perform initial mandrel test:
      a. After cleaning and completion of other tests.
      b. After placement and compaction of backfill.
      c. Before construction of pavement or surfacing.
      d. Not sooner than 30 days after pipe installation.
      e. Not later than 60 days after installation.
   2. Utilize a 9 rod mandrel with minimum length equal to NPS and diameter as follows:

Nominal Pipe Size (NPS)	Mandrel Diameter, inches
6	5.50
8	7.37
10	9.21
12	10.96
15	13.56

   3. Test procedure: Pull the mandrel through the line under test by 1 person, by hand, with reasonable effort, without the aid of mechanical equipment.
   4. Failing test: Where the mandrel test is not successful, remove and replace the section of piping with the obstruction; test the piping again, including visible leaks test, pressure test with maximum leakage allowance, mandrel tests, and other specified tests:
      a. Correction of excessive deflection or obstructions by methods other than removal of the affected piping and replacement of the removed piping with new piping will not be accepted.

END OF SECTION

SECTION 40_05_31.14

POLYVINYL CHLORIDE (PVC) PIPE: PRESSURE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. AWWA C900 PVC pipe and fittings.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. Abbreviations:
   1. DR: Dimension ratio = OD/t (OD is pipe outer diameter, t is pipe wall thickness).
   2. NPS: Nominal pipe size followed by the size designation.

B. Standards:
   1. American Water Works Association (AWWA):
      a. C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
      b. C605 - Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings.
      c. C900 - Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. Through 60 In.
      d. M23 - PVC Pipe - Design and Installation Manual.
   2. ASTM International (ASTM):
      a. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
      b. D3139 - Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
      c. F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
      d. F645 - Standard Guide for Selection, Design, and Installation of Thermoplastic Water-Pressure Piping Systems.
   3. NSF International (NSF):
      a. 61 - Drinking Water System Components - Health Effects.

1.03 SUBMITTALS

A. Submit as specified in Section 01 33 00 - Submittal Procedures.

B. As specified in Section 40_05_00.01 - Common Work Results for General Piping.

C. Shop Drawings.

1.04 QUALITY ASSURANCE

A. Pipe in potable water applications: Provide pipe bearing NSF 61 seal.

B. Mark plastic pipe with date of extrusion, nominal size, class, manufacturer, and markings required in accordance with ASTM and AWWA standards.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Protect from sunlight, scoring, and distortion.

B. Do not allow surface temperatures to exceed 120 degrees Fahrenheit.

C. Deliver, offload, handle, and store pipe in accordance with manufacturer's or pipe supplier's recommendations and best practices provided by AWWA M23 and AWWA C605, including compliance with minimum recommended bending radius and maximum safe pulling forces for each specific pipe.

PART 2 PRODUCTS

2.01 PIPE

A. General:
   1. As specified in Section 40_05_00.01 - Common Work Results for General Piping.
   2. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.
   3. In accordance with AWWA C900.
   4. Made from a PVC compound conforming to cell classification 12454 in accordance with ASTM D1784.
   5. Marked verifying suitability for potable water service in accordance with NSF 61.

B. Pipe:
   1. Bell and spigot:
      a. Pipe with integral bell.
      b. Pressure Class as scheduled in Section 40_05_00.01 - Common Work Results for General Piping with a maximum DR of P
      c. Manufacturers: One of the following or equal.
         1) CertainTeed.
         2) Diamond Plastics Corp.
         3) Westlake Pipe and Fittings.

2.02 FITTINGS

A. Material:
   1. Cast or ductile iron fittings as specified in Section 40_05_19.01 - Ductile Iron Pipe: AWWA C151 sized for the dimensions of the pipe being used.

B. Equal to or greater pressure rating than the pipe.

2.03 JOINTS

A. Bell and spigot joints:
   1. Push-on or mechanical joint type as identified in the Piping Schedule in Section 40_05_00.01 - Common Work Results for General Piping.
   2. Gasketed joint assembly: Meet or exceed the requirements in accordance with ASTM D3139.
   3. Factory installed gaskets: EPDM in accordance with ASTM F477.
   4. Joint restraint at fittings:
      a. Concrete thrust blocks:
         1) Install at changes in pipe diameter and at fittings.
         2) Design using a safety factor of at least 1.5:1 for both the test and peak operating pressures.
      b. Mechanical wedge action joint restraints:
         1) Manufacturers: One of the following or approved equal:
            a) EBAA Iron, Inc.:
               (1) For pipes 3- to 36-inch: Series 2000PV.
               (2) For pipes 42- and 48-inch: Series 2200.
            b) Sigma Corp.:
               (1) For pipes 3- to 36-inch: One-Lok Model SLCE.
               (2) For pipes 42- and 48-inch: PV-Lok Model PWM.
            c) Star Pipe Products, Series 4000.
         2) Materials:
            a) Mechanical joints bolts and nuts as specified in Section 40_05_00.01 - Common Work Results for General Piping.
            b) Gland body: Ductile iron in accordance with ASTM A536.
            c) Wedge and wedge actuating components: Ductile iron in accordance with ASTM A536:
               (1) Wedges: Heat-treated to a minimum of 370 BHN.
            d) Actuating bolts and nuts: Ductile iron in accordance with ASTM A536:
               (1) Provide torque-limiting twist off components to ensure proper installation.
         3) Coatings:
            a) Provide a manufacturer applied coating system.
            b) Manufacturers: One of the following or equal:
               (1) EBAA Iron Inc., Mega-Bond.
               (2) Sigma Corp., Corrsafe™ Electro-Deposition Coating.
               (3) Star Pipe Products, Star-Bond.
         4) Consist of multiple gripping wedges incorporated into a follower gland meeting the requirements in accordance with AWWA C111.
         5) Allow post assembly angular deflection that is a minimum of 50 percent of the angular deflection allowed by the mechanical joint.
         6) Pressure rating equal to or greater than that of the pipe on which it is being used and a minimum safety factor of 2:1 for all sizes.

2.04 SOURCE QUALITY CONTROL

A. Bell and spigot piping:
   1. Hydrostatic proof testing in accordance with AWWA C900: Test pipe and integral bell to withstand, without failure, 2 times the pressure class of the pipe for a minimum of 5 seconds.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Install PVC piping in accordance with ASTM F645, AWWA C605, and manufacturer's or pipe supplier's published installation instructions.
   2. Trenching and backfill as specified in Section 31_23_35 - Trenching.
   3. Install pipe with tracer wire as specified in Section 40_05_00.03 - Pipe Identification.

B. Tapping PVC:
   1. Direct tapping:
      a. Allowed for AWWA C900 have a pipe class of Class 235 or greater, NPS 6-inch through 12-inch only.
      b. 1-inch is the maximum allowable outlet size for performing a direct tap.
   2. Saddle tapping:
      a. Allowable on all sizes and classes of AWWA C900 pipe.
      b. 2-inch is the maximum allowable outlet size for performing a saddle tap.
      c. As specified in Section 40_05_06.01 - Piping Specialties for allowable service saddles.
   3. Tapping sleeves:
      a. Allowable on all sizes and classes of PVC AWWA C900.
      b. As specified in Section 40_05_06.01 - Piping Specialties for allowable tapping sleeves.

3.02 FIELD QUALITY CONTROL

A. Leakage test for piping:
   1. Subject to visible leak test and pressure test with maximum leakage allowance, as specified in Section 40_05_00.09 - Piping Systems Testing.
   2. Pressure test with maximum leakage allowance:
      a. Perform test after placing sufficient backfill.
      b. In areas requiring immediate backfill, test prior to placement of permanent surfacing.
      c. Test pressure: As specified in the Piping Schedule in Section 40_05_00.01 - Common Work Results for General Piping.

d. Maximum leakage allowance for bell and spigot pipe is as listed in the table below:

Test Pressure (psi)	Bell and Spigot Pipe Allowable Leakage (gallons per 50 joints per hour) Nominal Pipe Size (inches)									
	4	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**24**
50	0.19	0.29	0.38	0.48	0.57	0.67	0.76	0.86	0.96	1.15
75	0.23	0.35	0.47	0.59	0.70	0.82	0.94	1.05	1.17	1.40
100	0.27	0.41	0.54	0.68	0.81	0.95	1.08	1.22	1.35	1.62
125	0.3	0.45	0.6	0.76	0.91	1.06	1.21	1.36	1.51	1.81
150	0.33	0.50	0.66	0.83	0.99	1.16	1.32	1.49	1.66	1.99
175	0.36	0.54	0.72	0.89	1.07	1.25	1.43	1.61	1.79	2.15
200	0.38	0.57	0.76	0.96	1.15	1.34	1.53	1.72	1.91	2.29
225	0.41	0.61	0.81	1.01	1.22	1.42	1.62	1.82	2.03	2.43
250	0.43	0.64	0.85	1.07	1.28	1.50	1.71	1.92	2.14	2.56
275	0.45	0.67	0.90	1.12	1.34	1.57	1.79	2.02	2.24	2.69
300	0.47	0.70	0.94	1.17	1.40	1.64	1.87	2.11	2.34	2.81

END OF SECTION

SECTION 40_05_51.01

COMMON WORK RESULTS FOR VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Basic requirements for valves.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C111/A21.11 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe Fittings.

B. ASTM International (ASTM):
   1. A126 - Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
   2. A480 - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
   3. A536 - Standard Specification for Ductile Iron Castings.

C. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

D. Society for Protective Coatings (SSPC):
   1. SP7 - Brush-Off Blast Cleaning.
   2. SP10 - Near-White Blast Cleaning.

E. NSF International (NSF):
   1. Standard 61 - Drinking Water System Components - Health Effects.

F. City of Santa Cruz Water System Standard Specifications.

G. City of Santa Cruz Public Works Standards.

1.03 SUBMITTALS

A. Submit as specified in Section 01 33 00 - Submittal Procedures.

B. Product data:
    1. Submit the following information for each valve:
        a. Valve type, size, pressure rating, Cv factor.
        b. Coatings.
        c. Power valve actuators:
            1) Information on valve actuator including size, manufacturer, model number, limit switches, mounting; and motor enclosure, seating and unseating torque coefficient, dynamic torque, and bearing friction for calculation of maximum operating torque.
            2) Complete wiring diagrams and control system schematics.
        d. Manual valve actuators:
            1) Information on valve actuator including size, manufacturer, model number.
        e. Certified drawings with description of component parts, dimensions, weights, and materials of construction.
        f. Certifications of reference standard compliance:
            1) Submit certification that the valves and coatings are suitable in potable water applications in accordance with NSF 61.
        g. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
        h. Factory test data.

C. Provide vendor operation and maintenance manual as specified in Section 01 78 23 - Operation and Maintenance Data:
    1. Furnish bound sets of installation, operation, and maintenance instructions for each type of manual valve 4 inches in nominal size and larger, and all non-manual valves. Include information on valve operators.

D. Provide Manufacturer’s Certificate of Source Testing as specified in Section 01 79 00 - Demonstration and Training.

E. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01 79 00 - Demonstration and Training.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications:
    1. Valves manufactured by manufacturers whose valves have had successful operational experience in comparable service.

1.05 DELIVERY STORAGE AND HANDLING

A. Protect valves and protective coatings from damage during handling and installation; repair coating where damaged.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Pressure rating:
   1. Suitable for service under minimum working pressures of 150 pounds per square inch gauge.
   2. When a piping system is specified in the Piping Schedule to be tested at a pressure greater than 150 pounds per square inch gauge, provide valves for that piping system with design working pressure which is sufficient to withstand the test pressure.

B. Valve to piping connections:
   1. Metallic valves:
      a. Valves 3 inches nominal size and larger: Flanged ends.
      b. Valves less than 3 inches nominal size: Screwed ends.
   2. Plastic valves in plastic piping systems:
      a. Up to 4 inches: Provide solvent or heat welded unions, except for plastic butterfly valves:
         1) Plastic butterfly valves shall be flanged per Section 40_05_64 - Butterfly Valves.
      b. 6 inches and above: Provide solvent or heat-welded flanges.

2.02 MATERIALS

A. Stainless steel: In accordance with ASTM A480, Type 316, or Type 304, UNS Alloy S31600 or S30400.

B. Valve and operator bolts and nuts (not including flange bolts and nuts, which are specified in Section 40_05_00.01 - Common Work Results for General Piping):
   1. Fabricated of stainless steel for the following installation conditions:
      a. Submerged in sewage or water.
      b. In an enclosed space above sewage or water.
      c. In structures containing sewage or water, below top of walls.
      d. At openings in concrete or metal decks.
   2. Where dissimilar metals are being bolted, use stainless steel bolts with isolation bushings and washers.
   3. Underground bolts: Low-alloy steel in accordance with AWWA C111/A21.11.

C. Bronze and brass alloys: Use bronze and brass alloys with not more than 6 percent zinc and not more than 2 percent aluminum in the manufacture of valve parts; UNS Alloy C83600 or C92200 unless specified otherwise.

D. Cast iron valve bodies: In accordance with ASTM A126, Class 30 minimum.

E. Ductile iron valve bodies: In accordance with ASTM A536, Grade 65-45-12 minimum unless specified otherwise.

2.03 INTERIOR PROTECTIVE LINING

A. When specified in the particular valve specification, provide valves with type of protective lining specified in the particular valve Specification.

B. Apply protective lining to interior, non-working surfaces, except stainless steel surfaces.

C. Lining types:
   1. Fusion bonded epoxy:
      a. Manufacturers: The following or equal:
         1) 3-M Company, ScotchKote 134; certified to NSF 61 for drinking water use.
      b. Clean surfaces in accordance with SSPC SP 7 or SP 10, as recommended by epoxy manufacturer.
      c. Apply in accordance with manufacturer's published instructions.
      d. Lining thickness: 0.010 to 0.012-inch, except that:
         1) Lining thickness in grooves for gaskets: 0.005-inch.
         2) Do not coat seat grooves in valves with bonded seat.
      e. Quality control:
         1) Lining thickness: Measured with a non-destructive magnetic type thickness gauge.
         2) Verify lining integrity with a wet sponge-testing unit operating at approximately 60 volts, or as recommended by the lining manufacturer.
         3) Consider tests successful when lining thickness meets specified requirements and when no pinholes are found.
         4) Correct defective lining disclosed by unsuccessful tests, and repeat test.
         5) Repair pinholes with liquid epoxy recommended by manufacturer of the epoxy used for lining.
   2. High solids epoxy:
      a. Product equivalent to high solids epoxy EPX-M-1-PWSas specified in Section 09_96_01 - High-Performance Coatings:
         1) Certified in accordance with NSF 61 for drinking water use.
         2) Interior: Coat valve interior with manufacturer's equivalent high performance high solids epoxy coating system with a certifiable performance history for the service conditions and as approved by the Engineer. Manufacturer shall provide for approval, coating information sufficient to allow Engineer to assess equivalence to the specified high solids epoxy EPX-M-1-PWS as specified in Section 09_96_01 - High-Performance Coatings.
      b. Clean surfaces to meet SP-7 or SP-10, or as recommended by coating manufacturer.
      c. Quality control: After coating is cured, check coated surface for porosity with a holiday detector set at 1,800 volts, or as recommended by coating manufacturer:
         1) Repair holidays and other irregularities and retest coating.
         2) Repeat procedure until holidays and other irregularities are corrected.

2.04 UNDERGROUND VALVES

A. Provide underground valves with flanged, mechanical, or other type of joint required for the type of pipe to which the valve is to be connected.

B. Coating and wrapping:
   1. Prior to installation, coat buried valves with 2 coats of protective coal tar as specified in Section 09_96_01 - High-Performance Coatings.
   2. After installation, encase valves in polyethylene wrap as specified for ductile iron piping in Section 40_05_19.01 - Ductile Iron Pipe: AWWA C151:
      a. Ascertain that polyethylene wrapping does not affect operation of valve.

2.05 VALVE BOXES

A. Provide cast-iron valve boxes at each buried valve to access valve and valve operators.

B. Do not support boxes on valve, valve operator, or pipe.

C. Boxes:
   1. 2-piece, fabricated of cast iron; provide cover, with asphalt varnish or enamel protective coating.
   2. Adjustable to grade, install centered around the upper portions of the valve and valve operator.

D. Manufacturers: One of the following or equal:
   1. Tyler Pipe Industries, Inc.
   2. Neenah Foundry Co.

2.06 VALVE OPERATORS

A. Valve operator "Open" direction: Open counterclockwise.

B. Provide valves located below operating level or deck with extensions for key operation or floor stands and handwheels, as indicated on the Drawings.

C. Provide manually operated valves located not more than 6 feet above the operating level with tee handles, wrenches, or handwheels:
   1. Make the valve operator more conveniently accessible by rolling valves, located more than 5 feet but less than 6 feet above the operating level, toward the operating side.
   2. Secure tee handles and wrenches to the valve head or stem, except where a handle or wrench so secured constitutes a hazard to personnel; in which case, stow handle or wrench immediately adjacent to the valve on or in a suitable hanger, bracket, or receptacle.

D. Fit valves located more than 6 feet above operating level with chain operated handles or valve wheels:
   1. Chains: Sufficient length to reach approximately 4 feet above the operating level.

2. Where chains constitute a nuisance or hazard to operating personnel, provide holdbacks or other means for keeping the chains out of the way.

E. Provide an operator shaft extension from valve or valve operator to finished grade or deck level when buried valves, and other valves located below the operating deck or level, are specified or indicated on the Drawings to be key operated; provide 2 inches square AWWA operating nut, and box and cover as specified, or a cover where a box is not required.

PART 3 EXECUTION

3.01 EXAMINATION

A. Preparation prior to installation:
   1. Install valves after the required submittal on installation has been accepted.
   2. Determine after flanged valves and flanged check valves are selected, the face-to-face dimensions of flanged valves and flanged check valves.

B. Fabricate piping to lengths taking into account the dimensions of flanged valves and flanged check valves.

3.02 INSTALLATION

A. Provide incidental work and materials necessary for installation of valves including flange gaskets, flange bolts and nuts, valve boxes and covers, concrete bases, blocking, and protective coating.

B. Where needed, furnish and install additional valves for proper operation and maintenance of equipment and plant facilities under the following circumstances:
   1. Where such additional valves are required for operation and maintenance of the particular equipment furnished by Contractor.
   2. Where such additional valves are required as a result of a substitution or change initiated by Contractor.

C. Valve and actuator orientation:
   1. Contractor shall coordinate with valve supplier final orientation of valve and actuator assembly based on Contractor's selection of equipment manufacturers and the valve and piping arrangement as indicated on the Drawings:
      a. Contractor shall rotate valve and/or actuator mounting orientation as specified in this Section unless otherwise indicated on the Drawings.
   2. Install valves with their stems in vertical position above the pipe, except as follows:
      a. Butterfly valves, gate valves aboveground, globe valves, ball valves, and angle valves may be installed with their stems in the horizontal position.
      b. Install buried plug valves with geared operators with their stems in a horizontal position.
   3. Install valves so that handles clear obstructions when the valves are operated from fully open to fully closed.

D. Place top of valve boxes flush with finished grade or as otherwise indicated on the Drawings.

E. Valves with threaded connections:
   1. Install valves by applying wrench on end of valve nearest the joint to prevent distortion of the valve body.
   2. Apply pipe joint compound or Teflon™ tape on external (male) threads to prevent forcing compound into valve seat area.

F. Valves with flanged connections:
   1. Align flanges and gasket carefully before tightening flange bolts.
   2. When flanges are aligned, install bolts and hand tighten.
   3. Tighten nuts opposite each other with equal tension before moving to next pair of nuts.

G. Valves with soldered connections:
   1. Do not overheat connection to prevent damage to resilient seats and metal seat rings.
   2. Position valves in full open position before starting soldering procedure.
   3. Apply heat to piping rather than to valve body.

3.03 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer's coating system and as specified in Section 09_96_01 - High-Performance Coatings:
   1. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
   2. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

3.04 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training and this Section.

B. Manufacturer services from each manufacturer for all valves supplied:
   1. Provide Manufacturer's Certificate of Source Testing.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance.

C. As specified elsewhere for specific valve types, sizes or actuators:
   1. Source testing.
   2. Manufacturers on site services for Owner Training, Installation Testing, Functional Testing, and during the Process Operational Period.

END OF SECTION

SECTION 40_05_52

SPECIALTY VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Specialty valves.

B. As specified in Section 40_05_51.01 - Common Work Results for Valves.

C. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Society of Civil Engineers (ASCE):
   1. 25 - Earthquake-Actuated Automatic Gas Shutoff Devices.

B. American Society of Mechanical Engineers (ASME):
   1. B16.42 - Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300.

C. American Water Works Association (AWWA):
   1. C511 - Standard for Reduced Pressure-Principle Backflow-Prevention Assembly.
   2. C800 - Underground Service Line Valves and Fittings (Also Included: Collected Standards For Service Line Materials).

D. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. A126 - Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
   3. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   4. A536 - Standard Specification for Ductile Iron Castings.
   5. B584 - Standard Specification for Copper Alloy Sand Castings for General Application.

E. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

F. City of Santa Cruz Water System Standard Specifications.

G. City of Santa Cruz Public Works Standards.

1.03 SUBMITTALS

A. Submit as specified in Section 01 33 00 - Submittal Procedures.

B. Product data: As specified in Section 40_05_51.01 - Common Work Results for Valves.

C. Commissioning submittals:
   1. Backflow preventer certification.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01 79 00 - Demonstration and Training.

1.04 WARRANTY

A. Provide warranty as specified in Section 01 78 36 - Warranties, except where specialty warranty requirements are otherwise indicated for products below.

PART 2 PRODUCTS

2.01 DOWNHOLE CONTROL VALVE (DHCV)

A. Manufacturers: One of the following or approved equal:
   1. Baski, Inc., Inflex FCV.

B. Special Warranty Requirements:
   1. Provide 5-year manufacturer warranty for DHCV.

C. Function: Alternately control the recharge flow rate into a well or allow a pump to discharge well water to the surface.

D. Design: DHCV shall be designed to eliminate cavitation and aeration in the column piping during recharge at the conditions indicated on Drawing 00G05 - Design Criteria. DHCV shall be capable of controlling the injection flow rate from zero to 125 percent of the target injection rate:
   1. Target injection rate: 375 gpm.
   2. DHCV design injection rate: 470 gpm.

E. Placement: Install DHCV as indicated on Drawing 00G05.

F. Materials:
   1. Valve body: Type 316 or 316L stainless steel.
   2. Nuts, bolts, washers, fittings, and appurtenant features: Type 316 or Duplex 2205 stainless steel.
   3. Size as indicated on Drawing 00G05 - Design Criteria.
   4. End connections: Match column piping as required.
   5. Reinforced natural rubber.
   6. Contractor shall notify the valve manufacturer of the following information from the approved column piping submittal:
      a. Column pipe thread type.
      b. Column pipe outside diameter (OD).

G. Equipment:
   1. The DHCV valve package shall include necessary actuating and operating equipment to permit throttling control over the entire range from zero to 125 percent of the target injection rate. Such equipment shall be located at the surface, as indicated on the Drawings, and be capable of being operated from the well head manually or automatically.
   2. Control lines:
      a. The DHCV shall include two control lines extending from the control panel to the ports on the top of the DHCV. Control lines shall be secured and protected at every coupling joint of the column pipe. Control lines shall be 1/4-inch OD Duplex 2205 stainless steel, tested to a minimum of 10,000 psi, or approved equal. Stainless steel banding, buckles and over-the-coupling-protectors shall provided for protecting the control lines at the couplings of the column pipe.
   3. Control panel with pressure transducer and nitrogen regulator:
      a. The DHCV shall be supplied with a control panel for manual or SCADA-controlled automatic operation. Control panel valves shall be brass, with soft seats for positive shutoff. Blocks shall be aluminum. Control panel valves, blocks and gauges shall be mounted to a NEMA back panel for attachment to an enclosure or wall. A gas silencer muffler shall be included to discharge nitrogen to a safe location. A Rosemount 3051T Pressure Transmitter with an LCD display shall be mounted on the control panel which shall display the inflation pressure of the DHCV. A nitrogen regulator capable of 450 psi delivery shall also be provided.
   4. DHCV manufacturer shall supply a fully functional nitrogen feed and regulating system including two fully charged nitrogen cylinders, in-place and operational, as part of the manufacturer's scope of services. Nitrogen cylinders shall be furnished to the City and may not be provided under a lease agreement:
      a. Provide two nitrogen cylinders, minimum.
      b. Nitrogen cylinders and controls shall be installed within separate locking enclosures mounted to supports on the MCC-8A concrete pad as indicated on Drawings 08C02 and 08M02.
         1) Nitrogen cylinder enclosure:
            a) Minimum dimensions: 32 x inches wide x 16 inches deep x 72 inches tall.
            b) 14-gauge minimum solid steel top.
            c) 13-gauge minimum steel mesh sides.
            d) All welded construction.
            e) In accordance with OSHA 1910.
            f) Manufacturer:
               (1) Airgas (City approved vendor).
         2) Controls enclosure:
            a) Minimum dimensions: 20 x inches wide x 8 inches deep x 30 inches tall.
            b) 14-gauge minimum solid steel top.
            c) 13-gauge minimum steel mesh sides.
            d) All welded construction.
            e) In accordance with OSHA 1910.
            f) Manufacturer:
               (1) Airgas (City approved vendor).

3) Secure nitrogen cylinder and controls enclosures to the building exterior per Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
4) Furnish two padlocks with identical key for enclosures.

2.02 FOOT VALVE (SUBMERSIBLE PUMP CHECK VALVE)

A. Manufacturers: One of the following or equal:
1. Flomatic, Series 80DIVFD.

B. Function: Prevent recharge water from reversing flow through the well pump and column piping.

C. Placement: Install as indicated on Drawing 00G05.

D. Materials:
1. Valve body: Ductile iron.
2. Valve Guide: Ductile iron.
3. Elastomer Disc: Buna-N.
4. Lead-free certification (NSF/ANSI 61/372).
5. Size as indicated on Drawing 00G05.

2.03 BACKFLOW PREVENTERS

A. Manufacturers: One of the following or equal:
1. Zurn/Wilkins:
a. Model 975XL for 1/2-inch through 2-inch.
b. Model 375AST for sizes 2 1/2 inch, 3 inch, 8 inch, and 10 inch.
c. Model 375 and 375DA for sizes 4 inch and 6 inch.

B. Design: Reduced pressure chamber type in accordance with AWWA C511 and City of Santa Cruz Water Department Standard Specifications and Public Works Standards.

C. Include shutoff valves at each end of backflow preventer with properly located test cocks.

D. Shutoff valves:
1. Backflow preventers 2-inch and smaller: Provide with full-port, quarter turn, resilient seated ball valves.
2. Backflow preventers larger than 2-inch: Provide with resilient seated, outside stem and yoke gate valves.

2.04 SOLENOID VALVES

A. 2-way solenoid valves:
1. Manufacturers: One of the following or equal:
a. ASCO, Series 8210 “Red Hat”:
1) Contractor shall provide external bypass to solenoid valve. External bypass shall use pipe of same material and size as main line and include a ball valve for manual operation.

B. 3-way solenoid valves:
   1. Manufacturers: One of the following or equal:
      a. ASCO, Series 8320 “Red Hat”.

C. 4-way solenoid valves:
   1. Manufacturers: One of the following or equal:
      a. ASCO, Bulletin 8344 “Red Hat”.

D. Design:
   1. Valves: Suitable for service under the following conditions:
      a. Fluid drinking water.
      b. Temperature of fluid: 90 degrees Fahrenheit.
      c. Piping test pressure: 150 pounds per square inch gauge.
   2. Unless otherwise indicated on the Drawings, provide valves that meet the following requirements:
      a. Minimum NEMA Type 4 enclosure.
      b. 120 VAC operation.
      c. Suitable for use as indicated on the Drawings and specifications.
      d. Minimum Class F coil insulation.
   3. 2-way valves: Furnish with openings of size equal to or larger than the nominal size designation of the valve.
   4. Furnish with manual/bypass operators.

E. Materials:
   1. Body: Brass or bronze.
   2. Seats: Resilient material.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install as specified in Section 40_05_51.01 - Common Work Results for Valves in accordance with manufacturer's published instructions.

B. Install with a minimum clearance of 12 inches and with maximum clearance of 30 inches between the relief port and the floor or finished grade or top of containment wall.

C. Downhole control valve:
   1. Installation of the DHCV shall be completed in accordance with the manufacturer's recommendations.

D. Backflow preventers:
   1. Install with a minimum clearance of 12 inches and with maximum clearance of 30 inches between the relief port and the floor or finished grade or top of containment wall.
   2. Install with sufficient side clearance for access for testing and maintenance.

3.02 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer's Certificate of Installation and Functionality Compliance.
   2. Manufacturer's Representative onsite requirements:
      a. DHCV:
         1) Installation: 1 trip, 1 day minimum each trip.
         2) Startup, testing, and training: 1 trip, 1 day minimum each trip.

C. Functional testing:
   1. Backflow preventer:
      a. Test witnessing: Witnessed.
      b. Conduct pressure and leak test as specified in Section 40_05_51.01 - Common Work Results for Valves.
      c. Backflow preventer certification.

END OF SECTION

SECTION 40_05_57.24

ELECTRIC ACTUATORS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Electric motor-driven actuators for valves and gates.

B. Equipment tag numbers:
   1. As scheduled.

C. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C504 - Standard for Rubber-Seated Butterfly Valves.
   2. C542 - Standard for Electric Motor Actuators for Valves and Slide Gates.

B. International Organization for Standardization (ISO):
   1. 12944 - Paints and Varnishes.

C. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

1.03 SUBMITTALS

A. Submit as specified in Section 01 33 00 - Submittal Procedures and Section 01 61 00 - Common Product Requirements.

B. Provide a complete list/schedule of actuators being provided with their associated tag names, as indicated on the Drawings and/or Specifications, service process area and the size of the valve they are actuating.

C. Product data:
   1. Electrical ratings:
      a. Voltage and number of phases.
      b. Starting and running current.
      c. Voltage levels and source for control and status.
   2. Description of integral control interface.
   3. Remote control station components (If applicable).

4. Environmental ratings, including NEMA enclosure rating and submergence capabilities.
5. Gear ratios for both manual and motorized actuation.
6. Opening and closing directions.
7. Electric motor data.
8. Allowable starts per hour.
9. List of included options and accessories.
10. Full travel times.
11. Gearbox data, including gear ratio, and gearbox efficiency.

D. Shop Drawings:
   1. Wiring diagrams:
      a. Include options and expansion cards furnished with each actuator.
   2. Dimensioned drawings of each valve and actuator combination.
   3. Dimensioned drawings of each valve gearbox.

E. Calculations:
   1. Operating torque.
   2. Maximum torque calculations for seating and unseating.
   3. Maximum operating torque at starting and normal operation.

F. Installation instructions:
   1. Detail the complete installation of the equipment, including rigging, moving, and setting into place.
   2. Provide manufacturer's installation instructions.

G. Quality Control Submittals:
   1. Manufacturer's representative qualifications.
   2. Manufacturer's Certificate of Source Testing as specified in Section 01 79 00 - Demonstration and Training.
   3. Manufacturer's Certificate of Installation as specified in Section 01 79 00 - Demonstration and Training.
   4. Manufacturer's Certificate of Functional Compliance as specified in Section 01 79 00 - Demonstration and Training.

H. Owner Training Submittals:
   1. As specified in Section 01 79 00 - Demonstration and Training.

I. Operation and maintenance manuals:
   1. As specified in Section 01 78 23 - Operation and Maintenance Data.
   2. Include a list of configurable parameters and the final values for each.
   3. Include a troubleshooting chart covering the complete valve and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.

1.04 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01 61 00 - Common Product Requirements, Section 46_05_10 - Common Work Results for Mechanical, and the manufacturer's instructions.

1.05 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.06 MAINTENANCE

A. As specified in Section 01 61 00 - Common Product Requirements.

B. Spare parts:
   1. Provide the following (minimum 10 percent of total number of actuators of each model type furnished, but not less than 1 for each model of actuator furnished):
      a. Stem nut.
      b. Worm shaft subassembly.
      c. Drive sleeve subassembly.
      d. Complete actuator seal kit.
      e. Actuator gearbox oil (sufficient quantity to fill 4 gearboxes).
      f. Encoder.
      g. Control module.

C. Setting tool:
   1. If required for setting or configuring the actuator, provide a handheld setting tool:
      a. Furnish 1 setting tool for every 10 actuators.

1.07 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Lines 3 inches and smaller:
   1. The following or equal:
      a. Rotork Controls Inc.

B. Lines 4 inches and larger:
   1. One of the following, or equal: Rotork Controls Inc. IQ3 Range:
      a. IQ for multi-turn applications.
      b. IQT for quarter-turn applications.

2.02 MATERIALS

A. Enclosures:
   1. Constructed of materials suitable for the environment where the actuator will be installed.
   2. Stainless steel external fasteners.
   3. Provide O-ring seals for each of the following areas:
      a. Between the terminal compartment and the internal electrical elements.

b. Between the mechanical and electrical portions to protect from the ingress of oil, and to protect the mechanical components of oil from dust and moisture when the electrical terminal is open.

4. Ratings:
   a. As scheduled and specified:
      1) NEMA Type 6P: Double sealed and IP68 rated for prolonged submergence.
      2) XP: Factory Mutal (FM) approved for Class I, Division 1 and Division 2 locations.

B. Coatings:
   1. Material requirements:
      a. Factory prime and coat with an ISO 12944 classification coating of C5M (Marine, offshore estuaries with high salinity) coating with 15 year durability.
      b. Touch-up damaged coatings with manufacturer provided coating repair kit.
   2. Application requirements:
      a. Painting shall commence within 4 hours of blast cleaning.
      b. Each paint coat within the system is to be applied in accordance with the paint manufacturer's instructions.
      c. Paint thickness shall be checked for each coat on each actuator.
   3. Qualification requirements:
      a. Operators shall be experienced and proficient in surface preparation and coating application techniques.
      b. Personnel shall have relevant knowledge of health and safety hazard, use of protective equipment, coating materials, mixing and thinning coatings, coating pot life, surface requirements, etc.
      c. Personnel carrying out inspection or verification shall be certified as NACE coating inspector or equivalent such as ICorr.

2.03 CHARACTERISTICS FOR ACTUATORS ON LINES 3 INCHES AND SMALLER

A. Actuators for valves 3 inches and smaller:
   1. Complete and operable with all components and accessories required for operation.
   2. Power supply:
      a. Valve motion independent of power supply phase rotation.
      b. As indicated on the Drawings.
   3. Size actuator to move valves from full open to closed position within the time indicated in the Actuator Schedule:
      a. If an operating time is not indicated on the Actuator Schedule, size the actuator to move valves at minimum 12 inches per minute under maximum load. Measure closure rate for valves at the maximum diameter of disc, plug, or ball.
   4. For outdoor or vault installations, provide an integral anti-condensation heater when available as an option.
   5. Control inputs:
      a. Capable of using discrete dry contacts.
      b. Controls the valve when local-stop-remote is in REMOTE.
      c. Material: Type 316 stainless steel.

d. Provide the following inputs at the actuator:
    1) OPEN.
    2) CLOSE.

6. Status outputs:
    a. Dry contact outputs configured for the functions indicated on the Drawings. Provide the following outputs for all actuators:
        1) FULLY CLOSED.
        2) FULLY OPEN.
        3) REMOTE.
    b. Output contacts rated for 5 amps, 120 VAC.
7. Analog input:
    a. Provide a 4 to 20 analog input for analog modulating valves when indicated on the Drawings.
    b. Modulate valve to maintain position based on analog input value.
    c. Maximum input impedance 250 ohms.
8. Analog output:
    a. Provide an isolated 4 to 20 mA analog output when indicated on the Drawings.
9. Components:
    a. Motors:
        1) Torque ratings equal to or greater than that required for valve seating and dynamic torques with a 25 percent factor of safety.
        2) Rated for operating under the following conditions without exceeding temperature limits with ambient temperature of 40 degrees Celsius:
            a) Continuous operation for 15 minutes or twice the open-to-close operating time (whichever is greater) at normal operating torque or 33 percent of maximum torque (whichever is greater).
            b) 60 starts per hour minimum for open/close service.
    b. Manual actuation:
        1) Handwheel for manual operation.
    c. Gearing: Self-locking, high-alloy steel gears.
10. Communication options:
    a. As specified in the Contract Documents.

2.04 CHARACTERISTICS FOR ACTUATORS ON LINES 4 INCHES AND LARGER

A. Provide actuators complete and operable with all components and accessories required for operation.

B. Power supply:
    1. Voltage and phases as indicated in the Actuator Schedule.
    2. Valve or gate motion independent of power supply phase rotation.
    3. Provide an internal backup power source or mechanical indicator to maintain settings and track valve position when main power is off.
    4. Actuators shall incorporate major components such as the motor, starter, local controls, terminals, etc., housed within a self-contained, sealed enclosure.

C. Size actuator to move gates or valves from full open to closed position within the time indicated in the Actuator Schedule:
    1. If an operating time is not indicated on the Actuator Schedule, size the actuator to move gates or valves at minimum 12 inches per minute under

maximum load. Measure rate of closure for valves at maximum diameter of disc, plug, or ball.

2. Size actuators so that gear boxes are not required where possible.

D. Control interface:
   1. Configuration:
      a. Provide a non-intrusive, non-contacting interface for configuring input and output settings, control values, ranges, torque switch settings, valve positions switch settings, and options:
         1) Configurable from a handheld configuring tool or input devices on the actuator.
   2. Local interface, integral to actuator:
      a. Non-intrusive, non-contacting selector switches:
         1) LOCAL-STOP-REMOTE:
            a) Motor actuator operation is prevented with the switch in STOP.
         2) OPEN-CLOSE:
            a) Controls the valve when LOCAL-STOP-REMOTE is in LOCAL.
            b) Spring return to center.
            c) Configurable between maintained (actuator runs until end of travel, high torque, or a LOCAL-STOP-REMOTE is switched to STOP) and momentary (actuator stops when lever is released).
      b. Local display:
         1) Valve fully open and fully closed indicators.
         2) Numerical display showing actual valve or gate position in percent of travel.
   3. Control inputs:
      a. Capable of using discrete 24 VDC or 120 VAC as indicated on Drawings.
      b. Controls the valve when LOCAL-STOP-REMOTE is in REMOTE.
      c. Isolated inputs capable of operating from external control voltage source or internal power supply:
      d. Provide the following inputs:
         1) OPEN.
         2) CLOSE.
         3) STOP.
      e. OPEN and CLOSE inputs configurable between maintained (actuator runs until end of travel, high torque, or a STOP input) and momentary (actuator stops when command is removed).
   4. Status outputs:
      a. Monitor relay output: Dry contact, normally closed, opens when actuator is not in REMOTE or in the event of any internal fault or alarm condition.
      b. Dry contact outputs configured for the functions indicated on the Drawings. Provide the following outputs for all actuators:
         1) Fully closed.
         2) Fully open.
         3) LOCAL-STOP-REMOTE in REMOTE position.
      c. Contacts and communications:
         1) As specified in the Contract Documents.
         2) Dry contacts rated for both 120 VAC and 24 VDC.
      d. Analog input:
         1) 4-20 mA analog input for analog modulating valves when indicated on the Drawings.

e. Analog output:
1) Isolated 4-20 mA analog output when indicated on the Drawings:
a) Loop power sourced from the actuator power supply.
b) Output proportional to process value(s) indicated on the Drawings.

E. Features:
1. Time delay on reversal: Incorporate time delay between stopping actuator and starting in opposite direction to limit excessive current, torque, and heating from instantaneous reversal.
2. Data logging:
a. Store diagnostic data and reference data.
b. Time-stamped historical operating data, including number of operations.
3. Provide display of logged data on the actuator, or provisions to download to a personal computer.

F. Components:
1. Motors:
a. Specifically designed for valve actuator service with high starting torque, totally enclosed non-ventilated construction.
b. Torque ratings equal to or greater than that required for valve seating and dynamic torques with a 25 percent factor of safety:
1) Design requirements for rubber-seated AWWA butterfly valves:
a) Design actuators for maximum gate or valve operating torque, in accordance with and using safety factors required in AWWA C504 and AWWA C542:
(1) Valve actuator torque requirement for open-close service: Not less than the required valve-seating and dynamic torques under design operating conditions in accordance with AWWA C504.
(2) Valve actuator torque requirement for modulating service: Not less than twice the required valve dynamic torque under design operating conditions in accordance with AWWA C504.
2) Design requirements for slide gates, gate valves, knife gate valves, globe valves, and diaphragm valves:
a) Design valves and actuators for maximum operating torque in accordance with and using safety factors required in AWWA C542.
b) Design for the maximum torque and thrust running load over the full cycle.
c) Maximum torque or thrust rating: Actuator stall torque or maximum thrust output shall not exceed the torque or thrust capability of the valve or gate, as determined by the valve or gate manufacturer.
c. Capable of being removed and replaced without draining the actuator gear case.
d. Motor bearings shall be amply proportioned of the anti-friction type and permanently lubricated.

e. Rated for operating under the following conditions without exceeding temperature limits with ambient temperature of 40 degrees Celsius:
    1) Continuous operation for 15 minutes or twice the open-to-close operating time (whichever is greater) at normal operating torque or 33 percent of maximum torque (whichever is greater).
    2) 60 starts per hour for open/close service or 1,200 starts per hour for modulating service.
f. Provide the following motor protection features:
    1) Jammed valve (no valve motion detected through a time delay).
    2) High motor temperature (sensed by an embedded thermostats).
    3) High torque.
    4) Single phasing protection.

G. Position sensing:
1. Electronic and adjustable using a solid-state encoder wheel:
    a. Mechanical limit switches and potentiometers are not acceptable.
2. Capable of retaining position and monitoring valve or gate motion when valve is manually actuated and when main power is not present.
3. Valve range and position switch outputs field adjustable.

H. Torque sensing:
1. Torque shutdown setting: 40 percent to 100 percent rated torque:
    a. Adjustable in 1 percent increments.
2. Torque display: 0 to 100 percent-rated torque.
3. Capable of interrupting control circuits during both opening and closing and when valve torque overload occurs.
4. Electrical or electronic torque sensing.
5. Independent of variations in frequency, voltage, or temperature.
6. Actuator shall store actual operational torque curves for retrieval by plant maintenance staff.
7. Provide a temporary inhibit of the torque sensing system during unseating or during starting in mid-travel against high inertia loads.
8. Provide visible verification of torque switch status without any housing disassembly.

I. Manual actuators:
1. Hand wheel for manual operation:
    a. Maximum 80-pound pull on rim when operating gate or valve under maximum load.
    b. Provide pull chain when motorized actuator is located more than 6 feet above floor surface:
        1) Chain shall be of sufficient length to reach approximately 4 feet above the operating level.
        2) Where the chain obstructs an aisle or walkway, provide holdback or other means to ensure chain does not create a nuisance or hazard to operating personnel.
        3) Provide Type 316 stainless steel.
2. Declutch lever: Padlockable, capable of mechanically disengaging motor and related gearing and freeing hand wheel for manual operation.

J. Gearing: Hardened alloy steel spur or helical gears and self-locking, alloy bronze worm gear set:
   1. Accurately cut to ensure minimum backlash.

K. Bearings:
   1. Anti-friction bearing with caged balls or rollers throughout.
   2. Sealed-for-life type thrust bearings housed in a separate thrust base.

L. Drive bushing:
   1. Easily detachable for machining to suit the valve stem or gearbox input shaft.
   2. Positioned in a detachable base of the actuator.

M. Lubrication:
   1. Provide totally enclosed actuator gearing with oil or grease filled gear case suitable for operation at any angle.
   2. Actuators requiring special or exotic lubricants are not acceptable.

2.05 ACCESSORIES

A. Software:
   1. Furnish PC-based diagnostic and configuration software to display diagnostic data and configure actuators.
   2. Provide software communications to the valve actuator and handheld setting tool:
      a. Provide accessories and drivers required for operation and communications with a standard personal computer running Microsoft Windows.

B. Termination module cover:
   1. For actuators on a valve network, provide a means to keep the valve network in service, in the event where the actuator must be removed.
   2. Provide sunshades for outdoor installations of remote-control stations that use an LCD or similar screen. Regular pushbutton, sector switches, and pilot light control stations will not require a sunshade.

2.06 SOURCE QUALITY CONTROL

A. Source Testing:
   1. Design and performance test reports in accordance with AWWA C542.
   2. Test each actuator with a simulated load:
      a. Simulate a typical valve load.
   3. Furnish test reports and the Manufacturer’s Certificate of Source Testing.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.

B. Install the equipment in accordance with the manufacturer’s instructions.

C. Position visual indicators so that they are most easily visible.

D. Installation Verification:
   1. Furnish Manufacturer's Certificate of Installation Verification.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 01 79 00 - Demonstration and Training, Section 46_05_94 - Mechanical Equipment Testing, and this Section.

B. Functional Testing:
   1. Installed actuator:
      a. Test witnessing: Witnessed.
      b. Conduct Level 2 General Equipment Performance Tests.
      c. Conduct Level 2 Vibration Tests.
      d. Conduct Level 2 Noise Tests.
   2. Electrical Instrumentation and Controls:
      a. Test witnessing: Witnessed.
      b. Conduct testing as specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.
   3. Furnish test reports and the Manufacturer's Certificate of Functional Compliance.

3.03 OWNER TRAINING

A. Perform Owner Training as specified in Section 01 79 00 - Demonstration and Training:
   1. Number of sessions:
      a. Operations: 1.
      b. Maintenance: 1.

3.04 ACTUATOR SCHEDULE

A. Provide actuators indicated on the Drawings:
   1. Major process actuators are listed in the Actuator Schedule shown in Attachment A - Actuator Schedule. Other actuators are as indicated on the Drawings.
      a. Attachment A - Actuator Schedule does not include all number and types of actuators required for the Project.

END OF SECTION

ATTACHMENT A - ACTUATOR SCHEDULE

ACTUATOR SCHEDULE

Item	Reference DWG	Type	Size	Duty	NEMA Rating	Voltage/ Phase/Hz	Notes	Service	Controls
BFV-9905050	08M02	BFV	2”	STD	4X	120/1/60 Hz	-	O/C	D
BFV-9905020	08M02	BFV	6”	STD	4X	120/1/60 Hz	-	O/C	D
BFV-9905110	08M02	BFV	6”	MOD	4X	120/1/60 Hz	-	CTRL	A
BFV-9905030	08M02	BFV	6”	STD	4X	120/1/60 Hz	-	O/C	D

Notes:
(1) Provide actuators with remote control station.
(2) New motorized actuator to be installed on existing equipment. Field verify characteristics prior to sizing motor actuator.

Abbreviations:

Type:
BFV = Butterfly Valve.
BV = Ball Valve.
PV = Plug Valve.
SG = Slide Gate.

NEMA Rating:
4X for general locations.
6P for vaults and possible submergence.
XP for Class I, Division 1 and Division 2 locations.

Controls:
A = Analog.
D = Discrete.
DP = Profibus DP.
E-IP = Ethernet/IP.

Duty:
MD = Modulating duty (~1,200 starts/hr).
MOD = Modulating.
STD = Standard service (0-60 starts/hr) duty.

Service:
CTRL = Control.
O/C = Open/Close.

E-TCP = Ethernet TCP or TCP/IP.
FF = Foundation Fieldbus H1.
MB = Modbus RTU (RS-485).
NET = Manufacturer’s proprietary network.
PA = Profibus PA.

SECTION 40_05_63

BALL VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Ball valves.

B. As specified in Section 40_05_51.01 - Common Work Results for Valves.

C. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.

B. American Water Works Association (AWWA):
   1. C507 - Standard for Ball Valves 6 Inch Through 48 Inch.

C. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. A216 - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
   3. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.

D. NSF International (NSF):
   1. Standard 61 - Drinking Water System Components - Health Effects.

1.03 SUBMITTALS

A. Submit as specified in Section 01 33 00 - Submittal Procedures.

B. Product data: As specified in Section 40_05_51.01 - Common Work Results for Valves:
   1. Metal body ball valves: 6 inches and larger only: Submit affidavit of compliance in accordance with AWWA C507.
   2. Operation and maintenance manual.

C. Commissioning submittals:
   1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01 79 00 - Demonstration and Training.

1.04 WARRANTY

A. Provide warranty as specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. General: Unless otherwise indicated on the Drawings or specifications use:
   1. Metal body ball valves on metallic pipelines.
   2. Plastic body ball valves on plastic pipelines.

B. Do not use metal body ball valves in sodium hypochlorite or sodium bisulfite systems.

2.02 METAL BODY BALL VALVES – FULL PORT (BAV00)

A. Metal body ball valves, less than 6-inch size:
   1. Manufacturers: One of the following, or equal:
      a. Conbraco Industries, Inc., Apollo Valves.
      b. NIBCO, Inc.
   2. General:
      a. Type: Non-lubricated, full port and capable of sealing in either direction.
      b. End connections:
         1) Threaded or solder ends for sizes 3-inch and smaller.
         2) Class 150 flanged for sizes larger than 3 inches:
            a) Flanges: In accordance with ASME B16.1 standards.
      c. Stem packing: Manually adjustable while valve is under pressure.
      d. Shafts:
         1) Rigidly connected to the ball by a positive means:
            a) Design connection to transmit torque equivalent to at least 75 percent of the torsional strength of the shaft.
      e. Handles: Stainless steel latch lock handle with vinyl grip and stainless steel nut designed to open and close the valve under operating conditions.
      f. Temperature limits: Suitable for operation between minus 20 and 350 degrees Fahrenheit.
   3. Materials:
      a. Valves in copper lines: Bronze body.
      b. Valves in steel and ductile iron piping: Ductile iron or cast steel body.
      c. Valves in stainless steel piping: Stainless steel body, material type to match piping material as specified in Section 40_05_00.01 - Common Work Results for General Piping.
      d. Ball: Type 304 or 316 stainless steel.
      e. Seats: PTFE.
      f. Stem seals: PTFE or Viton™.

g. Bearings: Self-lubricated, corrosion resistant material that will not contaminate potable water.

4. Venting requirements:
   a. Metal ball valves for hydrogen peroxide service:
      1) Provide valve with factory drilled 0.125-inch hole in the upstream side of the ball.
      2) Provide an engraved Type 316 stainless steel tag permanently attached to the valve stem stating, “One side of ball drilled for hydrogen peroxide service.”

2.03 PLASTIC BODY BALL VALVES – FULL PORT (BAV40)

A. Manufacturers: One of the following or equal:
   1. Asahi America.
   2. Chemtrol Division, NIBCO, Inc.

B. General:
   1. Type: Non-lubricated and capable of sealing in either flow direction.
   2. End connections:
      a. 4 inches and smaller size: Socket end true unions for solvent welded connection to adjacent piping.
      b. 6-inch size: Socket end true unions with attached flanges for flanged connection to adjacent piping.
   3. All valves shall have integral ISO 5211 mounting pad for actuator installation.
   4. All valves shall have integral plate for lock-out/tag-out.
   5. Stem: Double O-ring seal with shear point above seal.
   6. Pressure rating: Suitable for the test pressure and maximum temperature of the corresponding piping system listed in the Piping Schedule.

C. Materials:
   1. Body and ball:
      a. PVC piping systems: PVC.
      b. CPVC piping systems: CPVC.
   2. Seats: PTFE (Teflon™).
   3. O-rings: Match gasket material of corresponding piping system listed in the Piping Schedule.

D. Limit switches, when indicated on the Drawings and specifications:
   1. Mechanical cam type with watertight enclosure and suited for remote indication of valve open-close status.
   2. Mount on valve actuator.
   3. Contacts: 120-volt alternating current, 20 amperes at 75 to 100 percent power factor and 24-volt direct current, 5 amperes minimum.

E. Valve actuator:
   1. Valves shall be quarter turn operated with valve seat adjustability.
   2. Manually operated valves: Lever.
   3. Electric motor operated valves, when indicated on the Drawings and specifications: Provide electric motor operator as specified in Section 40_05_57.24 - Electric Actuators.

F. Venting requirements:
    1. PVC and CPVC ball valves for hypochlorite service:
        a. Provide valve with factory drilled 0.125-inch hole in the upstream side of the ball.
        b. Provide an engraved plastic tag permanently attached to the valve stem stating, “One side of ball drilled for hypochlorite service.”
        c. Provide an arrow inscribed on the valve body to indicate direction of flow.

2.04 PLASTIC BODY BALL VALVES – V-PORT (BAV50)

A. Provide proportional flow control (“V-port”) ball valve when indicated on the Drawings and specifications.

B. Manufacturer and model shall be the following or equal:
    1. Hayward Flow Control CVH Series.

PART 3 EXECUTION

3.01 INSTALLATION

A. General: Install each type of valve in accordance with manufacturers’ printed instructions.

3.02 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training and this Section.

B. Manufacturer services:
    1. Provide certificates:
        a. Manufacturer’s Certificate of Installation and Functionality Compliance.

C. Functional testing:
    1. Valves:
        a. Test witnessing: Witnessed.
        b. Conduct pressure and leak test, as specified in Section 40_05_00.09 - Piping Systems Testing.

END OF SECTION

SECTION 40_05_64

BUTTERFLY VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Butterfly valves:
      a. As specified in Section 40_05_51.01 - Common Work Results for Valves.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Classes 25, 125, and 250.
   2. B16.5 - Pipe Flanges and Flanged Fittings, NPS 1/2 through NPS 24.

B. American Water Works Association (AWWA):
   1. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
   2. C504 - Rubber-Seated Butterfly Valves.
   3. C540 - Standard for Power-Actuating Devices for Valves and Sluice Gates.
   4. C550 - Protective Interior Coatings for Valves and Hydrants.
   5. C606 - Standard for Grooved and Shouldered Joints.

C. ASTM International (ASTM):
   1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A216 - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for Higher-Temperature Service.
   3. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   4. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
   5. A395 - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
   6. A479 - Standard Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels.
   7. A515 - Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate - and Higher-Temperature Service.
   8. A516 - Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate - and Lower-Temperature Service.

9. A536 - Standard Specification for Ductile Iron Castings.
10. A564 - Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes.
11. A743 - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
12. A890 - Standard Specification for Castings, Iron-Chromium-Nickel-Molybdenum Corrosion-Resistant, Duplex (Austenitic/Ferritic) for General Application.
13. B462 - Standard Specification for Forged or Rolled UNS N06030, UNS N06022, UNS N06035, UNS N06200, UNS N06059, UNS N10362, UNS N06686, UNS N08020, UNS N08024, UNS N08026, UNS N08367, UNS N10276, UNS N10665, UNS N10675, UNS N10629, UNS N08031, UNS N06045, UNS N06025, UNS R20033 Alloy Pipe Flanges, Forged Fittings, and Valves and Parts for Corrosive High-Temperature Service.
14. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
15. B691 - Standard Specification for Iron-Nickel-Chromium-Molybdenum Alloys (UNS N08366 and UNS N08367) Rod, Bar, and Wire.
16. D429 - Standard Test Methods for Rubber Property-Adhesion to Rigid Substrate.

D. NSF International (NSF):
   1. Standard 61 - Drinking Water System Components - Health Effects.

E. United States Code of Federal Regulations (CFR):
   1. 21 - Food and Drugs.

1.03 SUBMITTALS

A. Submit as specified in Section 01 33 00 - Submittal Procedures.

B. Product data: As specified in Section 40_05_51.01 - Common Work Results for Valves:
   1. For general purpose AWWA butterfly valves, include description of the method of attachment of the disc edge to the valve disc.
   2. Interior epoxy coatings: Affidavit of compliance attesting that epoxy coatings applied to interior surfaces of butterfly valves comply with all provisions in accordance with AWWA C550.
   3. Certification, for valves and coatings in contact with potable water, that the products used are suitable for contact with drinking water in accordance with NSF Standard 61.

C. Commissioning Submittals:
   1. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01 79 00 - Demonstration and Training.

1.04 WARRANTY

A. Provide warranty as specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Design requirements:
   1. Valve pressure rating shall be greater than or equal to the piping system test pressure specified in the Piping Schedule at the maximum service temperature.
   2. General purpose AWWA butterfly valves:
      a. Design standard: Provide valves designed and manufactured in accordance with AWWA C504.
      b. Class:
         1) Provide butterfly valves in accordance with AWWA Class 150B, unless otherwise specified.
         2) Provide butterfly valves in accordance with AWWA Class 250B in piping systems with test pressure greater than 150 pounds per square inch gauge and less than 250 pounds per square inch gauge.
   3. High pressure butterfly valves.
   4. Piping systems designed for test pressures greater than 250 pounds per square inch gauge and less than 500 pounds per square inch gauge: Provide ASME B16.5, Class 300 flanged high pressure valves.
   5. Industrial class butterfly valves:
      a. Industrial class butterfly valves capable of 150 pounds per square inch gauge leak tight shut off.
   6. Stainless steel butterfly valves:
      a. Stainless steel butterfly valves capable of a minimum of 100 pounds per square inch gauge leak tight shut off and with special cleaning, packaging, and handling.

B. Usage:
   1. Provide and install butterfly valve types as outlined in the Butterfly Valve Application Schedule at the end of this Section.

C. Design requirements for butterfly valves with power actuating devices:
   1. Design valves and actuators for maximum operating torque, in accordance with and using safety factors required in AWWA C540, using the following values:
      a. Maximum water velocity: 16 feet per second with valve fully open.
      b. Maximum pressure differential across the closed valve equal to the pressure class designation.
      c. Coefficient for seating and unseating torque, dynamic torque, and bearing friction in accordance with valve manufacturer's published recommendations.
   2. Valve disc: Seat in an angular position of 90 degrees to the pipe axis and rotate an angle of 90 degrees between fully open and fully closed positions:
      a. Do not supply valves with stops or lugs cast with or mechanically secured to the body of the valve for limiting the disc travel.
   3. Unacceptable thrust bearings: Do not provide valves with thrust bearings exposed to the fluid in the line and consisting of a metal bearing surface in rubbing contact with an opposing metal bearing surface.

D. Performance requirements:
   1. Tight shutoff at the pressure rating of the valve with pressure applied in either direction.
   2. Suitable for the following service conditions:
      a. Throttling.
      b. Frequent operation.
      c. Operation after long periods of inactivity.
      d. Installation in any position and flow in either direction.

2.02 GENERAL PURPOSE AWWA BUTTERFLY VALVES (BFV00)

A. Manufacturers: One of the following or equal:
   1. DeZURIK/Sartell Model BAW.
   2. Mueller/Pratt Co.
   3. Clow.

B. Valve body:
   1. Material: Cast iron, ASTM A126, Grade B, or ductile iron, ASTM A536, Grade 65-45-12.
   2. Body design:
      a. Flanged body valves:
         1) Usage: Comply with limitations specified in the Butterfly Valve Application Schedule.
         2) Flanges: In accordance with ASME B16.1 Class 125 flanges for Class 150B valves, in accordance with ASME B16.1 Class 250 flanges for Class 250B valves.
      b. Mechanical joint body valves:
         1) Usage: Comply with limitations specified in the Butterfly Valve Application Schedule.
         2) Mechanical joint design: In accordance with AWWA C110.
         3) When mechanical joint body valves are used, incorporate valve into thrust restraint analysis as specified in Section 40_05_19.01 - Ductile Iron Pipe: AWWA C151:
            a) Utilize test pressure on 1 side of valve and zero pressure on the opposite side of the valve.
            b) Restrain pipe joints on both sides of valve as determined by thrust analysis calculations.
      c. Grooved end body valves:
         1) Usage: Butterfly valves with grooved ends may be used in piping systems specified in the Piping Schedule to have grooved end joints. Comply with additional limitations specified in the Butterfly Valve Application Schedule.
         2) Grooved end joint design: In accordance with AWWA C606.

C. Disc:
   1. Material: Cast iron or ductile iron with Type316 stainless steel edge that matches seat in valve body.
   2. Secure valve disc to shaft by means of smooth-sided, taper or dowel pins, Type 316 stainless steel, or Monel.
   3. Extend pins through shaft and mechanically secure in place.

D. Shaft and bearings:
   1. Shaft design:
      a. Valves 20-inches and less: 1-piece, through disc design.
      b. Valves greater than 20-inch size: 2-piece, stub shaft design.
   2. Shaft seal: Vee type, chevron design.
   3. Shaft material for Class 150B valves: Type 316 stainless steel, ASTM A276.
   4. Shaft material for Class 250B valves: Type 17-4 pH stainless steel, ASTM A564.
   5. Shaft bearings: Self-lubricating sleeve type:
      a. Valves 20 inches and less: Nylatron.
      b. Valves greater than 20-inch size: Teflon™ with stainless steel or fiberglass backing.

E. Seats:
   1. Seat materials: EPDM.
   2. For valves 20 inches in nominal size and smaller, bond or vulcanize seat into the valve body.
   3. For valves 24 inches in nominal size and larger, retain seats mechanically or by adhesive:
      a. Mechanical retainage: Retain seat by a clamping ring with segmented clamping ring locks with adjusting locking screws:
         1) Clamping ring, ring locks, and adjusting locking screws: Type 316 stainless steel.
         2) Provide means to prevent ring locks and screws used to retain seats from loosening due to vibration or cavitation.
      b. Adhesive retainage: Inset the seat within a groove in the valve body and retain in place with epoxy injected behind the seat so that the seat expands into the body.
      c. Do not provide valves with seats retained by snap rings or spring-loaded retainer rings.
   4. Resilient seat: Withstand 75 pounds per inch pull when tested in accordance with ASTM D429, Method B.

F. Valve packing:
   1. Valves 4 to 48 inches nominal size: Self-adjusting V-type packing or chevron-type packing. NBR or EPDM to match seat material.
   2. Valves 54 inches nominal size and larger: Adjustable V-type packing with bronze packing gland or self-adjusting V-type packing. NBR or EPDM to match seat material.

2.03 COATING REQUIREMENTS FOR METAL VALVES

A. Shop coat interior and exterior metal surfaces of valves, except as follows:
   1. Interior machined surfaces.
   2. Surfaces of gaskets and elastomeric seats and stem seals.
   3. Bearing surfaces.
   4. Stainless steel surfaces and components.

B. Coating material for components in contact with potable water applications:
   1. Formulate interior coating material from materials in accordance with CFR 21, AWWA C550, and NSF 61.
   2. Submit affidavit of compliance attesting that epoxy coatings applied to interior surfaces of butterfly valves in accordance with CFR 21, AWWA C550, and NSF 61.

C. Interior surfaces:
   1. Interior surfaces, except for valves used in low-pressure air service: High solids epoxy as specified in Section 09_96_01 - High-Performance Coatings, Attachment A - Coating Schedule.
   2. Interior surfaces of valves used in low-pressure air service: High temperature coating for range of 150 to 350 degrees Fahrenheit as specified in Section 09_96_01 - High-Performance Coatings, Attachment A - Coating Schedule.

D. Exterior surfaces:
   1. Exterior surfaces of valves, actuators, and accessories coating as specified in Section 09_96_01 - High-Performance Coatings, Attachment A - Coating Schedule for the following conditions:
      a. Above ground, exposed: High solids epoxy with polyurethane topcoat.
   2. Polished and machined surfaces: Apply rust-preventive compound:
      a. Manufacturers: One of the following or equal:
         1) Houghton, Rust Veto 344.
         2) Rust-Oleum, R-9.

E. Field applied coatings of valve exterior:
   1. Match color and be compatible with manufacturer's coating system and as specified in Section 09_96_01 - High-Performance Coatings:
      a. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
      b. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install valves with valve shafts horizontal, unless a vertical shaft is required to suit a particular installation, and unless a vertical shaft is indicated on the Drawings.

B. Install pipe spools or valve spacers in locations where butterfly valve disc travel may be impaired by adjacent pipe lining, pipe fittings, valves, or other equipment.

3.02 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training, and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional Testing:
   1. Valves:
      a. Test witnessing: Witnessed.
      b. Conduct pressure and leak test, as specified in Section 40_05_51.01 - Common Work Results for Valves.

3.03 BUTTERFLY VALVE APPLICATION SCHEDULE

A. Acceptable butterfly valve types and body styles are listed in the Butterfly Valve Application Schedule provided at the end of this Section. Furnish and install butterfly valves in accordance with this Schedule.

Butterfly Valve Application Schedule	
Valve Type and Style	**Acceptable Applications**
General Purpose AWWA Butterfly Valves - Flanged Body Design	Aboveground or submerged in the following service applications only: • Acceptable in all service applications except oxygen and ozone service and high-pressure service. • May be used in buried applications when required by the specified piping system.
General Purpose AWWA Butterfly Valves - Mechanical Joint Body Design	Buried in the following service applications only: • Acceptable in all service applications except oxygen and ozone service and high-pressure service.

END OF SECTION

SECTION 40_05_65.01

GATE, GLOBE, AND ANGLE VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Gate, globe (non-pilot controlled), and needle valves.
   2. As specified in Section 40_05_51.01 - Common Work Results for Valves.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.
   2. B16.47 - Large Diameter Steel Flanges: NPS 26 through NPS 60, Metric/Inch Standard.

B. American Water Works Association (AWWA):
   1. C515 - Standard for Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Services.
   2. C550 - Protective Interior Coatings for Valves and Hydrants.

C. ASTM International (ASTM):
   1. B98 - Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.

D. Manufacturers Standardization Society (MSS) of the Valve and Fittings Industry:
   1. SP-81 - Stainless-Steel or Stainless-Steel-Lined, Bonnetless, Knife Gate Valves with Flanged Ends.

E. NSF International (NSF):
   1. Standard 61 - Drinking Water System Components - Health Effects.

1.03 SUBMITTALS

A. Submit as specified in Section 01 33 00 - Submittal Procedures.

B. Product data:
   1. As specified in Section 40_05_51.01 - Common Work Results for Valves.

C. Commissioning Submittals:
   1. For valves larger than 16 inches:
      a. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01 79 00 - Demonstration and Training.

1.04 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

B. Interior epoxy coatings: Affidavit of compliance attesting that epoxy coatings applied to interior surfaces of valves comply in accordance with all provisions of AWWA C550.

PART 2 PRODUCTS

2.01 GATE VALVES - GENERAL SERVICE (GV00)

A. Aboveground:
   1. Valves less than 3 inches in size for clean water and air service:
      a. Manufacturers: One of the following or equal:
         1) Nibco.
         2) Watts.
         3) Milwaukee.
         4) Matco-Norca.
      b. Design:
         1) Size and configuration: Indicated on the Drawings.
         2) Manufacturer's standard bronze, solid wedge disc, rising stem, screwed end, Class 150 pounds.
   2. Valves 3 inches in size and larger, single disk:
      a. Manufacturers: One of the following or equal:
         1) American Flow Control, Series 2500.
         2) M&H/Kennedy Valve Co.
         3) Mueller.
         4) Clow.
      b. Design:
         1) Size, material, configuration: Indicated on the Drawings and specifications.
         2) Resilient wedge type in accordance with AWWA C515.
         3) Flange, iron body, and bonnet rated for 200 pound working pressure:
            a) Provide O-ring seal between valve body and bonnet.
         4) Ductile or cast-iron wedge encapsulated in nitrile rubber and capable of sealing in either flow direction.
         5) Bronze stem with double or triple O-ring or braided packing stem seals.
         6) Rising stem configuration with handwheel diameter sized to allow opening of valve with no more than a 40-pound pull.
         7) Coat interior and exterior surfaces of valve body and bonnet with fusion-bonded epoxy in accordance with AWWA C550.

3. Valves 3 inches in size and larger, double disc:
    a. Flanged.
    b. Materials:
        1) 200 pound iron body.
        2) Bronze mounted.
    c. Configuration:
        1) Outside screw and yoke (OS&Y).
        2) Stems of silicon bronze in accordance with ASTM B98, Alloy No. C66100.
    d. Inside configuration:
        1) Double disc; parallel seat.
        2) Handwheel.
    e. Manufacturers: One of the following or equal:
        1) M&H Valve Co., Figure 68-02.
    f. Design:
        1) Size, material, configuration: Indicated on the Drawings.

2.02 GLOBE VALVES - NON-PILOT-CONTROLLED (GLV00 AND GLV20)

A. General (GLV00):
    1. Valves 3 inches and smaller:
        a. Manufacturers: One of the following or equal:
            1) Except in welded steel piping:
                a) Crane, No. 1 Globe or No. 2 Angle.
                b) Lunkenheimer Co. Figure No. 2140 Globe or No. 2141 Angle.
            2) In welded steel piping:
                a) Crane, No. 351.
                b) Lunkenheimer Co., Figure No. 1123; or equal with flanged ends.
        b. Design:
            1) Size and configuration: Indicated on the Drawings and specifications.
            2) Valve: Class 125 threaded ends, rated for 250 degrees Fahrenheit at pressure of 170 pounds per square inch.
    2. Valves larger than 3 inches:
        a. Manufacturers: One of the following or equal:
            1) Crane, No. 351.
            2) Lunkenheimer Co., Figure No. 1123.
        b. Design:
            1) Size and configuration: Indicated on the Drawings and specifications.

PART 3 EXECUTION

3.01 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training and this Section.

B. Functional Testing:
    1. Valves:
        a. Test witnessing: Witnessed.

b. Conduct pressure and leak test as specified in Section 40_05_51.01 - Common Work Results for Valves.

END OF SECTION

SECTION 40_05_65.24

CHECK VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Swing check valves:
      a. General swing check valves.
   2. Ball check valves:
      a. Metal body ball check valves.
      b. Plastic ball check valves.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

B. American Water Works Association (AWWA):
   1. C508 - Standard for Swing-Check Valves for Waterworks Service 2 Inch Through 24 Inch NPS.

C. ASTM International (ASTM):
   1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A213 - Standard Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes.
   3. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   4. A313 - Standard Specification for Stainless Steel Spring Wire.
   5. A536 - Standard Specification for Ductile Iron Castings.
   6. A582 - Standard Specification for Free-Machining Stainless Steel Bars.
   7. A743 - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
   8. B16 - Standard Specification for Free-Cutting Brass Rod, Bar and Shapes for Use in Screw Machines.
   9. B61 - Standard Specification for Steam or Valve Bronze Casting.
   10. B62 - Standard Specification for Composition Bronze or Q=Ounce Metal Castings.
   11. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

D. National Electrical Manufacturers Association (NEMA).

E. NSF International (NSF):
   1. 61 - Drinking Water Components Health Effects.
   2. 372 - Drinking Water System Components - Lead Content.

F. Underwriters Laboratories, Inc. (UL).

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Product data:
   1. As specified in Section 01 61 00 - Common Product Requirements.

C. Quality Control Submittals:
   1. Provide Manufacturer's Certificate of Installation Verification as specified in Section 01 79 00 - Demonstration and Training.

1.04 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01 61 00 - Common Product Requirements and Section 40_05_51.01 - Common Work Results for Valves.

B. Provide check valves as shown on the Check Valve Schedule and suitable for service:
   1. In either horizontal or vertical position.
   2. For working pressures up to 150 pounds per square inch.

C. Check valve materials as follows unless otherwise specified:
   1. Cast iron in accordance with ASTM A126, Grade B.
   2. Ductile iron in accordance with ASTM A536, Grade 65-45-12.
   3. Type 303 stainless steel in accordance with ASTM A582 (UNS S30300).
   4. Type 316 stainless steel in accordance with ASTM A313.

D. Flanges: Drilled in accordance with ASME B16.1 Class 125/150, unless otherwise specified or indicated on the Drawings.

2.02 GENERAL SWING CHECK VALVES (CKV00)

A. Valves 1/4 inch through 3 inches:
   1. Manufacturers: One of the following or equal:
      a. Crane Valve Co., Number 36.
      b. Lunkenheimer Co., Figure 554Y.

2. Design:
    a. Y-pattern body with integral seat.
    b. Female threaded ends.
    c. Renewable hinged disc.
    d. Threaded cap for access to valve seat without disassembly of piping.
    e. Integral seats suitable for regrinding.
3. Materials:
    a. Body: Bronze in accordance with ASTM B62-83600.
    b. Disc: Bronze in accordance with ASTM B62 C92200:
        1) On valves less than 1-inch: Brass in accordance with ASTM B16.
    c. Hinge: Bronze in accordance with ASTM B584 C 87600.
    d. Lock nut and hinge pin plug: Brass in accordance with ASTM B16 HO2.
    e. Hinge pin: Stainless steel in accordance with ASTM A276.
    f. Cap: Bronze in accordance with ASTM B61 C92200.
    g. If used for steam service:
        1) Body and disc: S1 steam bronze in accordance with ASTM B61.

B. Valves 4 inches through 24 inches:
1. Manufacturers: One of the following or equal:
    a. American Series 600.
    b. Clow Model 159-02.
2. Design:
    a. In accordance with AWWA C508.
    b. Constructed to permit top entry and removal of internal components without removing the valve.
    c. Equipped with outside lever and weight.
3. Materials:
    a. Body: Cast iron, ASTM A126, Class B, or ASTM A536, Grade 65-45-12 ductile iron.
    b. Disc:
        1) Valve disc shall be ASTM A126 cast iron, ASTM A536 ductile iron, or ASTM B584 bronze.
        2) 4-inch valves: Bronze or stainless steel rings and seats.
        3) 6 inches and larger valves: Bronze-faced or stainless steel rings and seats.
        4) Rubber seat: EPDM.

2.03 PLASTIC BALL CHECK VALVES (CKV65)

A. Manufacturers: One of the following or equal:
1. Georg Fischer Piping Systems.
2. Hayward Flow Control.
3. Nibco, Chemtrol Series.
4. Plast-O-Matic.

B. Design:
1. Ball type design, true union style.
2. Materials: PVC Schedule 80.

3. Inlet pressure rating:
    a. PVC, CPVC, or PVDF: 150 pounds per square inch at 77 degrees Fahrenheit.
    b. PP: 100 pounds per square inch at 77 degrees Fahrenheit.
4. Seats and O-rings: compatible with process material.

2.04 INTERIOR PROTECTIVE LININGS

A. As shown in the valve schedules and as specified in Section 40_05_51.01 - Common Work Results for Valves.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

A. Manufacturer services:
    1. Provide the Manufacturer’s Certificate of Installation Verification.

B. Functional Testing:
    1. Test witnessing: Witnessed.
    2. Conduct pressure and leak test, as specified in Section 40_05_00.09 - Piping Systems Testing.

END OF SECTION

SECTION 40_05_65.26

RUBBER “DUCK BILL” CHECK VALVE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Rubber “Duck Bill” Check Valve.

B. As specified in Section 40_05_51.01 - Common Work Results for Valves.

C. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   2. D2000 - Standard Classification System for Rubber Products in Automatic Applications.

1.03 SUBMITTALS

A. Submit as specified in Section 01 33 00 - Submittal Procedures and Section 01 61 00 - Common Product Requirements.

B. Product data.

C. Shop Drawings.

D. Vendor operation and maintenance manuals: As specified in Section 01 78 23 - Operation and Maintenance Data.

E. Commissioning Submittals:
   1. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01 79 00 - Demonstration and Training.

1.04 WARRANTY

A. Provide warranty as specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Proco Products, Proflex.
   2. Red Valve, Tideflex Technologies.

B. Anchor bolts: Provided by valve manufacturer.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. As specified in Section 01 61 00 - Common Product Requirements.

B. Check valve shall open when the line pressure exceeds the backpressure and close when the backpressure exceeds the line pressure thereby preventing backflow.

2.03 MATERIALS

A. Stainless steel: ASTM A276, Type 304, 304L, 316, or 316L.

B. Neoprene: ASTM D2000, BC 615 to 625.

2.04 COMPONENTS

A. Thimble and flanges: Type 316 stainless steel:
   1. Flanges:
      a. Sizes and configuration as indicated on the Drawings.
      b. Mount as indicated on the Drawings.
   2. Thimble:
      a. Cast in 1 piece or welded and shall be designed to maximize strength, rigidity, and minimize weight.
      b. 1-inch spacers may be cast or welded onto the bottom of the thimble at the 5 o'clock and 7 o'clock position to support valve position during installation. Spacers shall be of such length and positioned such that they will be fully embedded in and will not hinder the grouting of the valve during installation.

B. Insert: Material(s) as specified by manufacturer with exterior surfaces being Neoprene rubber.

C. Bolts, nuts, and fittings: Type 316 stainless steel.

2.05 ANCHOR BOLTS

A. When required, hooked end type, of sufficient quantity and length to anchor the valve.

B. Material: Type 316 stainless steel.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions meeting the requirements as indicated on the Drawings.

B. Mount plumb in both vertical planes and level in horizontal plane.

3.02 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training, and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer’s Certificate of Installation and Functionality Compliance.

C. Functional Testing:
   1. Check valve:
      a. Test witnessing: Witnessed.
      b. Leakage tests: Demonstrate compliance with allowable leakage limits set forth in this Section.
      c. After the gate installation and checking, exercise each gate from the closed position to fully open position and back to the closed position at least twice and verify gate is properly seated.
      d. Conduct Level 2 General Equipment Performance Test.

END OF SECTION

SECTION 40_05_67.37

PRESSURE CONTROL VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Pressure reducing and pressure relief valves for water, air, sludge and chemical service.

B. As specified in Section 40_05_51.01 - Common Work Results for Valves.

C. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.42 - Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300.

B. ASTM International (ASTM):
   1. A536 - Standard Specification for Ductile Iron Castings.

C. Underwriters Laboratories, Inc. (UL).

1.03 SUBMITTALS

A. Submit as specified in Section 01 33 00 - Submittal Procedures.

B. Product data: As specified in Section 40_05_51.01 - Common Work Results for Valves.

C. Commissioning submittals:
   1. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01 79 00 - Demonstration and Training.

1.04 WARRANTY

A. Provide warranty as specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 METAL BODY PRESSURE REDUCING VALVES - WATER SERVICE (PRV00)

A. Metallic pressure reducing valves for water service, 2 1/2 inches and smaller:
   1. Manufacturers: One of the following or equal:
      a. Watts, Series LF223.
      b. Zurn Wilkins, 500 Series.
   2. Direct operated, single seat type pressure reducing valve.
   3. Downstream pressure adjustment range: 30 to 300 pounds per square inch gauge (psig).
   4. Materials:
      a. Body and spring cover: Bronze or brass alloy meeting the zinc and aluminum requirements of Section 40_05_51.01 - Common Work Results for Valves.
      b. Valve seat: Type 316 stainless steel.
      c. Diaphragm: Reinforced Buna Nitrile.
      d. Disk: EPDM.

B. Metallic pressure reducing valves for water service, 3 inches and larger:
   1. Manufacturers: One of the following, or equal:
      a. Watts, Ames Fire and Waterworks ACV Series LF910GD-01.
      b. Cla-Val Model 90-01 KO with CV flow control and integral check feature.
   2. Design:
      a. Pilot controlled, hydraulically operated, diaphragm actuated, globe patterned valve.
      b. Rated for the test pressure of the corresponding piping system, as specified in the Piping Schedule.
      c. Downstream pressure adjustment range: 30 to 300 psig.
      d. Pilot line: Equipped with a strainer.
      e. Flanges: Class 150, in accordance with ASME B16.42.
      f. Anti-cavitation trim.
      g. One-way flow through valve with integral check feature.
   3. Materials:
      a. Body and cover: Ductile Iron ASTM A536.
      b. Valve trim: Bronze.
      c. Pilot control: Cast bronze with Type 316 stainless steel trim.
      d. Diaphragm: EPDM.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install as specified in Section 40_05_51.01 - Common Work Results for Valves.

3.02 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training and this Section.

B. Manufacturer services:
    1. Provide certificates:
        a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional testing:
    1. Valves:
        a. Test witnessing: Witnessed.
        b. Conduct pressure and leak test as specified in Section 40_05_51.01 - Common Work Results for Valves.

END OF SECTION

SECTION 40_05_67.40

AIR AND VACUUM RELIEF VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Air release valves, air and vacuum valves, and combination air valves.

B. As specified in Section 40_05_51.01 - Common Work Results for Valves.

C. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.

B. American Water Works Association (AWWA).

C. ASTM International (ASTM):
   1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   3. A270 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Sanitary Tubing.
   4. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

1.03 SUBMITTALS

A. Submit as specified in Section 01 33 00 - Submittal Procedures.

B. Product data: As specified in Section 40_05_51.01 - Common Work Results for Valves.

C. Commissioning Submittals:
   1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01 79 00 - Demonstration and Training.

1.04 WARRANTY

A. Provide warranty as specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 METAL BODY COMBINATION AIR VALVES - WATER SERVICE (CAV00)

A. Manufacturers: One of the following or equal:
   1. Multiplex Manufacturing Co., Crispin UL Series.
   2. Valve and Primer Corp., DeZURIK/APCO, Series 140C.

B. Design:
   1. Operation: Automatic exhaust of large quantities of air from pipelines during filling and draining and release of accumulated air while pipeline is under pressure.
   2. Utilize compound lever system in conjunction with large and small orifices.
   3. Internal parts removable through top cover without removing valve from pipeline.
   4. Pressure rating: 125 pounds per square inch.
   5. Inlet: Screwed, 2-inch size.

C. Materials:
   1. Body: Cast iron.
   2. Float: Type 316 stainless steel.
   3. Needle: Buna-N.
   4. Lever frame: Cast iron or Delrin.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install as specified in Section 40_05_51.01 - Common Work Results for Valves and the manufacturer's instructions.

B. Install air release valves and air and vacuum valves with suitable discharge lines to nearest drainage system.

3.02 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional Testing:
   1. Valves:
      a. Test witnessing: Witnessed.
      b. Conduct pressure and leak test as specified in Section 40_05_51.01 - Common Work Results for Valves.

END OF SECTION

SECTION 40_61_00

COMMON WORK RESULTS FOR PROCESS CONTROL AND INSTRUMENTATION SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Process control and instrumentation systems requirements for common components including installation, including, but not limited to, the following:
      a. Hardware.
      b. Software.
      c. Programming.
      d. Testing.
      e. Commissioning.
   2. Loop drawings:
      a. Provide complete loop drawings for all systems, including packaged equipment furnished as part of a vendor furnished package, and pre-purchased equipment.
      b. The form, minimum level of detail, and format for the loop drawings must match that of the sample loop drawings included in the Contract Documents.
      c. Owner and Engineer are not responsible for providing detailed loop diagrams for Contractor furnished equipment.
   3. Requirements of the Instrumentation and Control Specifications apply to all Instrumentation and Control Work specified in Technical Sections, including packaged mechanical systems, LCPs, VCPs, etc.
   4. As specified in Section 01 11 13 - Summary of Work, PLC programming and SCADA/HMI software configuration will be provided by SyCal Engineering, Inc. hereinafter referred to as the Programmer.

B. Contract Drawings:
   1. Schematic diagrams:
      a. Use schematic diagrams in conjunction with the descriptive operating sequence in the Technical Sections to furnish a coordinated and fully functional control system.
      b. Schematic diagrams show control function only:
         1) Incorporate other necessary functions for proper operation and protection of the system.
      c. Controls are indicated on the Drawings as de-energized.
      d. Add relays, where required, to provide necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
      e. Mount devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated on the Drawings.

C. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. Abbreviations:
   1. ACB: Automatic current balance.
   2. ATS: Automatic Transfer Switch.
   3. CCS: The PCS central computer system (CCS) consisting of computers and software. The personal computer-based hardware and software system that includes the operator interface, data storage, data retrieval, archiving, alarming, historian, reports, trending, and other higher level control system software and functions.
   4. DPDT: Double-pole, double-throw.
   5. ECP: Electronic circuit protector.
   6. ES: Ethernet Switch.
   7. FAT: Factory acceptance test also known as Source Test.
   8. HART: Highway addressable remote transducer.
   9. HMI: Human machine interface is a software application that presents information to an operator or user about the state of a process, and to accept and implement the operators control instructions. Typically, information is displayed in a graphical format.
   10. HOA: Hand-Off-Auto control function that is totally PLC based. In the Hand mode, equipment is started or stopped, valves are opened or closed through operator direction under the control of the PLC software. In the Auto mode, equipment is started or stopped, and valves are opened or closed through a control algorithm within the PLC software. In the Off mode, the equipment is prohibited from responding from the PLC control.
   11. I/O: Input/Output.
   12. ICSC: Instrumentation and control system contractor: Subcontractor who specializes in the design, construction, fabrication, software development, installation, testing, and commissioning of industrial instrumentation and control systems.
   13. IJB: Instrument junction boxes: A panel designed with cord sets to easily remove, replace, or relocate instrument signals.
   14. IP: Internet protocol or ingress protection.
   15. LAN: Local area network: A control or communications network that is limited to the physical boundaries of the facility.
   16. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
   17. LOI: Local Operator Interface is an operator interface device consisting of an alphanumeric or graphic display with operator input functionality. The LOI is typically a flat panel type of display mounted on the front of an enclosure with either a touch screen or tactile button interface.
   18. LOR: Local-Off-Remote control function. In the Remote mode, equipment is started or stopped, and valves are opened or closed through the PLC based

upon the selection of the HOA. In the Local mode, equipment is started or stopped, valves are opened or closed based upon hardwired control circuits completely independent of the PLC with minimum interlocks and permissive conditions. In the Off mode, the equipment is prohibited from responding to any control commands.

19. NJB: Network junction box. An enclosure that contains multiple access points to various networks within the facility. Networks could be Ethernet, Ethernet/IP, Fieldbus, RIO, etc.
20. P&ID: Process and instrumentation diagram.
21. PC: Personal computer.
22. PCIS: Process control and instrumentation system: Includes the entire instrumentation system, the entire control system, and all of the Work specified in the Instrumentation and Control Specifications and depicted on the Instrumentation Drawings. This includes all the PCS and instruments and networking components as well as the various servers, workstations, thin clients, etc.
23. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
24. PCS: Process Control System: A general name for the computerized system that gathers and processes data from equipment and sensors and applies operational controls to the process equipment. It includes the PLCs and/or RIOs, LOIs, HMIs, both LCPs, VCPs and all data management systems accessible to staff.
25. PJB: Power junction box: An enclosure with terminal blocks that distribute power to multiple instruments.
26. PLC: Programmable logic controller.
27. PS: Power supply.
28. RIO: Remote I/O device for the PLC consisting of remote I/O racks or remote I/O blocks.
29. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
30. SCADA: Supervisory control and data acquisition system: A general name for the computerized system that gathers and processes data from sensors and equipment located outside of the facility, such as wells, lift stations, metering stations, etc.
31. SELV: Safety extra-low voltage.
32. SFP: Small form-factor pluggable.
33. SPDT: Single-pole, double-throw.
34. SPST: Single-pole, single-throw.
35. UPS: Uninterruptible power supply.
36. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, LOI, HMI, etc.
37. WAN: Wide area network: A control or communications network that extends beyond the physical boundaries of the facility.

B. Standards:
   1. American Petroleum Institute (API):
      a. RP 550 - Manual on Installation of Refinery Instruments and Control Systems; Part II-Process Stream Analyzers; Section 5-Oxygen Analyzers.

b. RP 551 - Process Measurement Instrumentation.
2. International Organization for Standardization (ISO):
   a. 9001 - Quality Management Systems - Requirements.
3. International Society of Automation (ISA):
   a. 5.1 - Instrumentation Symbols and Identification.
   b. 5.4 - Instrument Loop Diagrams.
   c. 20 Instrument Forms Plus Pro-Combo-Enterprise Version (Microsoft SQL Server Express Database Software based).
4. National Electrical Manufacturers Association (NEMA).
5. National Fire Protection Association (NFPA):
   a. 70 - National Electrical Code (NEC).
6. National Institute of Standards and Technology (NIST).
7. Underwriters Laboratories, Inc. (UL):
   a. 508 - Standard of Safety for Industrial Control Equipment.
   b. 508A - Standard of Safety for Industrial Control Panels.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning:
   1. 2-Wire transmitter (loop powered): A transmitter that derives its operating power supply from the signal transmission circuit and requires no separate power supply connections. As used in this Section, 2-wire transmitter refers to a transmitter that provides a signal such as 4 to 20 mA 24 VDC regulation of a signal in a series circuit with an external 24 VDC driving potential:
      a. Fieldbus communications signal or both.
   2. Control circuit: Any circuit operating at 120 volts alternating current (VAC) or direct current (VDC) or less, whose principal purpose is the conveyance of information (including performing logic) and not the conveyance of energy for the operation of an electrically powered device.
   3. Digital bus: A communication network, such as PROFIBUS, Foundation Fieldbus, or DeviceNet, allowing instruments and devices to transmit data, control functions, and diagnostic information.
   4. Instrument: A measurement device that includes a sensor for taking the measurement and one or both of the following:
      a. A local display.
      b. A device for communicating the measurement to a remote location such as a PLC or DCS.
   5. Modifications: Changing, extending, interfacing to, removing, or altering an existing circuit.
   6. Panel: An instrument support system that may be a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems.
   7. Power circuit: Any circuit operating at 90 volts (AC or DC) or more, whose principal purpose is the conveyance of energy for the operation of an electrically powered device.
   8. Powered transmitters: A transmitter that requires a separate power source (120 VAC, 240 VAC, etc.) in order for the transmitter to develop its signal. As used in this Section, the produced signal may be a 4 to 20 mA 24 VDC signal, a digital bus communications signal, or both.

9. Programmer: Responsible for PLC programming and SCADA/HMI software configuration.
10. RS-485: RS-485 is also known as TIA-485 or EIA-485, is a standard defining the electrical characteristics of drivers and receivers for use in serial communications system. Electrical signaling is balanced, and multipoint systems are supported, can be used with data rates up to 10 Mbit/s or at lower speeds distances up to 1,000 meters (4,000 feet).
11. Signal circuit: Any circuit operating at less than 50 VAC or VDC, which conveys analog information or digital communications information.

1.04 DELEGATED DESIGN

A. The requirements for Delegated Design are specified in the Technical Sections.

1.05 SUBMITTALS

A. General:
   1. Adhere to the wiring numbering scheme as specified in Section 26_05_53 - Identification for Electrical Systems throughout the Project:
      a. Uniquely number each wire.
      b. Wire numbers must appear on Equipment Drawings.
   2. Some items of Work are represented schematically, and are designated for the most part by numbers, as derived from criteria in ISA-5.1:
      a. Employ the nomenclature and numbers designated in this Section and indicated on the Drawings exclusively throughout Shop Drawings, datasheets, and similar Submittals.
      b. Replace any other symbols, designations, and nomenclature unique to a manufacturer's, Supplier's, or Subcontractor's standard methods with those identified in this Section and indicated on the Drawings.

B. Specific Submittal requirements:
   1. Control Panel Drawings:
      a. General Requirements:
         1) Submit panel, enclosure, console, furniture, and cabinet layout drawings for all items provided.
         2) Use equipment and instrument tags as depicted on the P&IDs for all Submittals.
         3) Nameplates and Wire Labeling:
            a) Nameplate legend including text, letter size, materials, and colors.
            b) As specified in Section 26_05_53 - Identification for Electrical Systems or as indicated on the Drawings.
         4) Structural Requirements:
            a) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project site seismic criteria.
            b) Weight.
         5) Clearly show modifications to existing circuits:
            a) Show existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.

b. Required for materials and equipment listed in this and other Technical Sections.
c. Front, side, rear, internal, external elevations, and top and bottom views, showing all dimensions and all to scale:
    1) Locations of conduit entrances and access plates.
    2) Component layout and identification.
    3) Complete and detailed bills of materials:
        a) Including quantity, description, manufacturer, and part number for each assembly or component for each control panel.
        b) Include all items within an enclosure.
    4) Requirements for physical separation between control system components and 120 VAC, 480 VAC, and medium-voltage power cables.
    5) Complete grounding requirements for each system component including any requirements for PLCs, process LANs, and Control System equipment.
    6) PLC rack and card layout:
        a) Provide a count of current I/O allocation.
        b) Future I/O allocation.
        c) Quantity of spares provided.
    7) NEMA rating.
    8) Material and finish.

2. Schematics and Wiring Diagrams:
    a. General Requirements:
        1) Submit panel wiring diagrams for every panel that contains wiring.
        2) Use equipment and instrument tags as depicted on the P&IDs for all Submittals.
        3) Nameplates and Wire Labeling:
            a) As specified in Section 26_05_53 - Identification for Electrical Systems or as indicated on the Drawings.
        4) Clearly show modifications to existing circuits:
            a) Show existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.
    b. Include the following information:
        1) Name of panel.
        2) Wiring sizes and types.
        3) Terminal strip numbers.
        4) Terminal identification for device and field connections.
        5) Wire tags and labels.
        6) Functional name and manufacturer’s designation for items to which wiring are connected.
        7) Set points for relays and control or alarm contact settings.
    c. Incorporate equipment manufacturer’s Shop Drawing information into the schematic diagrams in order to document the entire control system.
3. Loop drawings:
    a. General Requirements:
        1) Submit loop drawings for every analog, discrete, fieldbus signal, vendor supplied equipment packages, and control panels:
            a) Includes monitoring, alarming, interlocks, and control devices.

2) Use equipment and instrument tags as depicted on the P&IDs for all Submittals.
3) Show and identify each component of each loop or system using requirements and symbols from ISA-5.4.
4) Provide Drawings for every instrumentation loop system:
a) Furnish a separate Drawing sheet for each system or loop diagram.
5) Nameplates and Wire Labeling:
a) As specified in Section 26_05_53 - Identification for Electrical Systems or as indicated on the Drawings.
6) Clearly show modifications to existing circuits:
a) Show existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.
7) Provide loop drawings in the format indicated in the Contract Drawings.

b. Provide a complete index in the front of each bound volume:
1) Index the loop drawings by systems or process areas.

c. In addition to the ISA-5.4 requirements, show the following details:
1) Functional name of each loop.
2) Reference name, drawing, and loop diagram numbers for any signal continuing off the loop diagram sheet.
3) Show all terminal numbers, regardless of the entity providing the equipment.
4) MCC panel, circuit, and breaker numbers for power feeds to the loops and instrumentation.
5) Terminal assignments associated with every manhole, pull-box, junction box, conduit, and panel through which the loop circuits pass.
6) Show vendor control panel, instrument panel, conduit, junction box, equipment and PCS terminations, termination identification, wire numbers and colors, power circuits, and ground identifications.
7) Cables required for communication requirements.

4. PLC I/O List:
a. A complete listing of the PCS system point I/O database:
1) Include for each data point relevant parameters such as range, contact orientation, limits, incremental limits, I/O hardware address, and PLC assignment.
2) Organize on a site-by-site basis and separate by point type.
3) In addition to the active I/O points, list the implemented spare I/O points and the available I/O points remaining on each card, as well as other defined future points specified or shown.
4) Upon completion of the Work, update I/O lists to indicate the final as-built configuration of the systems:
a) Organize as-built I/O list on a site-by-site basis, separated by equipment and point type.

5. Control Descriptions:
a. For each control loop, provide programming logic in the form of a written functional description of the operation of the equipment, signals, and controls based on the requirements as specified in Section 40_61_15 -

Control Strategies, Section 40_61_16.08 - Specific Control Strategies - Beltz 8, and as shown on the P&IDs and I/O tables:

1) Functional descriptions shall be modified to reflect the actual programming to be implemented in the PLCs.
2) Include each function depicted or described in the Contract Documents.
3) Include within the Control Description content:
    a) Specific requirements.
    b) Common requirements that pertain in general to all loops.
    c) Listing ranges, setpoints, timers, values, counter values, etc.
    d) Manual keyboard entries.
    e) Entry codes.
    f) System responses.
    g) Modes:
        (1) Startup.
        (2) Routine and normal operation.
        (3) Regulation and control.
        (4) Shutdown under specified modes of operation.
        (5) Emergency operating shutdown.

6. Instrument Datasheets:
    a. The datasheets provided with the instrument specifications are preliminary and are not complete but are provided to assist with the completion of final instrument datasheets. Additional datasheets may be required.
    b. Furnish fully completed datasheets for each instrument and component according to ISA-20 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves.
    c. Format: Provide datasheets in Microsoft Word or Microsoft Excel:
        1) Features and options that are furnished.
    d. Provide completed datasheet as specified in the Technical Sections and for each control system component.
7. Instrument Installation Drawings:
    a. Provide instrument installation, mounting, and anchoring details for components and assemblies, including access requirements and conduit connection or entry details.
    b. Each installation shall be identified by the equipment or instrument by tag number.
    c. Provide certification by the instrument manufacturer that the proposed installation is in accordance with the instrument manufacturer’s recommendations and is fully warrantable.
    d. Provide, at a minimum, the following contents for each detail:
        1) Necessary sections and elevation views required to define instrument location by referencing tank, building, or equipment names and numbers, and geographical qualities such as north, south, east, west, basement, first floor, etc.
        2) Ambient temperature and humidity where the instrument is to be installed.
        3) Corrosive qualities of the environment where the instrument is to be installed.
        4) Hazardous rating of the environment where the instrument is to be installed.
        5) Process line pipe or tank size, service, and material.

6) Process tap elevation and location.
7) Upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.
8) Routing of tubing and identification of supports.
9) Mounting brackets, stands, anchoring devices, and sunshades.
10) Conduit entry size, number, location, and delineation between power and signal.
11) NEMA ratings of enclosures and components.
12) Clearances required for instrument servicing.
13) List itemizing manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.

8. Product data:
   a. Provide a technical brochure or bulletin (“cutsheet”) for each instrument or equipment on the project labeled with equipment and instrument tags as depicted on the P&IDs:
      1) Submit with the corresponding datasheets.
      2) Organization: Index product data in the Submittal by systems or loops.
   b. Engineering data:
      1) Test data and performance curves, when applicable.
   c. Manufacturer’s technical reference manuals.
9. Commissioning Submittals:
   a. As specified in Section 01 79 00 - Demonstration and Training.
   b. Manufacturer representative qualifications.
   c. Manufacturer certificates.
   d. Test plans.
   e. Test reports.
   f. Owner Training Submittals.
   g. Operation and maintenance manuals:
      1) Organize the operation and maintenance manuals for each process in the following manner:
         a) Section A - Process and Instrumentation Diagrams.
         b) Section B - Control Panel Drawings.
         c) Section D - Schematics and Wiring Diagrams.
         d) Section E - Loop Drawings.
         e) Section F - Network Diagrams.
         f) Section G - PLC I/O List.
         g) Section H - Control Descriptions.
         h) Section I - Instrument Datasheets.
         i) Section J - Instrument Installation Drawings.
         j) Section K - Product Data.
         k) Section L - Sizing Calculations.
         l) Section M - Test Results.
         m) Section N - Operational Manual.
         n) Section O - Spare Parts List.

1.06 QUALITY ASSURANCE

A. Manufacture instruments at facilities certified to the quality standards of ISO 9001.

B. Provide equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

C. The ICSC must have their own operating UL listed panel fabrication facility:
   1. Panels must be fabricated at this facility and meet UL 508/508A requirements.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Upon receipt of instruments in the field:
   1. Outside of the package: Prominently display tag number identification.
   2. On each instrument: Provide a nameplate as specified in this Section.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

B. Area classifications:
   1. Furnish enclosures that match the area classifications as specified in Section 26_05_00 - Common Work Results for Electrical.

1.09 ADMINISTRATIVE REQUIREMENTS

A. Project PCIS overview conference:
   1. Contractor leads the meeting.
   2. Timing:
      a. Prior to start of ICSC and Programmer Work.
   3. Attendees:
      a. Engineer, Owner, ICSC, and Programmer.
      b. Contractor.
      c. Electrical subcontractor.
      d. Manufacturers furnishing major pieces of equipment must attend, including, but not limited to:
         1) Vendor control panels.
         2) Chemical feed systems.
         3) Motor control centers.
         4) Switchgear.
         5) Variable frequency drives.
         6) Lighting.
         7) Engine generators.
   4. Agenda:
      a. Meeting purpose:
         1) Review the entire project, equipment, control philosophy, schedules, and Submittal requirements.
      b. Review entire project.
      c. Review equipment lists.
      d. Review control philosophy.
      e. Review schedules.
      f. Review Submittal requirements.
      g. Safety and security.
      h. Action items.
      i. Next meeting.

B. System configuration meetings: Meet on at least the following occasions:
    1. Preliminary meeting:
        a. Contractor leads the meeting.
        b. Timing:
            1) Before configuration work begins.
        c. Attendees:
            1) Engineer, Owner, ICSC, and Programmer.
        d. Agenda:
            1) Meeting purpose:
                a) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.
            2) Review the ICSC provided examples of displays, display symbols, reports, etc., to show the capabilities of the system software.
            3) Safety and security.
            4) Action items.
            5) Next meeting.
    2. Development review meeting:
        a. Contractor leads the meeting.
        b. Timing:
            1) After the initial database is entered and typical screens and reports have been entered.
        c. Attendees:
            1) Engineer, Owner, ICSC, and Programmer.
        d. Agenda:
            1) Meeting purpose:
                a) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.
            2) Review the system configuration.
            3) Review the HMI system database.
            4) Review the control schemes.
            5) Review the displays.
            6) Review the report formats.
            7) Safety and security.
            8) Action items.
            9) Next meeting.
    3. Pre-submittal review meeting:
        a. Contractor leads the meeting.
        b. Timing:
            1) Before producing any Submittals.
        c. Attendees:
            1) Engineer, Owner, Programmer, and ICSC.
        d. Agenda:
            1) Meeting purpose:
                a) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.
                b) Review an informal hardcopy of developed HMI screens for review by the Engineer.
            2) Review the system configuration.
            3) Review the HMI system database.
            4) Review the control schemes.
            5) Review the displays.

6) Review the report formats.
7) Review an informal hardcopy of developed HMI screens.
8) Review the Submittal schedule.
9) Safety and security.
10) Action items.
11) Next meeting.

4. Final review meeting:
   a. Contractor leads the meeting.
   b. Timing:
      1) After initial completion of configuration work.
      2) Prior to the Source Test.
   c. Attendees:
      1) Engineer, Owner, Programmer, and ICSC.
   d. Agenda:
      1) Meeting purpose:
         a) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.
      2) Review the system configuration.
      3) Review the HMI system database.
      4) Review the control schemes.
      5) Review the displays.
      6) Review the report formats.
      7) Safety and security.
      8) Action items.
      9) Next meeting.
   e. Make final format revisions after this review.
5. Additional requirements as specified in the following:
   a. Section 40_61_15 - Control Strategies.
   b. Section 40_61_16.08 - Specific Control Strategies - Beltz 8.
   c. Section 40_64_01 - Control Systems: Programmable Logic Controllers.

C. Control logic meetings: Meet on at least the following occasions:
1. Preliminary meeting:
   a. Contractor leads the meeting.
   b. Timing:
      1) Before configuration work is begun on any PLCs programmed by the Contractor (including those provided through Subcontractors and Suppliers).
   c. Attendees:
      1) Owner, Engineer, Programmer, and ICSC.
      2) Individuals responsible for programming PLCs and other programmable devices supplied by the Contractor may attend by telephone conference call.
   d. Agenda:
      1) Meeting purpose:
         a) Discuss overall control logic.
      2) Review list of each PLC and other programmable devices that will interface to the rest of the control system, including make, model, and a description of the interface.
      3) Review contact information for each individual responsible for programming each said PLC and other programmable device.

4) Review schedule of Submittals that will contain HMI/LOI interface information.
5) Safety and security.
6) Action items.
7) Next meeting.

2. Development review meeting:
   a. Contractor leads the meeting.
   b. Timing:
      1) After approximately one-half of the HMI/LOI interface Submittals have been submitted.
   c. Attendees:
      1) Owner, Engineer, Programmer, and ICSC.
      2) Individuals responsible for programming PLCs and other programmable devices supplied by the Contractor may attend by telephone conference call.
   d. Agenda:
      1) Meeting purpose:
         a) Discuss progress on control logic.
      2) Discuss HMI/LOI interface Submittals to date.
      3) Discuss HMI/LOI interface future Submittals and their requirements.
      4) Discuss half of the screens “drafted” but not submitted.
      5) Review list of each PLC and other programmable devices that will interface to the rest of the control system, including make, model, and a description of the interface.
      6) Review contact information for each individual responsible for programming each said PLC and other programmable device.
      7) Review schedule of Submittals that will contain HMI/LOI interface information.
      8) Safety and security.
      9) Action items:
         a) Document Vendor Control Panel programming requirements.
      10) Next meeting.
3. Pre-submittal review meeting:
   a. Contractor leads the meeting.
   b. Timing:
      1) Before producing any Submittals.
   c. Attendees:
      1) Engineer, Owner, Programmer, and ICSC.
   d. Agenda:
      1) Meeting purpose:
         a) Coordinate Submittals.
      2) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.
      3) Review an informal hardcopy of developed HMI screens for review by the Engineer to determine that requirements are being sufficiently met.
      4) Review the Submittal schedule.
      5) Safety and security.
      6) Action items.
      7) Next meeting.

4. Vendor control panel programming meetings:
    a. Contractor leads the meeting.
    b. Timing:
        1) Prior to start of vendor control panel programming Work.
    c. Attendees:
        1) Owner, Engineer, Programmer, and ICSC.
        2) Individuals responsible for programming PLCs and other programmable devices supplied by the Contractor may attend by telephone conference call.
        3) Each equipment supplier who is providing equipment with a PLC and/or LOI.
    d. Agenda:
        1) Meeting purpose:
            a) Coordinate control logic requirements for specific equipment.
        2) Review minimum Vendor Control Panel programming requirements:
            a) PLC to PLC global data mapping.
            b) PLCs to HMI tags mapping.
            c) Communication methods.
        3) Review advanced Vendor Control Panel programming requirements, as applicable:
            a) Tag naming conventions.
            b) LOI screen colors and navigation.
            c) Interlock and permissive definitions.
            d) Alarms: Clearing, formats, colors, and status.
            e) Standard code blocks for common control functionality.
        4) Safety and security.
        5) Action items.
        6) Next meeting.
5. Final review meeting:
    a. Contractor leads the meeting.
    b. Timing:
        1) After HMI/LOI interface Submittals have been submitted.
    c. Attendees:
        1) Owner, Engineer, Programmer, and ICSC.
        2) Individuals responsible for programming PLCs and other programmable devices supplied by the Contractor may attend by telephone conference call.
    d. Agenda:
        1) Meeting purpose:
            a) Discuss HMI/LOI interface Submittals and requirements.
        2) Review minimum programming requirements:
            a) PLC to PLC global data mapping.
            b) PLCs to HMI tags mapping.
            c) Communication methods.
        3) Review advanced requirements, as applicable:
            a) Tag naming conventions.
            b) LOI screen colors and navigation.
            c) Interlock and permissive definitions.
            d) Alarms: Clearing, formats, colors, and status.
            e) Standard code blocks for common control functionality.

4) Safety and security.
5) Action items.
6) Next meeting.

6. Additional requirements as specified in the following:
   a. Section 40_61_15 - Control Strategies.
   b. Section 40_61_16.08 - Specific Control Strategies - Beltz 8.
   c. Section 40_64_01 - Control Systems: Programmable Logic Controllers.

PART 2 PRODUCTS

2.01 GENERAL

A. Furnish meters, instruments, and other components that are the most recent field proven models marketed by their manufacturers at the time of Submittal of the Shop Drawings unless otherwise specified to match existing equipment.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Non-conditioned spaces:
   1. Provide additional temperature conditioning equipment to maintain equipment in non-conditioned spaces subject to these ambient temperatures, with a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature, as determined by the equipment manufacturer’s guidelines.

B. Outdoor installations:
   1. Provide electrical, instrumentation and control equipment suitable for operation in the ambient conditions where the equipment is located.
   2. Provide heating, cooling, and dehumidifying devices incorporated into and included with electrical equipment, instrumentation and control panels to maintain the enclosures within the rated environmental operating ranges as specified in the Sections for the equipment.

C. This facility includes classified areas:
   1. As specified in Section 26_05_00 - Common Work Results for Electrical.
   2. Provide enclosures suitable for the area classification.
   3. Where suitable enclosures are not available, utilize other methods such as intrinsic safety barriers.

D. This facility includes potable water:
   1. Utilize NSF/ANSI/CAN 61 certification where available for instrumentation and instrumentation accessories.
   2. If there are no certified NSF/ANSI/CAN 61 alternatives:
      a. Provide a statement that there is no available certified alternative.
      b. Utilize instruments certified FDA food compliant or USP compliant that can be substantiated as being appropriate for contact with potable water.

c. Components of the instrument or instrument accessory in direct contact with water has an acknowledged and demonstrable history of use in the state for drinking water applications.
d. Components of the instrument or instrument accessory in direct contact with water shall conform with NSF/ANSI/CAN 372 requirements.

E. Unless otherwise specified, furnish individual instruments that have a minimum accuracy of within 0.5 percent of full scale and a minimum repeatability of within 0.25 percent of full scale.

F. Furnish current version of software unless specifically noted in the Contract Documents:
1. Use of an older version to maintain functionality of an existing system is acceptable with written permission from the Engineer.
2. Equipment or software with limited support or end of life with the vendor is not acceptable.

G. Discrete circuit configuration:
1. Configure discrete control circuits to fail safe, on loss of continuity or loss of power.
2. Alarm contacts: Fail to the alarm condition.
3. Control contacts fail to the inoperative condition unless otherwise indicated on the Drawings.

H. Grounding:
1. Analog signal cables shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
2. For communication and data line signal cable shields and drain wires should be grounded at both ends of the cable.
3. Insulate the shielding and exposed drain wire for each signal cable with heat-shrink tubing.
4. Terminate the signal cable shield on a dedicated grounding terminal block.
5. Provide isolating amplifiers within control panels for field equipment possessing a grounded input or output, except when the panel circuit is galvanically isolated.

I. Instrument air:
1. Where indicated on the Drawings, provide dry, filtered control air at 30 pounds per square inch gauge nominal pressure piped to field instruments and instrument panels requiring air:
a. Provide each field instrument with an integral, non-adjustable filter/regulator assembly to provide regulated air.
b. Provide each instrument panel requiring air with an adjustable filter/regulator assembly with gauge and an air manifold to provide air to pneumatic instruments.
c. Filter air to 5-micron maximum particle size.
d. Provide low pressure switch to alarm on insufficient air supply.

J. Terminal blocks:
   1. Schematics do not reflect the actual conductor routing. Add intermediate terminal in enclosures and equipment as needed based on the actual conductor routing.

K. Signal transmission:
   1. Analog signals:
      a. Furnish analog measurements and control signals that vary in direct linear proportion to the measured variable, unless otherwise indicated.
      b. Furnish electrical analog signals outside control panels that are 4 to 20 mA 24 VDC, except as indicated.
      c. Electrically or optically isolate analog signals from other signals.
      d. Furnish regulated analog signals that are not affected by changes in supply voltage or load resistance within the unit's rating.
      e. Maintain the total 4 to 20 mA loop impedance to 10 percent below the published value at the loop operating voltage.
      f. Where necessary, reduce loop impedance by providing current-to-current (I/I) isolation amplifiers for signal re-transmission.
   2. Pneumatic signals:
      a. Pneumatic signals: 3 to 15 pounds per square inch gauge.
   3. Discrete input signals:
      a. As indicated in the controller hardware specification.
   4. Discrete output signals:
      a. Dry contacts or TRIAC outputs (with express written approval by the Engineer) as needed to coordinate with the field device.
      b. Provide external terminal block mounted fuse with blown fuse indication for discrete outputs.
      c. Provide interposing relays for discrete outputs for voltage and/or current compatibilities.
      d. Provide interposing relays as required for functionality of the control circuit.
   5. Signal performance and design criteria:
      a. Stability:
         1) After controls have taken corrective action, oscillation of the final control element shall not exceed 2 cycles per minute or a magnitude of motion of 0.5 percent of full travel.
      b. Response:
         1) Any change in setpoint or controlled variable shall produce a corrective change in position of the final control element and stabilized within 30 seconds.
      c. Agreement:
         1) Setpoint indication of controlled variable and measured indication of controlled variable shall agree within 3 percent of full scale over a 6:1 operating range.
      d. Repeatability:
         1) For any repeated magnitude of control signal, from either an increasing or decreasing direction, the final control element shall take a repeated position within 0.5 percent of full travel regardless of force required to position the final element.

e. Sensitivity:
    1) Controls shall respond to a setpoint deviations and measured variable deviations within 1.0 percent of full scale.
f. Performance:
    1) Instruments and control devices shall perform in accordance with the manufacturers' specifications.

2.03 MANUFACTURERS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 ACCESSORIES

A. Provide flow conditioning devices or other required accessories as needed to meet the accuracy requirements in the Contract Documents.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. PCIS configurations are diagrammatic:
    1. Locations of equipment are approximate unless dimensioned.
    2. Where Project conditions require, make reasonable changes in locations and arrangements.

B. Field instruments installation:
    1. Install field instruments as specified in the Contract Documents, API RP 550 and RP 551, and the manufacturer's instructions.
    2. Mount field instruments so that they can be easily read, readily approached, and easily serviced, and so they do not restrict access to mechanical equipment:
        a. Mount field instruments on a pipe stand or local panel, if they are not directly mounted, unless otherwise indicated on the Drawings.
        b. Provide sun shields for field electronic instruments, panels, and enclosures located outdoors. Sun shields shall include standoffs to allow air gap between shield and equipment.
        c. Orient LED, LCD, or other readout screens north to minimize sun glare and reduce potential of sun damage.
    3. Make connections from rigid conduit systems to field instruments with PVC coated flexible conduit:
        a. Type of flexible conduit required for the area classification:
            1) Area classification as specified in Section 26_05_00 - Common Work Results for Electrical.
        b. Maximum length of 18 inches.

4. Connect field instruments with cable as specified in the Electrical Specifications, except when the manufacturer requires the use of special cable, or otherwise specified in this Section:
    a. Special cable applications shall be in accordance with the NEC.
5. Verify the correctness of each installation:
    a. Polarity of electric power and signal connections.
6. Ensure process connections are free of leaks.

C. Process sensing lines and air tubing:
1. Install individual tubes parallel and/or perpendicular to and near the surfaces from which they are supported.
2. Provide supports for rigid tubing at intervals of not more than 3 feet.
3. Slope horizontal runs of instrument tubing at a minimum of 1/16-inch per foot to allow for draining of any condensate.
4. Bends:
    a. Make bends for parallel lines symmetrical.
    b. Make bends without deforming or thinning the walls of the tubing.
5. Square-cut and clean ends of tubing before being inserted in the fittings.
6. Provide bulkhead fittings at panels requiring pipe and/or tubing entries.
7. Use stainless steel tubing for piping hard piped from the air header, unless otherwise indicated on the Drawings or not compatible with the fluids or atmosphere in the area:
    a. Use flexible connections only on moving equipment and under the constraint that the length shall be less than 1.5 times maximum travel of the equipment.

D. Cable and conductor termination:
1. Terminate cables and conductors on terminal blocks.
2. Terminal block enclosures:
    a. Suitable for the area classification as specified in Section 26_05_00 - Common Work Results for Electrical.

3.04 RE-INSTALLATION

A. Existing instrumentation:
1. Clean, recondition and re-calibrate each existing instrument to be reused, removed, or reinstalled using an authorized service facility of the instrument manufacturer.
2. Provide certification of this Work before reinstallation of each instrument.

3.05 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training and technical sections.

B. Functional Testing:
1. Assist with troubleshooting and correcting instrumentation and control issues.

3.06 FIELD QUALITY CONTROL (NOT USED)

3.07 ADJUSTING

A. Control valves:
   1. Stroke control valves, cylinders, drives and connecting linkages from the control system as well as local control devices and adjust to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position.
   2. Check control valve actions and positioner settings with the valves in place to ensure that no changes have occurred since the bench calibration.

B. Make revisions necessary to the control system software, as directed by the Engineer.
   1. It is understood that the Contractor knows and agrees that changes will be required in the control system software during commissioning.

3.08 CLEANING

A. Vacuum clean control panels and enclosures before process start-up and again after final completion of the project.

B. Clean panel surfaces.

C. Return to new condition any scratches and/or defects.

D. Wipe instrument faces and enclosures clean.

E. Leave wiring in panels, manholes, boxes, and other locations in a neat, clean, and organized manner:
   1. Neatly coil and label spare wiring lengths.
   2. Shorten, re-terminate, and re-label excessive spare wire and cable lengths, as determined by the Engineer.

END OF SECTION

SECTION 40_61_15

CONTROL STRATEGIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Contractor-developed loop description submittal requirements.
   2. General programming requirements.
   3. Common control functions:
      a. General control and monitoring functions to be provided throughout the PCS system:
         1) These requirements apply to all systems and supplement the specific loop descriptions in Section 40_61_16.08 - Specific Control Strategies - Beltz 8 and information indicated on the Drawings.

1.02 REFERENCES

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning:
   1. Clamp: Imposed upper and lower limits on setpoints to eliminate entries outside the allowable control parameters.
   2. Hardwired control: Control circuitry that does not utilize software to initiate functionality.
   3. Hardwired interlocks: A safety or protective feature that will interrupt equipment operation in all operating modes with no required operator intervention.
   4. Historize: To store data collected by a Supervisory Control and Data Acquisition system or Distributed Control system in a Historical Server or Historian for later use in trends and reports.
   5. Network link status: A proving register that allows the PCS to know if a PLC has lost communications with the PCS.
   6. Network time synch: Coordination of all PLCs in the system to one consistent time based on a server, GPS clock, or some other mechanism to set a global time.
   7. Software interlocks: A safety or protective feature interrupting equipment operation when the PLC has control.
   8. Software permissive: A protective feature that will prevent a piece of equipment from starting. Will not stop the equipment once it’s running.
   9. Slew rate: Rate of change with respect to time.
   10. Watchdog timer: Timers imposed to test components such as discrete I/O to verify the health of the card.

1.04 SUBMITTALS

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.05 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PROGRAMMING REQUIREMENTS

A. General:
   1. Use re-usable data types for variable names or aliases derived from tag and loop identification on the P&IDs for the equipment/instruments. For example:
      a. PMP_101.Auto.
      b. PMP_101.Running.
      c. PMP_101.Fault.
      d. PMP_102.Auto.
      e. PMP_102.Running.
      f. PMP_102.Fault.
   2. Use variable names or aliases derived from tag and loop identification on the P&IDs for all process values:
      a. Submit names for Owner approval.
      b. Unless otherwise noted, utilize a floating-point format for PLC algorithms and calculations.
      c. Provide PLC logic to convert raw input values into engineering units in a floating-point format.
   3. Store all adjustable parameters in the PLC and configure them so that an operator with sufficient security access can change the parameters from the OIT or HMI. Update and display the current value at all locations, regardless of where the last change was made.
   4. Reusable PLC code blocks:
      a. Develop and use new standard user defined function blocks (UDFBs) and user defined types (UDTs) where appropriate. One instance of each standard code block shall reside in each PLC and shall be referenced in main routines and subroutines.
      b. New code blocks that the Contractor would like to use as a standard shall be submitted to the Owner for review and approval.
   5. Documentation:
      a. All control logic shall be annotated, including rungs, instructions, and tags.
      b. Each routine shall have a title and a detailed description in complete sentences of the control strategy represented by the control logic. Where parameters are passed to the routine, all parameters shall be defined in the routine description. Analog tag descriptions representing process variables shall include the engineering unit range of the analog variable.

c. Digital tag descriptions shall include the On and Off state labels.
d. Analog tag descriptions representing process variables shall include the engineering units' range of the analog variable.
e. Equations developed in the process logic shall be fully documented in the rung or routine description. This description should include a description of each constant and variable utilized in the equation, including engineering units.

6. Setpoints:
   a. Provide an operator selection to save all setpoint values.
   b. Where possible, use a DFB or AOI to provide an operator selection to restore all setpoints to the initial start-up value.
   c. Provide an operator selection to restore all setpoints to the last saved value.
7. Calculated values:
   a. Program calculations such that division by zero errors cannot occur.
   b. Prevent calculations from generating values that exceed the limits of the equipment or data type structures (integers) internal to the PLC.
   c. Configure counting functions (start counts and operation counts) to allow a minimum of 10,000 counts and roll over to zero at an even decimal interval (1 followed by 4 or more zeros).
   d. Configure integrating functions to accurately accumulate the maximum rate from the instrument/equipment (totalizers, run time meters) for 30 years. Utilize manufacturer AOI/DFBs etc., where possible.
8. Timers:
   a. Provide programmable settling and proving timers in control sequences as required for starting and stopping of equipment to allow the process to settle to a steady state before proceeding with any additional control functions:
      1) Settling timers may be overridden by setting the timer to 0 seconds.
9. Control Panel status:
   a. Design the PLC system to function as a stand-alone unit that performs all of the control functions described in this Section completely independent from the functions of the PCS system PC-based operator interfaces:
      1) Failure of the PCS system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.
   b. Furnish a minimum of 1 screen that depicts the status of enclosures containing PLCs, communication equipment, UPS or I/O in the control system, including, but not limited to, the following:
      1) PLC cabinet over-temperatures from high temperature switch.
      2) Intrusion status on enclosures equipped with intrusion switches.
      3) AC power failure:
         a) Monitor ahead of UPS.
      4) DC power supply failure:
         a) For redundant power supplies, alarm when either power supply or the diode bridge fails.
      5) UPS failure signal.
      6) UPS low battery signal.
      7) Digital bus network coupler and or gateway failure signal.
      8) Ethernet switch failure signal.
10. Network link status:
    a. Alarm on the loss of communications between any PLCs (vendor or plant).

b. Provide an HMI and/or OIT screen depicting communication pathways and graphically showing the loss.
c. Use produced/consume tags to monitor PLC to PLC communications.
d. Coordinate with all vendor PLCs so that they match the plant PLC monitoring methods.

11. PLC system communication status:
    a. Furnish a minimum of 1 screen to display communication errors and status within the PCS:
        1) Communication between PCS and PLCs, PLC to PLC, PLC to RIO and PLC and or PCS to VCP.
        2) 4-20 mA HART interface cards.
        3) Network status:
            a) Profibus scanners.
            b) Gateways.
            c) Communication network cards.
            d) Protocol converters.
            e) Modbus gateway modules.
        4) Display the status of each node and a summary of failures over the past 60 minutes.
    b. Generate a communications alarm if a communication fault is detected or there is no response from a node for more than a user-specified time.
    c. In the event of communications loss:
        1) Continue normal operation at each PLC.
        2) Where control parameters are received over a communications link:
            a) If a link fails where process elements use the remote value for closed-loop control, hold operating status, speed, and position of the process elements at their last state before the communication alarm, unless other I/O local to that PLC indicates shutdown or override conditions:
                (1) Ensure the operator can control the process using PCI\S MANUAL mode at the local OIT.
            b) If a link fails where process elements use the remote value to determine setpoints, continue to operate using the last value received:
                (1) Provide a manual override entry at the local OIT to allow an operator to enter a different value for any such remote signal.
                (2) Generate an alarm whenever an override value is in use.

B. Common control functions:
    1. Incorporate common control functions into control loops and devices and into the control programming, whether or not specifically shown in the specific control descriptions or elsewhere in the Contract Documents.
    2. Alarms:
        a. Indicate alarms at the OIT and HMI. Enable acknowledgement from either the HMI or the OIT.
        b. Generate and include the following alarms for all analog or equivalent network signals:
            1) Low.
            2) Low-low.
            3) High.

4) High-high.
5) Out of range.
6) Rate of change.
7) Stale.

c. Indicate alarms at the OIT and HMI. Enable acknowledgment from either the HMI or the OIT.

d. Generate high, high-high, low, and low-low level alarms where indicated:
   1) Provide an alarm reset deadband for each analog value to prevent excessive repeated alarms.
   2) Provide logic and timers to inhibit analog alarms based on process events. For example, inhibit low-flow alarms when a pump is stopped or has not been running long enough to establish flow.

e. Flash alarm and fail conditions and their respective indicators on the PCS graphic screens and local indicating lights until the condition is acknowledged by the operator, even if the alarm condition is no longer present.

f. Once an operator acknowledges the alarm, display alarm conditions in a steady state (not flashing) while the alarm condition is still present:
   1) Flash with a cycle rate of 1/2 second on and 1/2 second off.

g. Once the alarm has been cleared and the operator has acknowledged the alarm or fail condition, turn the graphic alarm indicator off.

h. For alarms that do not have inherent timers, provide an operator-adjustable proving timer to limit nuisance alarms, continuously adjustable from 0 seconds to 100 minutes. The initial setting of proving timers shall be 0 seconds:
   1) PLC shall start the timer when it first detects an alarm condition and only activate it after the timer has expired.
   2) If the alarm condition clears while the timer is running, the timer shall reset, and the alarm shall not be activated.

i. Use interlocks and proving timers to prevent alarms from operating due to power loss, except for loss of power alarms.

j. Furnish an alarm silence pushbutton at each PCM, OIT, or LCP with an audible alarm to signal the PLC to turn off the audible alarm until the next alarm occurs.

k. Lamp test: Furnish lamp test pushbuttons at each control panel with more than 10 pilot lights that illuminate all pilot lights on the panel:
   1) May sequence through blocks of lights.
   2) Minimum on time for each lamp during lamp test 15 seconds.

l. Horns and beacons:
   1) Where indicated in the Contract Documents:
      a) Activate PCM horn and beacon on critical alarms and on other alarms as defined by the Facility Alarm Philosophy.
      b) Deactivate PCM horn and beacon when PCM reset pushbutton is activated.
      c) Silence PCM horn when PCM silence pushbutton is activated.

m. Dual analog instruments:
   1) For applications where 2 or more analog instruments are measuring the same process variable:
      a) Generate an operator adjustable percent deviation alarm.
      b) Allow operator to take each instrument out of service when an instrument is out of service.

3. Where a reset is shown for counts, totals and times maintained in the PLC:
    a. Provide a reset selection on the HMI screen that displays the value.
    b. Provide a preset function on the HMI to allow an operator-entered value to become the accumulated total.
    c. Limit access to the reset and preset functions to operators with suitable security levels.
    d. Log the value before reset, including the operator, time, and reset date in the PCS archive.
    e. Log the value before preset, preset value, operator, time, and date of preset in the PCS archive.
4. Count starts for each piece of equipment (off to on transitions of running status) in the PLC:
    a. Display total starts on PCS screens and provide a reset function.
    b. Calculate the number of starts for each day:
        1) Display current day and previous day starts on PCS displays.
        2) Do not reset daily start count when overall count is reset.
        3) Archive starts for each day through PCS.
    c. Calculate the number of starts per hour. Alarm when the number of starts per hour exceeds the manufacturer limit.
5. Run time accumulation:
    a. Integrate accumulated run time to the nearest 0.1 hour whenever the running status input indicates that the equipment is running.
    b. Display total run time in hours on PCS screens.
    c. Where indicated, calculate the total run time for each day:
        1) Display the current day and the previous day's run time on the HMI to the nearest 0.1 hour.
        2) Do not reset daily run time when overall time is reset.
        3) Archive run time for each day through PCS.
6. For all monitored analog values:
    a. Maintain trends in PCS:
        1) Display minima and maxima on the HMI, and archive through PCS.
    b. Flows and weights:
        1) Totalize flows in the PLC logic:
            a) Where totalized flows are input to a discrete input, count input pulses and multiply by the volume per pulse.
            b) Where no totalizer input is shown, integrate the analog input over time.
            c) Display totals on the HMI and OIT.
            d) Archive totals to the historical database through PCS.
    c. HMI Only - Calculate hourly, daily, and monthly averages:
        1) Display averages on the HMI, and archive through PCS.
        2) Display minima and maxima on the HMI, and archive through PCS.
    d. HMI Only - Calculate minimum and maximum values each day, and month:
        1) PLC or PCS may perform calculations.
        2) Display minima and maxima on the HMI, and archive through PCS.
7. Analog data processing:
    a. Engineering unit conversion:
        1) Use engineering units for all analog point values. Convert analog inputs to engineering units.

b. Analog magnitude checking:
    1) Provide upper and lower limits to prevent operator-entered values (setpoints, etc.) from falling outside acceptable limits.

8. Analog device override (OIT and HMI):
    a. Provide the following functions from the HMI and the local OIT all controlling analog input:
        1) An override value to be used in place of the analog input:
            a) Enter in engineering units:
                (1) Display the calibrated range in engineering units.
                (2) Only allow entries within the calibrated range of the instrument.
            b) When the analog input is enabled, track the analog input so that the override matches the analog input value when the input is initially disabled.
            c) Maintain override status and value in the PLC.
            d) Only allow access to override selections and settings to operators with sufficient security.
        2) An enable/disable selection:
            a) When enabled, the value used by the PCS system is equal to the analog input value.
            b) When disabled, the analog input is ignored, and the override value is used for all control and display functions.
            c) Generate an alarm whenever an analog input is disabled.
            d) Enter a value for the analog input from the PCS system to the PLC.
        3) Use the override value for all display and control functions instead of the actual analog input value.
    b. Provide the following functions in the PLC, with selections and value entry from the HMI and/or OIT:
        1) An override value to be used in place of the normal output value:
            a) Enter the percent of output span.
            b) When the analog output is enabled, track the analog input so that the override matches the analog output value when the output is initially disabled.
        2) An enable/disable selection:
            a) When enabled, the value sent to the output is the value determined by the PLC based on the control logic or operator-entered value in PCS MANUAL.
            b) When disabled, the calculated PCS MANUAL values are ignored, and the override value is sent to the output.
            c) Generate an alarm whenever an analog output is disabled.

9. I/O filtering and processing:
    a. Analog input filtering:
        1) For each analog input, provide an adjustable first-order filter for the purpose of smoothing out spikes and other noise for analog transmitter input signals. By default, configure analog inputs with no filtering effect.
        2) Monitor analog input signal quality:
            a) Over range: Input value is above the normal range (typically over 21 mA).

b) Under range: Input value is below the normal range (typically under 3 mA, indicating a probable broken connection).
c) Generate alarms for over- or under-range inputs.
d) Do not use over- or under-range values for control or calculation purposes:
(1) Where a second instrument is provided to monitor the same condition (a redundant instrument or additional instruments furnished for averaging or different operating modes) and has a valid signal, use that input for control.

3) Digital input filtering (proving timer):
a) Provide an adjustable time delay function (0 to 10 seconds) on discrete input for de-bouncing.
b) By default, discrete inputs shall be configured with de-bounce timers set to zero seconds.

10. Instrument scaling (HMI):
a. Provide 1 or more maintenance screens to display ranges and trigger points for all field instruments:
1) For analog instruments, use input scaling values in the PLC to determine minimum and maximum calibration points.

11. Levels:
a. Level measurements:
1) All level readouts displayed by the HMI, PLC, or SCADA shall be displayed in the actual level of the fluid or plant elevation, whichever the Owner desires.
b. Tank and vessel levels:
1) Display as a level (typically in feet of liquid), volume (typically in gallons) and percentage of rated capacity (percent):
a) Some individual displays may only be level or volume when agreed to by the Owner and Engineer during screen review meetings.

12. PCS MANUAL-AUTO:
a. Where indicated, provide MANUAL-AUTO and START-STOP selections in the PCS, accessed from an OIT or HMI for operators with sufficient security, to provide the following operating modes:
1) PCS AUTO: Normal, automatic control mode of the strategy allows complete PLC control in response to process conditions and programmed sequences.
2) PCS MANUAL: Enables PCS manual control where control decisions are made by an operator through the PCS START-STOP, OPEN/CLOSE, or other selections as indicated.
3) Program the PLC so that switching a strategy between AUTO and MANUAL (either direction) occurs with a smooth transition:
a) Keep running or position status unchanged when control is switched to MANUAL until a change is requested using the operator selections (START, STOP, OPEN, CLOSE).
b) Keep running and position status unchanged when control is switched to AUTO until the control logic determines a change is required.

13. Display the status of all operator selections (PCS MANUAL/AUTO, PCS START/STOP, etc.) on the PCS.

14. Interlocks:
    a. Implement software interlocks as indicated to place equipment in a safe condition in response to impending hazardous process conditions. Apply software interlocks when equipment is operating in PCS AUTO or PCS MANUAL.
15. Permissives:
    a. Implement software permissives where indicated to prevent equipment from starting in an unsafe condition.
    b. Apply software permissives when equipment is operating in PCS AUTO or PCS MANUAL.
16. Process control algorithms:
    a. PID algorithms:
        1) Provide a PID faceplate with the following displays and functions for each PID control algorithm:
            a) Display Output, CV.
            b) Display Setpoint, SP.
            c) Display Process Variable, PV.
            d) Allow for operator selection of automatic or manual control of the output.
            e) Under manual control of output, allow the operator to enter the desired output value.
            f) Allow for input of the 3 proportional, integral, and derivative tuning parameters.
            g) Configure PID loops to prevent reset windup when controlled equipment is operating in manual (local or PCS), or when the equipment has reached a physical limit.
            h) When controlled equipment is being operated in remote PCS MANUAL, configure the PID function to track the process variable to provide a smooth transfer between manual and automatic modes.
            i) Provide selectable slew rates with adjustable setpoints to allow the PID algorithm to slowly ramp to its final value to minimize system disturbance.
17. Equipment alternating and sequencing:
    a. Distribute number of starts and run time equally between identical equipment.
    b. Where multiple pieces of equipment are used to control a single process variable, alternating of lead and lag equipment assignments is done as follows:
        1) Automatic lead/lag equipment selection:
            a) Control system automatically selects the lead equipment and next lag equipment based on the lowest run time hours of the equipment.
            b) When multiple equipment is running, the control system determines which equipment to stop next based on the running equipment with the highest run time hours.
            c) A weighted run-time factor can be assigned to each individual piece of equipment:
                (1) Weighting factor is a percentage from 1 to 100 percent that is multiplied by the actual run time hours of the equipment to create a weighted run time hours of the equipment.

(2) Weighted run time hours of each piece of equipment are then used by the algorithms that select the equipment that will start or stop next.
(3) This is to allow for specific equipment to accrue more run-time hours so that all pumps do not reach their maximum run time hours at approximately the same time:
(a) Display both the weighted and actual runtime hours on the PCS screen.

2) Manual lead/lag selection:
a) Operator will assign the lead, “Next Lag” equipment through a selection matrix in the HMI.
b) When modifying this matrix, modifications shall not become active until an “ACCEPT ALL” software pushbutton is activated.
c) Provide a “CANCEL ALL” software pushbutton to clear all modification of the selection matrix and revert them to the last accepted changes.

18. Motor control:
a. Monitor the device’s LOCAL-OFF-REMOTE (LOR) switch (the hard-wired switch at the MCC, drive or equipment) to determine when the PLC has control of the associated equipment:
1) Display current REMOTE status on the PCS screens.
b. Monitor the device’s running status from the starter auxiliary or run status input:
1) Display the current status (running or stopped) on the PCS screens.
2) Use status to calculate total run time and daily run time, and to count total starts and daily starts.
3) Provide a time stamp for each start.
4) Provide software for motors 200 horsepower and greater to prevent exceeding the manufacturer’s recommended maximum starts per hour.
c. When equipment control has been given to the PLC as reported by the LOCAL-OFF-REMOTE switch, allow selection of PCS AUTO or PCS MANUAL control modes based upon operator selection using the PCS screens.
d. Starting, stopping and running when the device LOR is in LOCAL:
1) With the LOR switch in the LOCAL position, the motor is controlled by the START and STOP pushbuttons.
2) With the LOR switch in the OFF position, the motor is prohibited from running.
3) With the LOR switch in the REMOTE position, the motor is controlled remotely.

e. Starting, stopping, and running when the device LOR is in REMOTE:
    1) When the motor is expected to be running (PLC has issued a START or RUN due to process conditions or operator selection), LOR is in REMOTE, and the device is not reported to be running, start an operator adjustable “Control Activation” timer:
        a) Provide “Control Activation” timers for each piece of controlled equipment:
            (1) If the LOR and required running status do not change, and the PLC does not receive running status within the “Control Activation” time period:
                (a) De-activate the output.
                (b) Place the device in a “Failed” state.
                (c) Generate a “Failed to Respond” alarm.
    2) When the motor is not expected to be running (PLC has issued a STOP or removed the RUN output), LOR is in REMOTE, and the device is reported to be running, start the “Control Activation” timer:
        a) If the LOR and required stopped status do not change, and the PLC does not lose the running status within the “Control Activation” time period:
            (1) Keep the RUN output off or the STOP output on.
            (2) Place the device in a “Failed” state.
            (3) Generate a “Failed to Respond” alarm.
    3) Re-establish PLC control of a device in a “Failed” state only after the following:
        a) An operator turns the device’s LOR switch out of REMOTE, and back to REMOTE (i.e., REMOTE input to the PLC cycles off and back on).
f. Where motor winding high-temperature switches or RTD temperature elements are shown, generate an alarm when a high temperature is sensed (contact opens or temperature above the high alarm setpoint), but do not stop the motor unless otherwise indicated.
g. Motor equipped with current detection shall shut down and report a “failed” status for high current detection.
h. Control 2-speed motors similar to other motors, except as listed below:
    1) Motor states are RUN-FAST, RUN-SLOW, and STOP.
    2) Start 2-speed motors in the RUN-SLOW state. If or when the high speed is required (RUN-FAST operator selection or process conditions), transition to RUN-FAST after a designated time.
    3) When transitioning from RUN-FAST to RUN-SLOW, remove the RUN-FAST output or issue a STOP, then wait for a “Fast to Slow” time delay before energizing the RUN-SLOW or START-SLOW output.
i. Speed control:
    1) Modulate speed on VFD-driven motors using jog and hold, or PID control algorithms to maintain process conditions as described in the specific loop descriptions.
    2) Operate speed control within a pre-defined range:
        a) Minimum speed as determined by equipment manufacturer. The higher of:
            (1) Minimum motor speed to maintain adequate cooling for the type of load driven (constant or variable torque).

(2) Minimum equipment speed, such as minimum speed to deliver flow or to deliver minimum flow for equipment cooling or lubrication.

b) Maximum speed 100 percent (60 hertz) or as identified by the equipment manufacturer.

c) Scale analog signals to control speed at 0 to 100 percent of the operable speed range for the equipment.

3) Where multiple equipment may operate together to maintain the same process condition, alternatively referred to as “Lead/Lag”:

a) Start the first equipment at a preset starting speed.

b) When one or more of the equipment is running and the speed control algorithm reaches a preset “Start Next” speed value (initially 95 percent of speed range) through a preset time delay:

(1) Start the next available equipment at the preset starting speed.

(2) Ramp up the started equipment and ramp down the previously running equipment to the mid operating speed (adjustable in the PLC). Determine preset values for each condition based on equipment and system characteristics to provide approximately the same total flow or process condition with the new load running at the mid speed (for example if 1 pump is running and the second pump will be added, then the total flow of both pumps running at mid operating speed should be approximately the same as the flow of 1 pump at Start Next speed).

(3) Once both pieces of the equipment reach the mid-operating speed, resume the speed control algorithm for that equipment.

(4) Operate equipment at the same speed following the output of the speed control algorithm.

c) When two or more pieces of equipment are running, monitor for a “Stop Next” condition:

(1) Where the flow rate is monitored, use a preset “Stop Next” flow rate for each possible number and combination of equipment:

(a) Determine the initial “Stop Next” speed based on the flow that can be provided with one fewer piece of equipment running at a speed slightly below the “Start Next” speed.

(2) When the “Stop Next” condition exists through a preset time delay:

(a) Ramp speed of running equipment, except for the equipment to be stopped up to a preset value based on the number of items running. Determine preset values for each condition based on equipment and system characteristics to provide approximately the same total flow or process condition with 1 fewer load running (typically slightly below the preset “Start Next”

speed) while ramping speed of equipment to be stopped down to the preset minimum speed.

(b) Operate remaining equipment at the same speed following the output of the speed control algorithm. Stop the load once it reaches minimum speed.

19. Gate and valve control:
    a. Monitor the device's LOCAL-STOP-REMOTE (LSR) switch(es) (the integral switch in the actuator or hard-wired switch at the local control station):
        1) Display current REMOTE status on PCS screens.
    b. Start an "Open Activation" timer whenever the device is expected to be open (PLC has issued an OPEN command in PCS AUTO, or OPEN was selected in PCS MANUAL):
        1) Initially set "Open Activation" time to twice the normal opening time.
        2) If the LSR position and open command do not change, and the PLC does not receive fully open status feedback within the "Open Activation" time period:
            a) De-activate the open output.
            b) Place the device in a "Failed" state.
            c) Generate a "Failed to Open" alarm.
    c. Start a "Close Activation" timer whenever the device is expected to be closed (PLC has issued a CLOSE command in PCS AUTO, or CLOSE was selected in PCS MANUAL):
        1) Initially set "Close Activation" time to twice the normal closing time.
        2) If the LSR position and close command do not change, and the PLC does not receive fully closed status feedback within the "Close Activation" time period:
            a) De-activate the close output.
            b) Place the device in a "Failed" state.
            c) Generate a "Failed to Close" alarm.
    d. Limit the number of open/close commands so that it does not exceed the manufacturer requirements.
    e. For modulating valves (valves controlled from either a 4-20 mA signal or digital communications command) with position feedback, start a "Position Error" timer whenever the position feedback differs from the required position command by more than a setpoint error when the LSR is in REMOTE:
        1) For analog modulating devices, the error is determined by position feedback differing from position command by more than the setpoint error.
        2) For discrete modulating devices, error is determined by feedback not changing in the correct direction or changing at less than a setpoint rate when the OPEN or CLOSE PLC output is active.
        3) Initially, set the "Position Error" time to 60 seconds.
        4) If the LSR position does not change, and the position error stays outside of the setpoint error through the "Position Error" time period:
            a) Place the device in a "Failed" state.
            b) Generate a "Position Fail" alarm.
    f. Provide separate time delay settings for each function and for each device.

g. If the valve position inputs indicate an invalid state (i.e., valve open and closed at the same time), place the device in a “Failed” state and generate an “Invalid State” alarm.
h. Re-establish PLC control of a device in a “Failed” state after the following:
1) An operator turns the device’s LSR switch out of REMOTE and back to REMOTE (i.e., REMOTE input to the PLC cycles off and back on).
i. For all alarm conditions, control other devices (as stopping pumps, etc.) as stated in the individual loop descriptions to make the system safe.
j. For discrete modulating valves (valves positioned to intermediate positions to control process values through discrete OPEN and CLOSE outputs), count the number of actuations (OPEN or CLOSE commands) per hour in the PLC:
1) Display count on the HMI.

20. Chemical systems (OIT/HMI):
a. Provide the following chemical system screens:
1) Where 1 OIT manages more than 1 chemical system, a main menu screen will allow the operator to access the individual chemical system screens using software keys.
2) One or more screens for each individual chemical system controlled at that location, containing:
a) All status displays (running, failed, etc.).
b) Selections (lead/lag, which process flow to pace to, etc.).
c) Setpoint entry and display.
d) Calculated feed requirement (result of flow pacing calculation) in engineering units (typically milligrams of chemical per minute).
e) Output signal to feeder in percent of full span.
f) Actual chemical flow rate from flowmeter (where shown).
g) Process flow rate(s) used to pace each chemical on the individual chemical screens (PROC FLOW):
(1) Where different process flows can be selected for flow pacing, display and identify the selected source.
b. Chemical system calculations: Perform calculations as indicated on the Drawings and in the individual loop descriptions. Use the following assumptions, unless otherwise noted:
1) Where chemical flow feedback is not used, assume feeder output is linear in response to control signal.
2) Zero signal (typically 4 mA) produces zero flow.
3) Perform flow-pacing calculations using as indicated on the Drawings or described in the individual loop descriptions.
c. Provide the setpoints indicated on the Drawings and in the individual loop descriptions. Typical setpoints include:
1) Q_C: Chemical pump flow rate measured from calibration column at maximum feeder output (typically in gallons of solution per hour).
2) D: Desired chemical concentration in the process stream in engineering units (typically milligrams of chemical per liter of process fluid).
3) Q_f: Process flow measurement upstream of dosage point (typically in million gallons per day of process fluid).

4) ρ: Density of the chemical solution to be fed (typically in pounds per gallon). Used to calculate the concentration of the chemical in the solution.
5) C: Concentration of the chemical in the solution to be fed (typically in decimal format. For example, 0.25 for 25 percent chemical solution).

d. Provide the selections indicated on the Drawings and in the individual loop descriptions. Typical selections include:
1) OPEN/CLOSED LOOP:
a) Selection of method of controlling chemical flow-paced feed rate.
b) OPEN LOOP: Signal to feeder is based on feeder calibration (Q_C) to deliver calculated chemical solution feed rate. Chemical solution flowmeter is not used for control.
c) CLOSED LOOP: Chemical feed rate is directly controlled using the calculated chemical solution feed rate as the setpoint, and the flow rate from the chemical solution flowmeter as the process variable.
2) TRIM FACTOR: Refer to the equations below.

e. Chemical control algorithms:
1) Flow pacing algorithm:
a) Operator selects a desired dose, and the control system adjusts the chemical feed rate to dose based on process flow, chemical concentration, and feeder calibration.
b) Calculation is as follows (units may vary from those shown in the calculation below):

Use the following equation to calculate the chemical pump flow rate:

$$Q_C = \frac{D \cdot Q_f \cdot 8.34}{C \cdot p \cdot 24}$$

Where:
Q_C = Chemical Pump Flow Rate (gal/hr).
D = Dose setpoint (mg/L).
Q_f = Process Flow Measurement (MGD).
8.34 = Conversion Factor [(lbs • L)/(MG • day • mg)].
C = Chemical Concentration (ratio in decimal format. For example, use 0.25 for 25 percent chemical solution).
p = Chemical Density (lbs/gal).
24 = Conversion Factor (days to hours).

Use the following equation to calculate the chemical pump speed control setpoint:

$$S = \frac{Q_C}{Q_{max}}$$

Where:
S = Chemical Pump Speed Control Setpoint (0 to 100 percent).
Q_C = Flow Setpoint From Equation Above (gal/hr).
Q_{max} = Maximum Pump Flow Setpoint Based on Calibration Column Test (gal/hr).

2) Flow pacing with closed loop algorithm:
   a) Operator selects a desired dose, and the control system adjusts the speed of the chemical feeder through a speed control signal to match the measured chemical feed rate to a flow rate setpoint.
   b) This flow rate setpoint shall be derived from the process flow and operator setpoints for dosage and concentration.
   c) Calculation is as follows (units may vary from those shown in the calculation below):

   Use the following equation to calculate the chemical pump flow rate:

   $$Q_C = \frac{D \cdot Q_f \cdot 8.34}{C \cdot p \cdot 24}$$

   Where:
   Q_C = Chemical Pump Flow Rate (gal/hr).
   D = Dose setpoint (mg/L).
   Q_f = Process Flow Measurement (MGD).
   8.34 = Conversion Factor [(lbs • L)/(MG • day • mg)].
   C = Chemical Concentration *(ratio in decimal format. For example, use 0.25 for 25 percent chemical solution).*
   p = Chemical Density (lbs/gal).
   24 = Conversion Factor (days to hours).

3) The speed (control variable) of the chemical feed pump shall be determined by the output of a PID controller:
   a) Setpoint of the PID controller shall be the result of the equation in the paragraph above.
   b) Process variable (feedback) shall be the chemical feed flow as measured by a flow meter on the discharge of the chemical feed pump.
4) Flow pacing with analyzer trim algorithm:
   a) Operator selects a desired dose and desired analyzer setpoint band and the control system adjusts the chemical feed rate to dose based on process flow, chemical concentration, process analyzer output, and feeder calibration.
   b) Calculation is as follows (units may vary from those shown in the calculation below):

   Use the following equation to calculate the chemical pump flow rate pre-trim:

   $$Q_{CPT} = \frac{D \cdot Q_f \cdot 8.34}{C \cdot p \cdot 24}$$

   Where:
   Q_{CPT} = Chemical Pump Flow Rate Pre-Trim (gal/hr).
   D = Dose setpoint (mg/L).
   Q_f = Process Flow Measurement (MGD).
   8.34 = Conversion Factor [(lbs • L)/(MG • day • mg)].
   C = Chemical Concentration (ratio in decimal format. For example, use 0.25 for 25 percent chemical solution).
   p = Chemical Density (lbs/gal).
   24 = Conversion Factor (days to hours).

Use the following equation to calculate the trim factor:

$$TF = Q_{CPT} \cdot 0.1 \cdot \left(\frac{AI - \frac{1}{2}(QAH + QAL)}{-\frac{1}{2}(QAH - QAL)} \right)$$

Where:
TF = Trim Factor (gal/hr).
Q_{CPT} = Chemical Pump Flow Rate Pre-Trim (gal/hr).
AI = Analyzer Output to be Used For Trim Calculation.
QAH = Analyzer Band High Value.
QAL = Analyzer Band Low Value.

Use the following equation to calculate the chemical pump flow rate with trim:

$$Q_{CWT} = Q_{CPT} + TF$$

Where:
Q_{CWT} = Chemical Pump Flow Rate with Trim (gal/hr).
Q_{CPT} = Chemical Pump Flow Rate Pre-Trim (gal/hr).
TF = Trim Factor (gal/hr).

Use the following equation to calculate the chemical pump speed control setpoint:

$$S = \frac{Q_{CWT}}{Q_{max}}$$

Where:
S = Chemical Pump Speed Control Setpoint (0 to 100 percent).
Q_{CWT} = Flow Setpoint from Equation Above (gal/hr).
Q_{max} = Maximum Pump Flow Setpoint Based on Calibration Column Test (gal/hr).

5) Flow pacing with closed loop and analyzer trim algorithm:
   a) Operator selects a desired dose and desired analyzer setpoint band and the control system adjusts the speed of the chemical feeder through a speed control signal to match the measured chemical feed rate to a flow rate setpoint.
   b) An additional control algorithm is used in the calculation to fine-tune the feed based on an analytical measurement as measured by the process analyzer.

Use the following equation to calculate the chemical pump flow rate pre-trim:

$$Q_{CPT} = \frac{D \cdot Q_f \cdot 8.34}{C \cdot p \cdot 24}$$

Where:
Q_{CPT} = Chemical Pump Flow Rate Pre-Trim (gal/hr).
D = Dose setpoint (mg/L).
Q_f = Process Flow Measurement (MGD).
8.34 = Conversion Factor [(lbs • L)/(MG • day • mg)].
C = Chemical Concentration (ratio in decimal format. For example, use 0.25 for 25 percent chemical solution).
p = Chemical Density (lbs/gal).

24 = Conversion Factor (days to hours).

Use the following equation to calculate the trim factor:

$$TF = Q_{CPT} \cdot 0.1 \cdot \left(\frac{AI - \frac{1}{2}(QAH + QAL)}{-\frac{1}{2}(QAH - QAL)} \right)$$

Where:
TF = Trim Factor (gal/hr).
Q_{CPT} = Chemical Pump Flow Rate Pre-Trim (gal/hr).
AI = Analyzer Output to be Used For Trim Calculation.
QAH = Analyzer Band High Value.
QAL = Analyzer Band Low Value.

Use the following equation to calculate the chemical pump flow rate with trim:

$$Q_{CWT} = Q_{CPT} + TF$$

Where:
Q_{CWT} = Chemical Pump Flow Rate with Trim (gal/hr).
Q_{CPT} = Chemical Pump Flow Rate Pre-Trim (gal/hr).
TF = Trim Factor (gal/hr).

6) The speed (control variable) of the chemical feed pump shall be determined by the output of a PID controller:
   a) Setpoint of the PID controller shall be the result of the equation in the paragraph above.
   b) Process variable (feedback) shall be the chemical feed flow as measured by a flow meter on the discharge of the chemical feed pump.

f. Virtual day tanks:
   1) Chemical systems without actual day tanks will have their own “virtual” day tank, which will use either a pre-set volume (operator adjustable) or a calculated daily use rate based on the totalized flow (volume) of the chemical magnetic flowmeters over the virtual day tank cycle:
      a) The “virtual” day tank will start at the pre-set volume or the calculated volume (operator-selectable) and based on the storage tank level, the volume in the “virtual” day tank will decrease until the total “volume” in the virtual day tank is used.
      b) Virtual day tank will automatically compensate for any changes in the system due to the use of the dilution system (revised solution concentration).
      c) Once this occurs, the operator will be provided with a “pop-up” screen stating that the “virtual” day tank volume is used.
      d) Once this occurs, the operator will be provided with a “pop-up” screen stating that the virtual day tank needs to be refilled. Pop-up screen will contain the following information:
         (1) Time {hours and minutes} since the last day tank filling.
         (2) Volume utilized in the “virtual” day tank (based on the level transmitter measuring the chemical storage tank).
         (3) Dose {mg/L} based on the average flow rate over the “virtual” day tank cycle.
         (4) Target dose {mg/L} based on operator input.

2) Provide a double check using the actual flowmeter values to compare with the calculated dose:
    a) Compare the magnetic flowmeter value with the calculated dose.
    b) Magnetic flowmeter value will be based on an hourly average of chemical flow rate over the day tank cycle.
3) As an added level of control any chemical system that has an analyzer used for feedback will be tracked and alarmed if outside the operating parameters.
4) Alarm if any condition falls outside of the flow, or level parameters.

21. Breaker status:
    a. Display the following data to the extent it is available from the specified device:
        1) Open.
        2) Closed.
        3) Tripped.
        4) Ground fault.
        5) Settings.
        6) Racked out.
22. Power data:
    a. Retrieve data from:
        1) Power quality meters (PQM) at 480 V.
        2) Main breaker protective relays on 12.47 kV switchgear.
        3) Generator master control panel.
        4) Digital bus networks, as indicated.
        5) Where available, use EtherNet IP communications.
    b. Display the following data (to the extent it is available) from the specified device:
        1) Current XXXX.X A:
            a) A-Phase.
            b) B-Phase.
            c) C-Phase.
        2) Volts: XXXX.X V:
            a) A-Phase.
            b) B-Phase.
            c) C-Phase.
        3) Reactive power: XXXX.X kVAR.
        4) Real power: XXXX.X kW.
        5) Apparent power: XXXX.X kVA.
        6) Power factor: 0.XX.
        7) Energy: XXXXXXX kW*hr.
        8) Demand peak: XXXX amp.
        9) Demand peak: XXXX kW.
    c. For engine/generator system monitoring, also display percent of rated output.
23. Power supply and distribution displays power quality meters display:
    a. In addition to the power data listed above, display the following (where available) from PQMs, protective relays, and generator master control panel:
        1) Frequency: Hertz.
        2) THD (current and voltage): Up to 31st harmonic.

b. Calculate, indicate, historize, and trend data in a 12.47 kV meter table that lists measurements from the following protection relays:
    1) Protection Relay on 52-G1.
    2) Protection Relay on 52-G2.
    3) Protection Relay on 52-M1.
    4) Protection Relay on 52-M2.
    5) Protection Relay on 52-M3.
    6) Display calculated values for “Load At 12.47 kV”, which sums the current, kW, and kW-hr values for all 5 protection relays.
    7) Display calculated values for “Load At 480 V”, which sums the current, kW, and kW-hr values for all PQM meters.
    8) Display calculated values for “Transformer and Line Losses”, which subtracts “Load at 480 V” from “Load At 12.47 kV” for current, kW, and kW-hr values for all PQM meters.
c. Display the data in a 480 V meter table that lists measurements from all power quality meters on the plant.

24. Digital bus starters, RVSS and VFDs equipped with EtherNet IP communications:
    a. Communicate and display all values listed in the equipment specifications, indicated on the Drawings, or listed below.
    b. Communicate start and stop commands and receive running feedback over the fieldbus network.
    c. Provide data entry screen for the cost of electricity in dollars per (kw*hr), which will be used in calculations for display.
    d. Monitor the following additional values, and display on the HMI:
        1) Motor current, phase A, B, and C.
        2) Over current alarm.
        3) Under current alarm.
        4) Running status.
        5) Phase loss.
        6) Stall.
        7) Number of starts.
        8) History of past 5 trips.
    e. Calculate, indicate, historize, and trend, the following additional values:
        1) Full Load Amps (static value; Engineer will provide).
        2) Average Motor Operating Current.
        3) Run Time (Hours).
        4) Operating Hours (Hours/Year).
        5) Average Load Factor (equals Average Motor Current Operating Current/Full Load Amps) - *display as a percentage.*
        6) Annual Energy Use (kW*hr).
        7) Annual Operating Cost (dollars).
        8) Percent of Site Electric Use (equals Annual Energy Use/Sum of Annual Energy (kW*hr) values for all PQM meters).
    f. For variable frequency drives:
        1) Speed command.
        2) Speed feedback.
    g. For RVSS, variable frequency drives, and where otherwise shown or available, monitor the following over the digital bus network:
        1) Line voltage.
        2) Power.

3) Power factor.
4) Over voltage alarm.
5) Under voltage alarm.
6) Over current alarm.
7) Under current alarm.
8) Indicate, historize, trend, and alarm data as indicated on the Drawings.

25. Calculate, indicate, historize, and trend plant-wide calculated values for kW by the following groups.
    a. Calculated values (summed from starter data for all equipment within the groups identified below):
        1) Demand peak: XXXX amp.
        2) Demand peak: XXXX kW.
        3) Electric Power Consumption, by Process Group (kW): XXXX kW.
        4) Electric Power Consumption, by Process Group (percent): XX.XX percent (equals Electric Power Consumption, by Process Group (kW)/Sum of Electric Power Consumption on all 480 V Meters).
        5) Electric Energy Consumption, by Process Group (kW*hr): XXXX kW*hr.
        6) Electric Energy Consumption, by Process Group (percent): XX.XX percent (equals Electric Energy Consumption, by Process Group (kW)/Sum of Electric Energy Consumption on all 480 V Meters).
    b. Display a Process Energy Consumption Table that lists the calculated values for each of the identified groups.
    c. Display a Process Energy Pie Graph that portions wedges according to the values calculated in Electric Energy Consumption, by process group (5). Label wedges (with numeric percentage), for groups to cover at least 90 percent of the Pie Graph. Remainder wedge of pie graph area can be labelled as “Other” (with numeric percentage).
26. Instruments equipped with digital bus communications:
    a. Communicate and display all values listed in the equipment specifications, indicated on the Drawings, or listed below:
        1) Instrument diagnostics.
        2) Communications health.
        3) Process variable.
        4) Alarm summary.
        5) All totalizers (if applicable).
        6) Indicate, historize, trend, and alarm data as indicated on the Drawings.
27. Valves and gate operators equipped with digital bus communications:
    a. Communicate and display all controls and data listed in the equipment specification, as indicated on the Drawings, or listed below:
        1) Open, close, or direct position commands.
        2) Fully open and closed status.
        3) Position.
        4) High torque, overload and other applicable alarms.
        5) Indicate, historize, trend, and alarm data as indicated in the Drawings.
    b. Establish initial torque curves using manufacturer’s software for performance tracking and wear.

28. Power failure:
    a. Retain all operating setpoints during power failure.
    b. Restore plant operation to the state it was before the power loss:
        1) Store the operating state of all major equipment and systems in the PLC and retain the last state during a power loss.
    c. Provide an operator selection to permit the plant to re-start. Once re-start is selected:
        1) Allow plant loads to re-start and allow loads to sequence on and ramp up following normal control logic. Where loads were operating in PCS MANUAL, restore their operation to the state before the power loss.
        2) Use the logic described above for preventing concurrent starts to provide necessary delays between each start.
    d. Operating on generator power:
        1) Include running and starting kW and kVA requirements for each major equipment and system in registers in the PLC:
            a) Where running load can vary due to speed, valve position, etc., use the normal starting value plus 25 percent of the difference between the maximum and minimum values.
        2) Inhibit starting of loads from process control logic and from operator selection (in PCS MANUAL) that will exceed generator capability.

3.02 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training.

END OF SECTION

SECTION 40_61_16.08

SPECIFIC CONTROL STRATEGIES – BELTZ 8

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loop descriptions for Well 8 operating modes.
      a. Well 8 - Off (All Stop) and Trickle Flow (Maintenance) Mode.
      b. Well 8 - Extraction (Recovery) Mode.
      c. Well 8 - Injection (Recharge) Mode.
      d. Well 8 - Well Flush to Storm Drain Mode.
   2. Loop description for Well 8 Backwash/Reclaim tank operating modes.
      a. Well 8 Backwash/Reclaim Tank to Storm Drain Mode.

1.02 REFERENCES

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Abbreviations:
   1. bgs = below ground surface.

C. Definitions:
   1. Loop description: Specific control requirements and functional descriptions for individual control loops.

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Develop detailed loop descriptions based on the information in the Contract Documents:
   1. Submit loop descriptions with all implemented modifications from this Section clearly marked.
   2. Remove all markings on final loop descriptions submitted with the applicable operation and maintenance manuals.

1.04 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 WELL 8 - OFF (ALL STOP) AND TRICKLE FLOW (MAINTENANCE) MODE

A. General:
   1. References:
      a. 8N03.
      b. 8N04.
      c. 8N05.
      d. 8N06.
      e. 8N07.
   2. Key equipment:
      a. Downhole Flow Control Valve DHCV-9905130.
      b. Injection (Recharge) Valve BFV-9905110.
      c. Extraction (Recovery) Valve BFV-9905020.
      d. Flush to Storm Drain Valve BFV-9905030.
      e. Well Pump PMP-9905010.
      f. Manual Well Isolation Valve GV-9905010.
      g. Manual Trickle Flow Valve.
      h. Backwash Reclaim Tank to Storm Drain Valve BFV-9905050.
      i. Manual Flush to Reclaim Tank Valve GV-9905021.
   3. Abstract:
      a. Begin in any of these operational modes:
         1) Well Extraction (Recovery) Mode.
         2) Well Injection (Recharge) Mode.
         3) Well Flush to Storm Drain Mode.
         4) Well Flush to Reclaim Tank Mode.
      b. For OIT operation, Select the Off (All Stop) Mode on the Local Operator Interface (OIT) Screen.
      c. Depending on the current operating mode, PLC-8 will perform the following actions or verify that the following conditions already exist in the following order:
         1) Shut off the Well Pump.
            a) Operate the following valves in sequence. When the valve is in the desired full open/close position, then switch to the next valve without delay.
               (1) Close Downhole Flow Control Valve DHCV-9905130.
               (2) Close Injection (Recharge) Valve BFV-9905110.
               (3) Close Extraction (Recovery) Valve BVF-9905020.
               (4) Close Flush to Storm Drain Valve BFV-9905030.
               (5) Stop Well Pump PMP-9905010.
               (6) Close Backwash Reclaim Tank to Storm Drain Valve BFV-9905050.
         2) Operator to manually check that the Manual Well Isolation Valve (GV-9905010) is open.
         3) An Operator can also manually place the Well in Off mode by following the same sequence.

d. While in Off mode, an Operator can manually enable the Trickle Flow Mode.
    1) Open the Manual Trickle Flow Valve to adjust flow.
    2) Trickle flow is monitored and totalized with FM-9905120.
e. End in Off (All Stop) Mode.

B. Hardwired controls:
1. Pilot devices:
    a. Field:
        1) Motorized Valve Controls:
            a) Local-Stop-Remote Switch.
            b) Open-Stop-Close Switch.
    b. Drive/starter enclosure:
        1) Local-Off-Remote Switch.
        2) Stop Pushbutton.
        3) Start Pushbutton.
        4) Speed Potentiometer.
        5) Equipment Shutdown Pushbutton.
        6) Reset Pushbutton.
    c. VCP:
        1) None.
2. Interlocks:
    a. Drive/starter enclosure:
        1) Moisture.
        2) Overtemperature.
3. Indicators and alarms:
    a. Field:
        1) Motorized Valve Controls:
            a) Open Indication.
            b) Closed Indication.
            c) Failed Indication.
    b. Drive/starter enclosure:
        1) Running indication.
        2) Failed Alarm.
        3) Speed Indication.
    c. VCP:
        1) None.

C. OIT control:
1. Manual mode:
    a. Manual controls for each valve, motor, and control system shall be provided on the OIT screen.
2. Auto mode:
    a. As described in the Abstract.
3. Indicators and alarms:
    a. Refer to Abstract, Drawings and Section 40_61_15 - Control Strategies for indicators and alarms.
    b. Additional indicators and alarms:
        1) N/A.

D. PCS (SCADA) controls:
    1. The Operators at GHWTP shall be able to command the well site to off mode at the HMI.

3.02 BELTZ 8 - EXTRACTION (RECOVERY) MODE

A. General:
    1. References:
        a. 08N04.
        b. 08N05.
        c. 08N06.
    2. Key equipment:
        a. Flush to Storm Drain MOV BFV-9905030.
        b. Manual Flush to Reclaim Tank Valve GV-9905021.
        c. Manual RAW to WTP Aeration Tank GV-9905022.
        d. Well Pump PMP-9905010.
        e. Level Transmitter LIT-9905010.
        f. Flush to Storm Drain Flow Meter FM-9905030.
        g. Extraction (Recovery) MOV BFV-9905020.
        h. Extraction (Recovery) Flow Meter FM-9905020.
        i. Pressure Switch High PSH-9905010B.
    3. Preset adjustable inputs: (Note that these are starting points for adjustable inputs and are subject to change during startup and testing.)
        a. Input - Minimum Liquid Level 100 feet bgs. (Low pumping water surface elevation and top of well screen.)
        b. Input - Well Pump Start Speed ## percent. (To be determined during startup and testing.)
        c. Input - Pre-Extraction Flush Rate to Storm Drain/Reclaim Tank 565 gpm +/- 15%..
        d. Input - Pre-Extraction Flush Time to Storm Drain/Reclaim Tank 03:00 mm:ss.
        e. Input - Extraction (Recovery) Rate 565 gpm +/- 15%.
        f. Input - Extraction (Recovery) Run time 24:00 hh:mm.
        g. Input - Pressure Switch High Delay 00:00 mm:ss.
    4. Abstract:
        a. Begin in Off (All Stop) Mode:
            1) Verify that all motor operated valves are closed, the equipment is stopped, and the manual well isolation valve GV-9905010 is open.
        b. BWTP control, a relay output from BWTP will call Well 8 to run in extraction (recovery) mode. Start and shut down sequence will be as described below for OIT controls except the well pump will continue to run as long as the BWTP relay output is energized.
        c. For OIT controls, Select the Extraction (Recovery) Mode and select the Pre-Extraction Flush Rate Mode “Storm Drain” or “Reclaim Tank” on the Local Operator Interface (OIT) Screen. The PLC will operate as described below. An Operator can also manually run the well in extraction mode by following the same sequence manually.
            1) Before starting extraction (recovery) mode the well will be run through the pre-extraction flush to either storm drain (if constructed) or reclaim tank mode for a short period of time then switch over to extraction (recovery) mode.

2) Before selecting the Pre-Extraction Flush to Storm Drain mode, the operator must add Dechlorination Tablets to the basket if they are needed.
3) When the Pre-Extraction Flush to Reclaim Tank mode is selected, The Operator will need to manually open the Reclaim Tank Valve GV-9905021 and close the existing valve to the treatment plant GV-9905022.

d. Open Flush to Storm Drain MOV BFV-9905030:
1) Option: Prior to entering extraction (recovery) mode the well will be purged to either storm drain or to the backwash/reclaim tank. The control strategy below is pumping pre-extraction (recovery) flow to storm drain. For optional control strategy substitute the following control strategy for flush to storm drain with flush to backwash/recovery tank.
2) Check if flush to storm drain valve is fully open.
a) If yes, then start well pump.
b) If no, then stop process go to off (all stop) mode and send alarm.
c) Physically verify valve position to clear error and start process.

e. Start Well Pump PMP-9905010:
1) Start well pump and ramp up to the start speed over an operator adjustable time period initially set at 30 sec.
a) Input - Well Pump Start Speed initially set at 60 percent.
(1) The speed setting will be determined during start up and is operator adjustable.
(2) VFD ramp time to the Start Speed is operator adjustable and initially set at 30 sec.
b) If the system exceeds the preset pressure at Pressure Switch High PSH-9905010B, then stop pump, go to off (all stop) mode, and send alarm.
(1) Verify maximum distribution system pressure, pump dead head pressure, and maximum line pressure.
2) Continuously monitor that Level Transmitter LIT-9905010 is above preset minimum liquid level while the pump is running.
a) Input - Minimum Liquid Level Initially set at 100 feet bgs. Operator adjustable.
b) If groundwater level drops below minimum liquid level, then stop pump, go to off (all stop) mode, and send alarm.

f. Increase well pump speed and maintain preset pre-extraction flush rate.
1) The pre-extraction flush rate is equal to the backflush extraction rate 565 gpm but could be set differently so keep as separate preset inputs.
2) Input - Pre-Extraction Flush Rate to Storm Drain 565 gpm. Operator adjustable.
3) Maintain preset pre-extraction flush rate by adjusting well pump motor speed and signal from Flush to Storm Drain Meter FIT-9905030 or Flush to reclaim tank FIT-9905020.

4) Run well pump at pre-extraction flush rate for a for a preset time.
a) Determine flush time during startup and testing as the time needed for the well to run clear or a manufacturer minimum pump run time of 2 minutes.
b) Input - Pre-Extraction Flush Time to Storm Drain initially set at 03:00 mm:ss. Operator adjustable.

g. Decrease well pump speed from the pre-extraction flush rate down to the extraction rate.
1) The extraction rate was determined during pilot testing as 565 gpm +/- 15%.
2) Input - Extraction (Recovery) Rate 565 gpm.
3) Maintain preset extraction rate by adjusting well pump motor speed and signal from Extraction (Recovery) Flow Meter FM-9905020.

h. Open Extraction MOV BFV-9905020 valve and Close flush to storm drain valve.
1) First open the extraction (recovery) valve. After the extraction valve is fully open, close the flush to storm drain valve.
2) Check if extraction (recovery) valve is fully open.
a) If yes, then continue running well pump.
b) If no, then return to All Stop mode and send alarm.
c) Physically verify valve position to clear error and start process.
3) Check if flush to storm drain valve is fully closed.
a) If yes, then continue running well pump.
b) If no, then return to All Stop mode and send alarm.
c) Physically verify valve position to clear error and start process.

i. Run well pump for preset adjustable run time or until manually turned off.
1) Input - Extraction (Recovery) Run time 24:00 hh:mm.

j. Stop Extraction (Recovery) Mode:
1) Stop extraction (recovery) mode when preset run timer ends.
2) Stop extraction (recovery) mode when stop button is pushed.

k. Open Flush to Storm Drain valve BFV-9905030.

l. Close extraction (recovery) valve BFV-9905020.
1) Check if extraction (recovery) valve is fully closed.
a) If yes, then continue with no change.
b) If no, then send alarm.
(1) If valve is not fully closed, then there is still a single check valve to help prevent the water from backflowing into the well. The valve should be closed manually.
(2) Physically verify valve position to clear error and start process.

m. Stop well pump.

n. End in Off (All Stop) Mode.

B. Hardwired controls:
1. Pilot devices:
a. Field:
1) Motorized Valve Controls:
a) Local-Stop-Remote Switch.
b) Open-Stop-Close Switch.

b. Drive/starter enclosure:
1) Local-Off-Remote Switch.

2) Stop Pushbutton.
3) Start Pushbutton.
4) Speed Potentiometer.
5) Equipment Shutdown Pushbutton.
6) Reset Pushbutton.

c. VCP:
1) None.

2. Interlocks:
a. Drive/starter enclosure:
1) Moisture.
2) Overtemperature.

3. Indicators and alarms:
a. Field:
1) N/A.

b. Drive/starter enclosure:
1) Running indication.
2) Failed Alarm.
3) Speed Indication.

c. VCP:
1) None.

C. OIT control:
1. Manual mode:
a. N/A.

2. Auto mode:
a. As described in the Abstract.

3. Indicators and alarms:
a. Refer to Abstract, Drawings and Section 40_61_15 - Control Strategies for indicators and alarms.
b. Additional indicators and alarms:
1) While the well pump is running, if the water level goes below the minimum level setpoint, shut down the pump and alarm on low level.

D. PCS controls:
1. N/A.

3.03 BELTZ 8 - INJECTION (RECHARGE) MODE

A. General:
1. References:
a. 8N03.
b. 8N04.
c. 8N05.
d. 8N06.

2. Key equipment:
a. System Pressure Transmitter PIT-9905111
b. Downhole Flow Control Valve DHCV-9905130.
c. Level Transmitter LIT-9905010.
d. Injection (Recharge) Flow Control Valve BFV-9905110.
e. Injection (Recharge) Flow Meter FM-9905110.
f. Column pipe recharge pressure PIT-990510A

3. Preset adjustable inputs. (Note that these are starting points for adjustable inputs and are subject to change during startup and testing.)
    a. Input - Maximum Liquid Level 70.8 ft bgs.
    b. Input - Injection (Recharge) Rate 375 gpm +/- 15%.
    c. Input - Injection (Recharge) Run time 08:00 hh:mm.
    d. Input - Distribution System Low Pressure 55 psi.
    e. Input – H Strainer High Differential Pressure 110 psi.
4. Abstract:
    a. Begin in Off (All Stop) Mode:
        1) Verify that all motor operated valves are closed, the equipment is stopped, and the manual well isolation valve is open.
    b. For OIT controls, Select the Injection (Recharge) Mode on the Local Operator Interface (OIT) Screen. The PLC will operate as described below. An Operator can also manually run the well in Injection (Recharge) mode by following the same sequence manually.
        1) If the water in the potable water line has been stagnant for a while the WTP Operations group may decide to manually flush the potable water line for a time prior to injecting water down the well. This is a fully manual process.
        2) Refer to Potable Water Line Flush Mode for directions.
    c. Verify that the Downhole Flow Control Valve DHCV-9905130 is closed:
        1) Downhole flow control valve is at fully close setpoint pressure.
            a) During startup and testing the pressure required to fully close the downhole control valve will be determined. An additional amount of pressure will be added to insure the valve is fully closed. For example, if 200 psi is required to fully close the valve, then the manufacturer’s representative may add 50 psi for a total preset closed pressure of 250 psi.
    d. Partially Open modulating Injection Flow Control Valve BFV-9905110:
        1) Input - Injection (Recharge) Valve Pressure to Start Recharge Mode 50 percent.
        2) During startup and testing the pressure to start recharge and time delay to allow air to be expelled from the column pipe will be determined using field testing results and the setpoint will be adjusted.
    e. Preset Time Delay:
        1) Wait for a preset time for the air in the well column pipe and the above ground pipe to fill with water and expel all the air in the pipe out through the air release valves.
        2) During startup and testing the time it takes to fill the downhole column pipe and above piping will be recorded and the time entered into the preset time.
        3) Input - Recharge Pipe Fill Time 10 mins (minutes).
        4) Confirm column pipe pressure at PIT-9905010A is above the minimum setting to facilitate recharge.
            a) Monitor the column pipe pressure. If the distribution pressure drops below the minimum setting, shut down the recharge mode.
            b) Verify that the recharge line is full of water and empty of air.

f. Partially Open Downhole Flow Control Valve DHCV-9905130:
    1) Input - Downhole Flow Control Valve Pressure for Starting Injection (Recharge) Flow 150 psi.
    2) During startup and testing the nitrogen pressure required to slightly open the flow control valve will be determined and used as the input value to start injection flow downhole while maintaining backpressure.
    3) The downhole flow control valve is only partially opened so that enough flow resistance or backpressure remains in the column pipe to keep the pipe flowing full. This will prevent the free flow and cascading of water downhole which will introduce air bubbles into the well screen, gravel pack, and soil interface and potentially air bind the well.
g. Increase Percent Open of modulating Injection (Recharge) Flow Control Valve-BFV-9905110 to preset value.
    1) Input - Injection (Recharge) Flow Control Valve Percent Open for Starting Injection (Recharge) 25 percent.
    2) Wait for preset time for system flow to stabilize.
        a) Input - Preset Time Between Adjustments of Modulating Flow Control Valve.
    3) Maintain preset pre-extraction flush rate by making primary coarse adjusting with the downhole flow control valve, then making the fine adjustments using the above ground modulating injection (recharge) flow control valve.
    4) To prevent the 2 flow control valves from making continuous and conflicting adjustments only allow the downhole flow control valve to operate when the above ground modulating flow control valve is out of its' recommended effective range of operation.
    5) Allow for a preset time interval to expire and the system flow to stabilize before making another adjustment to the above ground modulating flow control valve.
h. Increase Percent Open of Downhole Flow Control (Recharge) Valve to maintain the preset flow rate.
    1) Input - Injection Flow Rate 375 gpm with an operator adjustable bandwidth (initial setting ±10 percent).
    2) Check the water level in the well water surface elevation using the Level Indicating Transmitter LIT-9905010.
    3) The water surface elevations in the well will be limited to the preset maximum water level.
    4) Input - Maximum Water Surface Elevation 0 ft bgs (0 psi). Operator adjustable.
i. Stop Injection (Recharge) Mode.
    1) Stop injection (recharge) mode when preset run timer ends.
    2) Stop injection (recharge) mode when stop button is pushed.
j. Close injection (recharge) valve.
    1) Check if injection (recharge) valve is fully closed.
        a) If yes, then no change.
        b) If no, then send alarm.
        c) Physically verify valve position to clear error and start process.
k. End in Off (All Stop) Mode.

B. Hardwired controls:
    1. Pilot devices:
        a. Field:
            1) Motorized Valve Controls.
                a) Local-Stop-Remote Switch.
                b) Open-Stop-Close Switch.
    2. Interlocks:
        a. Drive/starter enclosure:
            1) None.
    3. Indicators and alarms:
        a. Field:
            1) None.
        b. Drive/starter enclosure:
            1) None
        c. VCP:
            1) Downhole Control Valve.

C. OIT control:
    1. Manual mode:
        a. N/A.
    2. Auto mode:
        a. As described in the Abstract.
    3. Indicators and alarms:
        a. Refer to Abstract, Drawings and Section 40_61_15 - Control Strategies for indicators and alarms.
        b. Additional indicators and alarms:
            1) Low distribution system pressure (operator adjustable setting).

D. PCS controls:
    1. N/A.

3.04 BELTZ 8 - WELL FLUSH TO STORM DRAIN MODE

A. Note: If the Additive Bid Item for the 12-inch Flush Line is not executed, then this mode shall not be programmed. BFV-9905030 shall remain in the closed position at all times until the 12-inch Flush Line is constructed.

B. General:
    1. References:
        a. 8N05.
        b. 8N06.
    2. Key equipment:
        a. Well Pump PMP-9905010.
        b. Level Transmitter LIT-9905010.
        c. Flush to Storm Drain Meter FM-9905030.
        d. Pressure Switch High PSH-9905010B.
    3. Preset adjustable inputs. (Note that these are starting points for adjustable inputs and are subject to change during startup and testing.)
        a. Input - Minimum Liquid Level 100 feet bgs.
        b. Input - Well Pump Soft Start Speed ## percent.
        c. Input - Pre-Extraction Flush Rate to Storm Drain 565 gpm.

d. Input - Pre-Extraction Flush Time to Storm Drain 03:00 mm:ss.
e. Input - Pressure Switch High Delay 00:00 mm:ss.

4. Abstract:
   a. Begin in Off (All Stop) Mode.
      1) Verify that all motor operated valves are closed, the equipment is stopped, and the manual well isolation valve is open.
   b. Start Well Flush to Storm Drain Mode.
   c. Open Flush to Storm Drain MOV BFV-9905030 valve.
      1) Check if flush to storm drain valve is fully open.
         a) If yes, then continue with starting well pump.
         b) If no, then stop process and send alarm.
         c) Physically verify valve position to clear error and start process.
   d. Start Well Pump PMP-9905010:
      1) Start well pump and ramp up to the start speed over an operator adjustable time period initially set at 30 sec.
         a) Input - Well Pump Start Speed ## percent.
            (1) The speed setting will be determined during start up and is operator adjustable.
            (2) VFD ramp time to the Start Speed is operator adjustable and initially set at 30 sec.
         b) If the system exceeds the preset pressure at Pressure Switch High PSH-9905010B, then stop pump, go to off (all stop) mode, and send alarm.
            (1) Verify maximum distribution system pressure, pump dead head pressure, and maximum line pressure.
      2) Continuously monitor that Level Transmitter LIT-9905010 is above preset minimum liquid level while the pump is running.
         a) Input - Minimum Liquid Level Initially set at 100 feet bgs. Operator adjustable.
         b) If groundwater level in well is below minimum liquid level, then do not start pump and send alarm.
         c) If groundwater level drops below minimum liquid level, then stop pump, go to off (all stop) mode, and send alarm.
   e. Increase well pump speed and maintain preset pre-extraction flush rate.
      1) The pre-extraction flush rate is assumed to be equal to the backflush extraction rate to tank 565 gpm but could be set differently so keep as separate preset inputs.
      2) Input - Pre-Extraction Flush Rate to Storm Drain 565 gpm.
      3) There may be a difference in flushing rate and run time between discharge to storm drain and to backwash/reclaim tank.
   f. Maintain preset pre-extraction flush rate by adjusting well pump motor speed and signal from Flush to Storm Drain Meter FM-9905030.
   g. Run well pump at pre-extraction flush rate for a for a preset time.
      1) Determine flush time during startup and testing as the time needed for the well to run clear or a manufacturer minimum pump run time of 2 minutes.
      2) Input - Pre-Extraction Flush Time to Storm Drain 03:00 mm:ss.
      3) There may be a difference in flushing rate and run time between discharge to storm drain and to backwash/reclaim tank.
   h. Stop Extraction (Recovery) Mode.
      1) Stop flush to storm drain mode when preset run timer ends.

2) Stop flush to storm drain mode when stop button is pushed.

i. Decrease well pump speed to well pump soft start speed.

j. Close flush to storm drain valve.

1) Check if flush to storm drain valve is fully closed.

a) If yes, then continue with no change.

b) If no, then send alarm.

c) If valve is not fully closed, then there is still a single check valve to help prevent the water from backflowing into the well. The valve should be closed manually.

d) Physically verify valve position to clear error and start process.

k. End in Off (All Stop) Mode.

C. Hardwired controls:

1. Pilot devices:

a. Field:

1) Motorized Valve Controls.

a) Local-Stop-Remote Switch.

b) Open-Stop-Close Switch.

b. LCP:

1) N/A.

c. Drive/starter enclosure:

1) Local-Off-Remote Switch.

2) Stop Pushbutton.

3) Start Pushbutton.

4) Speed Potentiometer.

5) Equipment Shutdown Pushbutton.

6) Reset Pushbutton.

2. Interlocks:

a. Drive/starter enclosure:

1) Moisture.

2) Overtemperature.

3. Indicators and alarms:

a. Field:

1) N/A.

b. Drive/starter enclosure:

1) Running indication.

2) Failed Alarm.

3) Speed Indication.

D. OIT control:

1. Manual mode:

a. N/A.

2. Auto mode:

a. As described in the Abstract.

3. Indicators and alarms:

a. Refer to Abstract, Drawings and Section 40_61_15 - Control Strategies for indicators and alarms.

b. Additional indicators and alarms:

1) While the well pump is running, if the water level goes below the minimum level setpoint, shut down the pump and alarm on low level.

E. PCS controls:
    1. N/A.

3.05 BELTZ 8 BACKWASH/RECLAIM TANK TO STORM DRAIN MODE

A. General:
    1. References:
        a. 8N06.
        b. 8N07.
    2. Key equipment:
        a. Backwash to Storm Drain Valve BVF-9905050.
        b. Backwash to Storm Drain Flow Meter FIT-9905050.
        c. Existing Backwash Reclaimed Tank Mixing Pump.
    3. Preset adjustable inputs. (Note that these are starting points for adjustable inputs and are subject to change during startup and testing.)
        a. Input - Reclaim Tank Drain Time 08:00 hh:mm.
    4. Abstract:
        a. Begin in Any Mode:
        b. The backwash/reclaim tank to storm drain valve can be controlled independently by the water treatment plant operations group. The well can be run in any mode independent of the tank drain valve position.
        c. The decision to operate the tank drain mode at the same time as other well modes may depend on the following.
            1) The level in the backwash/reclaim tank is too high to send more water to the tank.
            2) Tank volume is needed for the backwash of the water treatment plant filters.
            3) Sending flush flow and tank drain flow to the storm drain may exceed the maximum allowable flow to the storm drain.
            4) The maximum capacity of the storm drain is exceeded.
        d. Push button to Start Backwash /Reclaim Tank to Storm Drain Mode:
            1) Open Backwash to Storm Drain Valve BFV-9905050:
                a) This motor operated valve is a full open/close valve with limit switches.
        e. Operator manually start existing Backwash Reclaimed Tank Mixing Pump.
        f. Adjust flows to the maximum allowable flow to storm drain or less using the Backwash Reclaimed Tank to Storm Drain Manual Globe Flow Control Valve located next to the motor operated valve and magnetic flow meter.
        g. Record totalized flows to storm drain using Backwash/Reclaim Tank to Storm Drain Flow Meter.
        h. Close backwash/reclaim tank to storm drain valve after a preset time
        i. Input - Backwash/Reclaim Tank Drain Time 08:00 hh:mm
        j. Stop existing Backwash Reclaimed Tank Mixing Pump.
        k. Close backwash/reclaimed tank to storm drain Valve BFV-9905050.
        l. End in Off (All Stop) Mode.

B. Hardwired controls:
    1. Pilot devices:
        a. Field:
            1) Motorized Valve Controls.
                a) Local-Stop-Remote Switch.

b) Open-Stop-Close Switch.

C. OIT control:
1. Manual mode:
a. N/A.
2. Auto mode:
a. As described in the Abstract.
3. Indicators and alarms:
a. Refer to Abstract, Drawings and Section 40_61_15 - Control Strategies for indicators and alarms.
b. Additional indicators and alarms:
1) N/A.

D. PCS controls:
1. N/A.

3.06 BELTZ 8 – WELL BACKFLUSH TO RECLAIM MODE

A. General:
1. References:
a. 08N04.
b. 08N05.
c. 08N06.
2. Key equipment:
a. Flush to Storm Drain MOV BFV-9905030.
b. Manual Flush to Reclaim Tank Valve GV-9905021.
c. Manual RAW to WTP Aeration Tank Valve GV-9905022.
d. Well Pump PMP-9905010.
e. Level Transmitter LIT-9905010.
f. Extraction (Recovery) MOV BFV-9905020.
g. Extraction (Recovery) Flow Meter FM-9905020.
h. Pressure Switch High PSH-9905010B.
3. Preset adjustable inputs: (Note that these are starting points for adjustable inputs and are subject to change during startup and testing.)
a. Input - Minimum Liquid Level 100 feet bgs. (Low pumping water surface elevation and top of well screen.)
b. Input - Well Pump Start Speed ## percent. (To be determined during startup and testing.)
c. Input - Pre-Extraction Flush Rate to Storm Drain/Reclaim Tank 565 gpm +/- 15%..
d. Input - Pre-Extraction Flush Time to Storm Drain/Reclaim Tank 03:00 mm:ss.
e. Input - Extraction (Recovery) Rate 565 gpm +/- 15%.
f. Input - Extraction (Recovery) Run time 24:00 hh:mm.
g. Input - Pressure Switch High Delay 00:00 mm:ss.
4. Abstract:
a. Begin in Off (All Stop) Mode:
1) Verify that all motor operated valves are closed, the equipment is stopped, and the manual well isolation valve GV-9905010 is open.
b. BWTP control, a relay output from BWTP will call Well 8 to run in extraction (recovery) mode. Start and shut down sequence will be as

described below for OIT controls except the well pump will continue to run as long as the BWTP relay output is energized.

c. For OIT controls, Select the Well Flush to Reclaimed Tank Mode and select the Pre-Extraction Flush Rate Mode “Storm Drain” or “Reclaim Tank” on the Local Operator Interface (OIT) Screen. The PLC will operate as described below. An Operator can also manually run the well in extraction mode by following the same sequence manually.
    1) When the Pre-Extraction Flush to Reclaim Tank mode is selected, The Operator will need to manually open the Reclaim Tank Valve GV-9905021 and close the existing valve to the treatment plant GV-9905022.

d. Close Flush to Storm Drain MOV BFV-9905030:
    1) Check if flush to storm drain valve is fully closed.
        a) If yes, then start well pump.
        b) If no, then stop process go to off (all stop) mode and send alarm.
        c) Physically verify valve position to clear error and start process.

e. Start Well Pump PMP-9905010:
    1) Start well pump and ramp up to the start speed over an operator adjustable time period initially set at 30 sec.
        a) Input - Well Pump Start Speed initially set at 60 percent.
            (1) The speed setting will be determined during start up and is operator adjustable.
            (2) VFD ramp time to the Start Speed is operator adjustable and initially set at 30 sec.
        b) If the system exceeds the preset pressure at Pressure Switch High PSH-9905010B, then stop pump, go to off (all stop) mode, and send alarm.
            (1) Verify maximum distribution system pressure, pump dead head pressure, and maximum line pressure.
    2) Continuously monitor that Level Transmitter LIT-9905010 is above preset minimum liquid level while the pump is running.
        a) Input - Minimum Liquid Level Initially set at 100 feet bgs. Operator adjustable.
        b) If groundwater level drops below minimum liquid level, then stop pump, go to off (all stop) mode, and send alarm.

f. Increase well pump speed and maintain preset flush to rate.
    1) The pre-extraction flush rate is equal to the backflush extraction rate 750 gpm but could be set differently so keep as separate preset inputs.
    2) Maintain preset pre-extraction flush rate by adjusting well pump motor speed and signal from Flush to reclaim tank FIT-9905020.

g. Decrease well pump speed from the pre-extraction flush rate down to the extraction rate.
    1) The extraction rate was determined during pilot testing as 565 gpm +/- 15%.
    2) Input - Extraction (Recovery) Rate 565 gpm.
    3) Maintain preset extraction rate by adjusting well pump motor speed and signal from Extraction (Recovery) Flow Meter FM-9905020.

h. Open manual gate valve GV-9905022 to WTP aeration tank.

i. Close manual gate valve GV-9905021 to reclaim tank.

j. Run well pump for preset adjustable run time or until manually turned off.
    1) Input – Flush to Reclaim Tank mode time XX:XX hh:mm.
k. Stop Backflush to Reclaimed Tank Mode:
    1) Stop backflush to reclaimed tank mode when preset run timer ends.
    2) Stop backflush to reclaimed tank mode when stop button is pushed.
    3) Open RAW to WTP aeration tank manual valve GV-9905022.
    4) Close flush to reclaimed tank manual valve GV-9905021.
    5) Check if extraction (recovery) valve is fully closed.
l. Stop well pump.
m. End in Off (All Stop) Mode.

B. Hardwired controls:
1. Pilot devices:
    a. Field:
        1) Motorized Valve Controls:
            a) Local-Stop-Remote Switch.
            b) Open-Stop-Close Switch.
    b. Drive/starter enclosure:
        1) Local-Off-Remote Switch.
        2) Stop Pushbutton.
        3) Start Pushbutton.
        4) Speed Potentiometer.
        5) Equipment Shutdown Pushbutton.
        6) Reset Pushbutton.
    c. VCP:
        1) None.
2. Interlocks:
    a. Drive/starter enclosure:
        1) Moisture.
        2) Overtemperature.
3. Indicators and alarms:
    a. Field:
        1) N/A.
    b. Drive/starter enclosure:
        1) Running indication.
        2) Failed Alarm.
        3) Speed Indication.
    c. VCP:
        1) None.

C. OIT control:
1. Manual mode:
    a. N/A.
2. Auto mode:
    a. As described in the Abstract.
3. Indicators and alarms:
    a. Refer to Abstract, Drawings and Section 40_61_15 - Control Strategies for indicators and alarms.
    b. Additional indicators and alarms:
        1) While the well pump is running, if the water level goes below the minimum level setpoint, shut down the pump and alarm on low level.

D. PCS controls:
   1. N/A.

3.07 BELTZ 8 BACKWASH/RECLAIM TANK TO WASTE DRAIN PUMP STATION MODE

A. Not used (future construction).

3.08 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training.

END OF SECTION

SECTION 40_64_01

CONTROL SYSTEMS: PROGRAMMABLE LOGIC CONTROLLERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Programmable logic controller (PLC) based control systems hardware.
   2. Development software to be used with the specified PLC hardware.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Abbreviations:
   1. CPU: Central processing unit.
   2. I/O: Input/Output.

C. Standards:
   1. Institute of Electrical and Electronics Engineers (IEEE).

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Application software: Software that is programmed specifically for the Project.
   2. Development operating software: Software provided by the PLC manufacturer for use in programming the PLC.

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Product data:
   1. CPU:
      a. Processor type.
      b. Processor speed.
      c. Memory.

d. Internal processor battery backup time.
2. I/O modules:
a. Type.
b. Standard wiring diagram.
3. Programming languages.
4. Operating system requirements.

C. Calculations:
1. Calculations or documented estimate to verify that memory requirements of this Section are met, including spare requirements. If possible, use the PLC manufacturer's calculation or estimating worksheet.
2. Calculations to verify that spare I/O requirements of this Section are met.
3. Calculations to verify that PLC power supply requirements of this Section are met.

D. Control logic:
1. Fully annotated copy of programmed PLC logic.
2. Cross-referenced index of PLC registers or points.

E. Provide application software for the specific Project process requirements:
1. Fully annotated copy of programmed PLC logic in its native format.
2. Cross-referenced index of PLC registers or points.

1.05 QUALITY ASSURANCE

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide PLC hardware manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

1.10 MAINTENANCE

A. Furnish the following:
1. CPU: 1 spare for each type of CPU in the system.
2. I/O cards: 1 spare for each type of I/O card in the system.

3. Power supplies: 1 spare for every power supply in the system.
4. Network/communications cards: 1 spare for every network or communications card in the system.
5. Remote adapter: 1 spare for every remote adaptor in the system.
6. Chassis: 1 spare for each chassis size in the system.
7. Communication cable: 1 spare for each type of cable used in the system.

B. Installed spare requirements:
1. I/O points:
a. Provide total of 25 percent spare I/O capacity for each type of I/O at every PLC/RIO rack using the following calculation:

$$\left(1 - \frac{\text{UTILIZED IO POINT COUNT}}{\text{TOTAL IO POINT COUNT}}\right) * 100 = \%\text{SPARE}$$

b. Wire spare I/O points to field terminal blocks in the same enclosure the PLC/RIO resides in.
2. PLC backplane capacity:
a. Provide 25 percent or 1 spare backplane slots, whichever is greater, in racks containing I/O.
3. PLC memory:
a. Provide 50-percent spare program volatile memory.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide PLC hardware as indicated on the Drawings and as specified in this Section.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide PLC system components by a single manufacturer:
1. Third-party communication modules may be used only for communication or network media functions not provided by the PLC manufacturer.

B. Use PLC manufacturer approved hardware, such as cable, mounting hardware, connectors, enclosures, racks, communication cable, splitters, terminators, and taps.

C. PLC hardware, CPUs, I/O devices, and communication devices shall be new, free from defects, and produced by manufacturers regularly engaged in the manufacture of these products.

D. Wherever possible, use the same model of each PLC module type throughout the Project.

2.03 MANUFACTURERS

A. The following, no equal:
1. General Electric:Modicon:
a. M340, BMXP3420 Series.

B. PLC programming software system shall be manufactured by PLC hardware manufacturer:
    1. Modicon:
        a. EcoStruxure.

2.04 MANUFACTURED UNITS

A. Programmable logic controller:
    1. Construction:
        a. Furnish plug-in modular system.
        b. Capable of operating in a hostile industrial environment without fans, air conditioning, or electrical filtering:
            1) Temperature: 0 to 60 degrees Celsius.
            2) RFI: 80 to 1,000 MHz.
            3) Vibration: 10 to 500 hertz.
            4) Humidity: 0 to 95 percent.
        c. Provide internal power supplies designed to protect against overvoltage and frequency distortion characteristics frequently encountered with the local power utility.
        d. Design the PLC system to function as a standalone unit that performs all of the control functions described in this Section completely independent from the functions of the HMI system PC-based operator interfaces:
            1) Failure of the HMI system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.
    2. CPU:
        a. Configure each CPU so that it contains the software relays, timers, counters, number storage registers, shift registers, sequencers, arithmetic capability, and comparators necessary to perform the specified control functions.
        b. Capable of interfacing with discrete inputs, analog inputs, discrete outputs, analog outputs, and communication cards to meet the specified requirements.
        c. Capable of supporting and implementing closed-loop floating-point math and PID control that is directly integrated into the CPU control program.
    3. Memory:
        a. Non-volatile memory: On-board complementary metal-oxide-semiconductor (CMOS), electrically erasable programmable read-only memory (EEPROM), PCMCIA, compact flash card, or SD card.
        b. Supply with sufficient memory to implement the specified control functions plus a reserve capacity as specified with the requirements of this Section:
            1) Reserve capacity:
                a) Totally free from any system use.
            2) Programmed in a multi-mode configuration with multiple series or parallel contacts, function blocks, counters, timers, and arithmetic functions.
    4. Programming:
        a. Provide a system where processors are programmed by:
            1) Portable laptop computer both locally and via the PLC control network.
    5. PLC power supply:
        a. Input: 120 VAC.
        b. Mounted in the PLC housing or as indicated on the Drawings.

c. Sized to power modules mounted in that housing, including an average module load for any empty housing slots, plus 50 percent above that total.

6. PLC input/output, I/O modules:
   a. General:
      1) Compatible with all PLCs being furnished under the Contract and by the same manufacturer as the PLCs.
      2) Provide I/O modules that:
         a) Isolate in accordance with IEEE Surge Withstand Standards and NEMA Noise Immunity Standards.
         b) Provide A/D and D/A converters with optically or galvanically isolated inputs and outputs.
         c) Accept dual-ended inputs.
      3) Use of common grounds between I/O points for modules that require individual isolation is not acceptable.
      4) Provide modules that are removable without having to disconnect wiring terminals:
         a) Utilize a swing-arm or plug-in wiring connector.
      5) Provide at each PLC the I/O modules for the following:
         a) Designated future I/O points contained in the I/O lists and/or shown on the P&IDs, control schematics, or described in the control strategies.
         b) Installed spare capacity in accordance with the requirements of this Section.
         c) Wire spares provided to the field terminal strip.
      6) Condition, filter, and check input signals for instrument limit conditions.
      7) Filter, scale, and linearize the raw signal into an engineering-units-based measurement.
      8) Alarm measurements for high, low, rate-of-change limits, and alarm trends.
      9) Provide external fuses mounted on the field connection terminal block for discrete input, discrete output, and analog input I/O points.
      10) When multiple cards of the same I/O type are provided and parallel equipment, instrumentation, or redundant processes exist, distribute I/O among cards to ensure that a single card failure will not render an entire process unavailable.
   b. Discrete input modules:
      1) Defined as contact closure inputs from devices external to the input module.
      2) Provide inputs that are optically isolated from low-energy common-mode transients to 1,500 volts peak from users wiring or other I/O modules.
      3) With LEDs to indicate status of each discrete input.
      4) Input voltage: 120 VAC.
      5) Provide input module points that are individually fused with blown-fuse indicator lights, mounted external of the module on the output terminal strip:
         a) Coordinate external fuse size with the protection located on the module so that the external fuse opens first under a fault condition.

c. Discrete output modules:
    1) Defined as contact closure outputs for ON/OFF operation of devices external to the output module:
        a) Triac outputs may be used, with the permission of the Engineer. Care must be used in applying this type of module to ensure that the leakage current through the output device does not falsely signal or indicate an output condition.
    2) Optically isolated from inductively generated, normal mode and low-energy common-mode transients to 1,500 volts peak.
    3) LEDs to indicate status of each output point.
    4) Output voltage: 120 VAC.
d. Analog input modules: individually isolated:
    1) Signal type: Provide 4 to 20 mA for most applications; other levels are acceptable to interface to vendor control panels.
    2) Analog-to-digital conversion: Minimum 12-bit precision with the digital result entered into the processor.
    3) Analog-to-digital conversion updated with each scan of the processor.
    4) Individually isolated each input.
    5) Coordinate the size of the external fuse with the protection located on the module, so that the external fuse opens first under a fault condition.
e. Analog output modules:
    1) Signal type: Provide 4 to 20 mA for most applications; other levels are acceptable to interface to vendor control panels.
    2) Individual isolated output points each rated for loads of up to 1,000 ohms.
f. Network communications modules:
    1) General:
        a) Install communications modules in the backplane.
    2) Provide network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.

7. PLC backplane housing:
    a. Mount the PLC power supply, CPU, communications module, and I/O modules in a suitable standard PLC backplane or housing.
    b. Provide spare slots in each PLC and RIO location in accordance with the requirements of this Section.
    c. Provide a blank slot filler module for each spare slot.

B. PLC programming software:
    1. Suitable for the PLCs specified above.
    2. For programming, monitoring, searching, and editing:
        a. Usable both on-line, while connected to the PLC, and off-line.
        b. Operating software shall display multiple series and parallel contacts, coils, timers, counters, and mathematical function blocks.
        c. Capable of disabling/forcing inputs, outputs, and coils to simulate the elements of the ladder logic; forced elements shall be identifiable by means of color change.
        d. Include a search capability to locate any address or element and its program location.

e. Display at the EC, PLC status information, such as faults and communication errors and amount of memory remaining.

3. Support IEC-61131-3 compliant programming languages:
4. Generate a PLC program printout, which is fully documented, through the PLC programming software:
   a. Fully documented program listings include, as a minimum, appropriate rungs, address, and coils shown with comments to clarify to a reader what that segment of the program accomplishes on an individual line-by-line basis.
   b. Include a sufficient embedded comment for every rung of the program explaining the control function accomplished in said rung.
   c. Use a mnemonic associated with each contact, coil, etc., that describes its function.
   d. Utilize the tag and loop identification as contained in the P&IDs:
      1) If additional internal coils, timers, etc., are used for a loop, they shall contain the loop number.
   e. Provide a cross-reference report of program addresses.
5. Software functions automatically without operator intervention, except as required to establish file names and similar information:
   a. Furnish the operating system software that is the standard uncorrupted product of the PLC manufacturer with the following minimum functions:
      1) Respond to demands from a program request.
      2) Dynamic allocation of the resources available in the PLC. These resources include main memory usage, computation time, peripheral usage, and I/O channel usage.
      3) Allotment of system resources based on task priority levels such that a logical allocation of resources and suitable response times are ensured.
      4) Queuing of requests in order of priority if one or more requested resources are unavailable.
      5) Resolution of contending requests for the same resource in accordance with priority.
      6) Service requests for execution of 1 program by another.
      7) Transfer data between programs as requested.
      8) Management of information transfers to and from peripheral devices.
      9) Control and recovery from program fault conditions.
      10) Diagnose and report real-time hardware device errors.
6. Program execution:
   a. Application software - program execution scheduled on a priority basis:
      1) A multilevel priority interrupt structure is required.
      2) Enter into a list of pending programs a program interrupted by a higher priority program:
         a) Resume its execution once it becomes the currently highest priority program.
      3) Schedule periodic programs.
      4) Base the allocation of resources to a time-scheduled program on its relative priority and the availability of resources.
7. Start-up and restart:
   a. Provide software that initializes and brings a PLC or any microprocessor-based hardware unit from an inactive condition to a state of operational readiness.

b. Initialization:
    1) Determination of system status before start-up of initializing operating system software and initializing application software.
    2) Loading of memory-resident software, initializing timers, counters, and queues, and initialization of dynamic database values.

8. Shutdown:
    a. Where possible, provide orderly shutdown capability for shutdowns resulting from equipment failure, including other PLC processor failures, primary power failure, or a manually entered shutdown command.
    b. Upon loss of primary power, a high-priority hardware interrupt initiates software for an immediate, orderly shutdown.
    c. Hardware is quickly and automatically commanded to a secure state in response to shutdown command or malfunction.
    d. Alarm PLC failure at the operator interface level.
9. Diagnostics:
    a. Furnish diagnostic programs with the PLC software package to detect and isolate hardware problems and assist maintenance personnel in discovering the causes for system failures.
    b. Use the manufacturer's standard diagnostic routines as much as possible.
    c. Furnish diagnostic software and test programs for each significant component in the control system.
    d. As a minimum, provide diagnostic routines to test for power supply, central processing unit, memory, communications, and I/O bus failures.
10. Calendar/time program:
    a. To update the second, minute, hour, day, month, and year and transfer accurate time and date information to system-level and application software.
    b. Variations in the number of days in each month and in leap years must be handled automatically by the program.
    c. Operator must be able to set or correct the time and date from any operator interface, only at the highest security level.
11. Algorithms:
    a. Implementation of algorithms for the determinations of control actions and special calculations involving analog and discrete data.
    b. Algorithms must be capable of outputting positional or incremental control outputs or providing the product of calculations.
    c. Algorithms must include alarm checks where appropriate.
    d. Provide, as a minimum, the following types of algorithms:
        1) Performs functions such as summing several variables, raising to a power, roots, dividing, multiplying, and subtracting.
        2) A switch algorithm, which reads the current and value from its input address and stores it as the value of its output address. 2 types of switches shall be accommodated: 2 outputs with 1 input and 1 output with 2 inputs.
        3) A 3-mode proportional-integral-derivative, PID, controller algorithm, with each of the 3 modes independently adjustable, supports both direct and reverse-acting modes.
        4) Lead, lag, dead time, and ratio compensators.
        5) Integration and totalization of analog process variables.

12. Furnish a comprehensive database for the analog inputs, calculated values, control modules, and outputs:
    a. In addition, provide spare database points for future expansion.
13. One integrated database can be utilized for all types of analog points or separate databases for each type; in either case, the database for each point must include all specified aspects.
14. All portions of the database must be available for use by the display, report, and other specified software modules.
15. Data fields and functions specified below must be part of the point definition database at the operator interface. Provide the capability to define new database points through the point display specified below as well as modifying defined points through these displays. This point definition and modification must include all features and functions defined below. Analog database software must support the following functions and attributes:
    a. Analog input signal types:
        1) Provide software at the remote terminal units (RTUs) and PLCs to read variable voltage/current signals and pulse duration/frequency type analog input signals.
    b. Input accuracy:
        1) Inputs must be read with an accuracy of within 0.05-percent full-scale or better.
        2) Data conversion errors must be less than 0.05-percent full-scale.
        3) Pulse accumulation error less than or equal to 1 count of actual input count at a scan rate of once per minute.
        4) Maintain for a minimum of 1 year the system accuracy stated above without adjustments.
    c. Filtering:
        1) For each analog input, provide a first order lag digital filter with an adjustable filter factor.
    d. Linearizing:
        1) Where analog inputs require square root extraction or other linearization, provide a mechanism to condition the filtered data before the process of scaling and zero suppression takes place.
    e. Calculated values:
        1) Provide means to allow for pseudo-inputs calculated by algebraic and/or Boolean expressions utilizing real inputs, other calculated values, constants, etc.
        2) These values must be handled the same as real inputs in terms of record-keeping, alarming, etc.
    f. Scaling and zero suppression:
        1) Provide a conversion program to convert input values into engineering units in a floating-point format.
    g. Alarms:
        1) Refer to Section 40_61_16.08 - Specific Control Strategies – Beltz 8 for specific requirements.
        2) Provide an alarm program to check analog variables against high-high, high, low, and low-low alarm limits.
        3) When an analog value exceeds a set limit, it must be reported as an alarm based on individually set priority level for each alarm point.
        4) Provide an adjustable hysteresis band in order to prevent excessive alarms when a variable is hovering around an alarm limit.

5) Must be possible to inhibit alarms based on external events, e.g., lock-out low pump flow alarm when the pump is off.

h. Averages:
   1) Refer to Section 40_61_16.08 - Specific Control Strategies – Beltz 8 for specific requirements.
   2) Provide a program to calculate and store hourly, daily, and monthly averages of analog variables.
   3) Continuously compute averages, e.g., the average for the current period to the present point in time must be stored in memory and available for use in displays, etc.
   4) Update hourly averages each minute or at the polling interval for the selected variable.
   5) Update daily averages at least once each hour and calculate using the results of the hourly averages.
   6) Update monthly averages at least once each day and calculate using the results of the daily averages.
   7) At the end of each averaging period, store the average values for the period on the hard disk for historical record-keeping and reset the present period average register to the present value of the variable.
   8) Active database must include the present period average and previous period average for each variable and averaging period.

i. Totals:
   1) Refer to Section 40_61_16.08 - Specific Control Strategies – Beltz 8 for specific requirements.
   2) Provide a program to calculate and store hourly, daily, and monthly totalization of analog variables.
   3) Assign a scaling factor to each variable to convert to the appropriate units based on a 1-minute totalizing interval.
   4) Assign a separate factor for each totalizing interval.
   5) Variables for which totalization is inappropriate must have scaling factors of zero.
   6) At the end of each totalizing period, store the totalized values for the period on the hard disk for historical record-keeping and reset the present period totalization register to zero.
   7) Active database must include the present period total and previous period total for each variable and totalizing period.

j. Engineering units:
   1) Provide software to allow the system and the operator to convert the measured analog variables to any desired engineering units.
   2) Operator must be able to view displays and generate reports of any measured variable in one or more engineering units, such as flow in gpm, mgd, cfs, and acre-feet per day.
   3) Pre-program the conversion of the engineering units, and, if not pre-programmed, the operator must be able to program new engineering unit conversions by using simple methods, e.g., multiplication of the database attributes by a constant.
   4) Programming method must be at a level and compatible with the specified training of the operator and the Owner’s personnel.
   5) New conversions must not require the services of a special programmer and/or special, high-level, programming training.

k. Control modules:
    1) For each control function configured, whether processed at the RTU, PLC, or operator interface, maintain a file of necessary data, including input values, setpoints, constants, intermediate calculated values, output value and limit clamps, etc.
    2) Input and output assignments, setpoints, and constants must be adjustable by the operator through the operator interface.
    3) Provide control algorithms for manual control with output values adjustable by the operator.
l. Analog outputs:
    1) Analog outputs must be maintained as part of the database.
    2) These outputs must be adjustable manually by the operator through the operator interface or through automatic control algorithms.

16. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.

C. General control functions:
1. Analog control functions:
    a. PID, lead/lag, signal select, alarm, limit, delay, and time base.
    b. Furnish the control system complete with a library of mathematical/calculation software to support averaging, weighted average, addition, subtraction, multiplication, division, square root extraction, exponential, AND, OR, NAND, NOR, XOR, and NXOR functions.
    c. Math utilities must be linkable to process data points or manual inputs via control block configuration.
    d. By linking control blocks to data points, the math library must support system unit conversion and calculation requirements.
2. Discrete control functions:
    a. AND, OR, NOT, EXCLUSIVE OR, comparators, delays, and time base.
3. Software support:
    a. Retain in firmware all control and logic functions at each RTU and PLC and in RAM at the operator interface.
    b. Call each function as required by the configured controls to perform the intended function.
4. Control and status discrepancies:
    a. Generate a discrepancy/fail alarm for any pump, valve, or final control element if a discrepancy exists between a system or operator command and the device status:
        1) For example, the system commands to start (call), and the pump fails to start (run status report back), within predetermined operator-programmable time delay (time disagree), then a discrepancy (fail) alarm shall be generated.
    b. Involuntary change in the device’s status must also generate an alarm:
        1) For example, a pump starts when not commanded to do so, or a pump shuts down while running even though it still has a command to run.
    c. Each command, status, and alarm must cause the color of the symbol to change.
    d. Because many discrete final control elements have a cycle time in excess of the scan interval, provide each control output with an associated delay

period selected to be longer than the operating period of the control element:
1) Delay periods for each final control element must be adjustable at the operator interface.
2) List time delays in the final documentation.

5. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.

D. Control configuration:
1. Provide software to allow control strategies to be developed, and their operation initiated through the operator interface.
2. Provide standardized control point displays for defining the control functions, including the function type, input/output addresses, setpoints, tuning constants, etc.
3. Provide a mechanism to link separate control functions together into an integrated control strategy.
4. Provide a mechanism to download operational/control setpoints developed at any operator interface to any PLC or RTU for operational implementation.
5. Provide a mechanism to define and implement operational/control setpoints locally at the PLC or RTU, and to upload them to the operator interface for operational record-keeping.
6. Perform control configurations on-line at the operator interface; the PLC or RTU may be taken off-line when being configured or downloaded.

E. Remote inputs and outputs (RIOs):
1. Compatible with all PLCs being furnished under this Contract, shall be by the same manufacturer as the PLCs, and, as a minimum, include:
a. Power supply.
b. Rack.
c. Backplane.
d. Communications module.
e. I/O modules.
f. Enclosure.
2. Provide cables and software needed for a complete and operational RIO system as specified in the Contract Documents.
3. Provide a group of pre-assigned diagnostic registers to report RIO system faults to the driver PLC.
4. Control system must continue operation should a fault occur on a single RIO drop:
a. Upon clearing the fault, restart communications to that drop automatically.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Utilize personnel to accomplish or supervise the physical installation of all elements, components, accessories, or assemblies:
   1. Employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies.

C. All components of the control system, including data network cables, are the installation responsibility of the ICSC unless specifically noted otherwise.

D. Control system logic program shall reside at the PLC level.

E. Use the tag and loop identifications found on the P&IDs for all tags used and/or assigned as part of the application software work provided by the ICSC.

3.03 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training.

B. Owner Training:
   1. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

END OF SECTION

SECTION 40_64_21

CONTROL SYSTEMS: LOCAL OPERATOR INTERFACE (LOI)

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Local Operator Interface (LOI) control systems hardware and software.

1.02 REFERENCES

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 SUBMITTALS

A. Furnish submittals in accordance with Sections 01 33 00 - Submittal Procedures and 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Product data:
   1. Complete manufacturer's brochures for each item of equipment.
   2. Complete manufacturer's brochures that identify LOI software and options. Mark up to clearly show options and components to be provided, and cross out any options or components that will not be provided.
   3. Manufacturer's operation and installation instructions.
   4. Additional requirements:
      a. Display type and size.
      b. Operator input.
      c. Processor type and speed.
      d. Memory size.
      e. Programming protocols.
      f. Communication protocols.
      g. Power requirements.
      h. Operating temperature and humidity ranges.
      i. NEMA ratings.

C. Shop drawings:
   1. Furnish the following:
      a. System block diagram showing relationship and connections between devices. Include manufacturer and model information, and address settings.
      b. Mounting drawings with dimensions and elevations for each equipment location, including identification of all components, preparation and finish data, and nameplates.
      c. Electrical connection diagrams.
      d. Complete grounding requirements.

2. Graphic screens:
    a. Color printouts of each graphic screen and all control pop-ups.
3. Furnish data sheets for each component together with a technical product brochure or bulletin:
    a. Manufacturer's model number.
    b. Project equipment tag.
4. Complete and detailed bills of materials identified by each cabinet. Include with each bill of material item the following:
    a. Quantity.
    b. Description.
    c. Manufacturer.
    d. Part numbers.

D. Operation and maintenance manuals:
1. Complete installation, operations, calibration, and testing manuals as described in Section 01 79 00 - Demonstration and Training.

E. Record documents:
1. Electrical connection diagrams revised to reflect any changes made in the field and submitted as record Drawings.

1.04 QUALITY ASSURANCE

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify that the LOI equipment is compatible with the installed conditions.

C. Notify the Engineer if any installation condition does not meet the manufacturer's recommendations or specifications.

D. Provide LOI hardware manufactured at facilities certified to the quality standards of ISO Standard 9001 - Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation, and Servicing.

E. System compatibility:
1. The software must be the standard operating software system designed specifically for use with the LOI hardware.
2. The software must be furnished and developed by the manufacturer of the LOI hardware.

1.05 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in technical sections and as indicated on the Drawings:
   1. Provide LOI equipment suitable for the installed site conditions including, but not limited to, site altitude, site seismic conditions, humidity, and ambient temperatures.

1.07 ADMINISTRATIVE REQUIREMENTS COORDINATION

A. Provide a licensed copy of the Manufacturer's Programming software for the selected LOIs.

1.08 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

1.09 MAINTENANCE

A. Provide system upgrades and maintenance fixes for a period of 2 years from substantial completion.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide all LOI hardware identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA (NOT USED)

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Schneider Electric.

B. Provide the LOI graphic software system manufactured by the LOI hardware manufacturer.
   1. One of the following or equal:
      a. Schneider Electric: Viejo Designer.

2.04 MANUFACTURED UNITS

A. Local Operator Interface:
   1. General:
      a. Provide Local Operator Interface located on the face of the PCM as indicated on the Drawings.
      b. NEMA 4X rated.
      c. Local Operator Interface consists of graphical display screen with operator input capabilities.
      d. Capable of stand-alone operation in conjunction with 1 PLC.
      e. Equipped with data network communication capabilities.

2. Display:
    a. Type:
        1) Color TFT LCD screen.
    b. Resolution:
        1) 1024 by 768 pixels.
    c. Size: As indicated on the Drawings.
    d. Easy display viewing at any angle in various ambient light conditions.
    e. Operator input:
        1) Configurable touch screen.
    f. Screen update speed: The screen update speed and screen change speed less than 1 second.
    g. Provide following features for outdoor use:
        1) Anti-glare screen overlay.
        2) Luminescence: Minimum 1,000 Nits.
3. Graphic configuration:
    a. Easily configured graphics by:
        1) Portable laptop computer both locally and via the PLC data network.
        2) SCADA Engineer's console via the PLC data network.
    b. As specified in this Section.
4. Memory:
    a. Application:
        1) 2 GB Flash EPROM.
5. CPU: Minimum 100 MHz.
6. Communications:
    a. RS232.
    b. Ethernet.
    c. Modbus.
7. Environment:
    a. Temperature: 0 to 50 degrees Celsius.
    b. Relative humidity: 10 to 90 percent.
8. Electrical:
    a. Power supply:
        1) 24 VDC.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. All components of the control system including all data network cables are the installation responsibility of the ICSC unless specifically noted otherwise.

C. Provide panel support bracing if more than 25 percent of the area has been removed to allow for the mounting of the LOI.

D. All tags used and/or assigned as part of the application programming work are to use the tag and loop identifications found on the P&IDs.

E. Station graphics:
   1. Configure the graphic display for each device both in the treatment plant, and/or process area, including but not limited to:
      a. Symbols for:
         1) Pumps.
         2) Valves.
         3) Major instruments.
         4) Flowmeters.
         5) Pressure transmitter.
         6) Major equipment.
      b. Alarm symbols including intrusion alarm.
      c. Relevant test and operational data.
      d. Status for each controller or controlled device:
         1) Hand-Off-Auto Status.
         2) Local-Off-Remote Status.
         3) Run.
         4) Call.
         5) Fail.
         6) Open.
         7) Close.
         8) Hold.
         9) Modulate.
         10) Running.
      e. Depict a change of state of pumps and valves by a change in color.
   2. Production and usage bar graph:
      a. Depict the production for each site and/or piece of equipment, as determined during the requisite graphics meeting, within the treatment plant, summarized to type, and total usage, with a bar graph and numeric value for each analog value.
   3. System level summary:
      a. Show the level for the plant influent and effluent production, etc., via a display using bar graphs and numbers, as determined during the requisite graphics meeting.

3.03 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training.

B. Owner Training:
   1. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

END OF SECTION

SECTION 40_66_01

CONTROL SYSTEMS: NETWORK MATERIALS AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Materials and equipment used in process control and LAN networks, including:
      a. Network switches.
      b. Media converters.
      c. Routers.
      d. Patch panels and other data network hardware.
      e. Related accessories.

1.02 REFERENCES

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Standards:
   1. Electronic Industries Alliance (EIA):
      a. 310-E - Cabinets, Racks, Panels, and Associated Equipment.
   2. Institute of Electrical and Electronics Engineers (IEEE):
      a. 802.1X - Standard for Local and Metropolitan Area Networks—Port-Based Network Access Control.
      b. 802.3 - Standard for Ethernet.
      c. 802.11b - Standard for Information Technology - Telecommunications and information exchange between systems - Local and Metropolitan networks - Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Higher Speed Physical Layer (PHY) Extension in the 2.4 GHz band.
   3. National Electrical Manufacturers Association (NEMA):
      a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
   4. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code (NEC).
   5. Telecommunications Industry Association (TIA):
      a. 569 - Telecommunications Pathways and Spaces.
      b. 607 - Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises.
   6. Underwriters Laboratories, Inc. (UL).

1.03 DELEGATED DESIGN

A. As specified in Section 01_35_73 - Delegated Design Procedures.

B. Anchoring and bracing.

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Product data:
   1. Include information on all network equipment.
   2. Manufacturer's operation and installation instructions.

C. Shop Drawings:
   1. Complete set of drawings, including, but not limited to:
      a. System block diagram showing relationship and connections between devices provided under this Contract, including connections to any existing equipment.
      b. Include manufacturer and model information, and address settings.
      c. Network riser diagram.
      d. Network port diagram, which physically locates all ports within the facility, and identifies their patch panel and switch port.
      e. Construction drawings for equipment cabinets, including dimensions, identification of components, preparation and finish data, and nameplates.
      f. Electrical connection diagrams.
      g. Complete grounding requirements.
   2. Furnish data sheets for each component together with a technical product brochure or bulletin:
      a. Manufacturer's model number.
      b. Project equipment tag.
   3. Complete and detailed bills of materials broken up by each cabinet. Each bill of material item will include the following:
      a. Quantity.
      b. Description.
      c. Manufacturer.
      d. Part numbers.

D. Delegated Design Submittals:
   1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in technical sections and as indicated on the Drawings.
      a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.

E. Calculations:
   1. Cooling calculations, including, but not limited to:
      a. Highest expected ambient temperature for the enclosure's location.
      b. Internal heat load.
      c. Exposure to direct sunlight.
      d. Dimensions of the enclosure in inches.
      e. Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.

F. Test reports:
   1. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

2. Signed test results as described in this Section.
3. Test results shall include:
    a. Narrative describing the test procedures followed.
    b. Block diagram of test set up.
    c. Manufacturer's information on test equipment used.
    d. Detailed test results.
    e. A narrative summarizing the results of the testing and identifying any further action required.

G. Operating manuals:
1. Complete installation, operation, calibration, and testing manuals as specified in Section 01 79 00 - Demonstration and Training.

H. Record drawings:
1. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.
2. Electrical connection diagrams shall be revised to reflect any changes made in the field and submitted as record drawings.

1.05 QUALITY ASSURANCE

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.07 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.08 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Vendor shall manufacture using low VOC-based materials to provide superior indoor air quality demonstrated by Greenguard certification.

2.03 MANUFACTURERS

A. As listed below in the individual component paragraphs.

2.04 MANUFACTURED UNITS

A. Ethernet switches:
   1. Unmanaged Ethernet switches:
      a. Manufacturers: One of the following or equal:
         1) Hirschmann.
         2) Moxa, 308/305 Series.
         3) N-Tron.
      b. Properties:
         1) Hardware:
            a) 100/1000BASE-TX RJ-45 copper ports (quantity as indicated on the Drawings).
            b) No fans or moving parts.
         2) Performance:
            a) Full/half-duplex.
            b) MDI/MDI-X autosensing.
         3) Environment:
            a) Operating temperature range: 32 to 140 degrees Fahrenheit.
            b) Humidity: 5 to 95 percent, non-condensing.
         4) Ethernet switch shall be capable of performing basic switching without special programming or configurations.
         5) Ports:
            a) As required to provide the number of connections required plus 10 percent spare of each type used.
         6) Connector type:
            a) Copper: RJ-45.
         7) Mounting:
            a) DIN rail.

PART 3 EXECUTION

3.01 INSTALLATION

A. Provide installation and configuration for the new and existing managed Ethernet switches. Provide configuration of the Ethernet switch network for a complete, functioning plant control system as indicated on the Drawings and as specified in this Section.
   1. Refer to SCADA block diagrams for new network connections.
   2. Provide configuration for managed Ethernet switches and other components, including, but not limited to, VLAN (virtual local area network), additional Plant PLC communication cards, and separate managed Ethernet switches as required, such that there is isolation of the following networks:
      a. Remote I/O network: This includes the connections between the Plant PLC and:
         1) Plant PLC expansion racks.
         2) Plant PLC remote I/O (RIO) racks.
      b. Field network: This includes the connections between the PLC and:
         1) Field devices.
         2) LOI (Local Operator Interface).
         3) Vendor furnished Ethernet network components.

4) Valve actuator network: This includes the connections between the PLC and the valve master stations.

c. PLC network: This includes the connections between the Plant PLCs and the I/O server(s).

d. Process control network: This includes the connections between the I/O server(s) and other equipment, including, but not limited to, servers, workstations, and printers.

e. Security control network: This includes any security hardware with Ethernet communication as provided by the security subcontractor.

3. Process floor managed Ethernet switches for the process control network shall be configured and programmed for rapid fail over protection.

4. Enterprise level managed Ethernet switches shall be configured for a communication protocol that is compatible with the process control network's rapid fail over protocol.

B. Racks shall be level and plumb.

C. Work shall be performed in a neat and workmanlike manner.

D. Cable management:

1. Cables and equipment shall be installed in strict conformance with the manufacturer's recommendations.
2. Install cable using lubricant designed for cable pulling.
3. Install hook-and-loop wrap on all cable bundles within the network rack/enclosure. Plastic tie-wraps are not acceptable.
4. Install network cables without splices.
5. Installed bend radius shall be a minimum of 10 times the cable diameter.
6. Terminate pairs at the jack and patch panel.
7. Route cables through cable management or other form of containment. No loose, unsupported cables are permitted to span across network equipment.
8. Use corner strips to protect cables from edges inside ducts and to maintain bend radius requirements.

E. Internal rack wiring:

1. Cables shall be installed avoiding sharp bends.
2. Provide enough working space inside rack or cabinets such that closing enclosure doors does not crush or compress cabling.
3. Bundle cables together in groups of no more than 12.
4. Route cables from both sides of the rack to patch panels. Do not bring all bundles from a single side.
5. No cabling shall obstruct equipment ventilation.
6. Individual pairs will be untwisted less than 1/2-inch at termination points.
7. Ground enclosure and equipment in accordance with TIA-607:
   a. Individually bond network equipment chassis to the rack's grounding busbar. Do not daisy-chain bonding conductors.
   b. Size the bonding conductor in accordance with the network equipment manufacturer's recommendation or #10 AWG, whichever is larger.

F. External rack wiring:

1. Do not install fiber cables in non-continuous cable supports such as cable ladders or wire baskets without radius cable supports or solid bottoms.

2. Maintain cable separation in accordance with TIA-569:
    a. Install cables a minimum of 40 inches away from electrical motors and transformers.
    b. Install cables a minimum of 12 inches away from fluorescent lighting.

G. Cables and terminations shall be labeled with cable designations as specified in Section 26_05_53 - Identification for Electrical Systems.

H. Each data port shall be individually labeled with its patch panel/switch port ID:
    1. Labeling must be printed. No handwritten labels will be allowed.

I. At the completion of the wiring installation, provide the following documentation:
    1. A plan-view of the premise(s) showing the jack numbering scheme.
    2. A printed certification report for the entire wiring installation showing compliance with TIA specifications for data cable.
    3. Reports such as those generated by Fluke DSP cable certification equipment meet this requirement.

J. Managed Ethernet switches:
    1. Configure switches to prevent broadcast storms.
    2. Installations shall employ IGMP snooping to limit multicast messaging.

3.02 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training.

B. Owner Training:
    1. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

3.03 FIELD QUALITY CONTROL (NOT USED)

3.04 ADJUSTING

A. Perform firmware installations, configuration, and other set up, as required, to place the network into proper operation.

END OF SECTION

SECTION 40_66_70

CONTROL SYSTEMS: WIRELESS COMMUNICATIONS - RADIO

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. General and design requirements applicable to industrial wireless radio communication system Work and submittals.
   2. General requirements for supply, installation, and commissioning of an industrial wireless radio communication system, including but not limited to the following:
      a. Materials, hardware, software, equipment fabrication, installation, configuration, programming, hardware and software testing, start-up, commissioning, training, and documentation.
      b. The Radio and associated components installed in the control panel shall be provided by Sycal.
      c. The Antenna, Mast, and all related components are the responsibility of the contractor.

1.02 REFERENCES

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Abbreviations:
   1. AGL: Above ground level.
   2. Antenna CL: Antenna center line mounting height.
   3. ASL: Above sea level.
   4. CPM: Critical path method.
   5. EIRP: Effective isotropic radiated power.
   6. FCC: Federal Communications Commission.
   7. FRN: FCC Registration Number.
   8. ITS: Institute for Telecommunications Science.
   9. LOS: Line of sight.
   10. RF: Radio frequency.
   11. RSSI: Receive signal strength intensity.
   12. SIM: Subscriber identity module.
   13. WLAN: Wireless local area network.

C. Definitions:
   1. BER: Bit error rate, a unitless measure of the number of bit errors that occur in a given number of bit transmissions.
   2. dB: Decibel, a relative expression representing a change in radio frequency power.
   3. dBi: A decibel referenced against an isotropic radiator.
   4. dBd: A decibel referenced to a dipole antenna.

5. dBm: A decibel referenced to 1 milliwatt (mW).
6. Direct Sequence Spread Spectrum (DSSS): A spread-spectrum technology used in IEEE 802.11 and IEEE 802.11b/g used to achieve data rates up to 2 Mbps.
7. Fade margin: The difference between the received signal level at the input to the receiver and the sensitivity of the receiver.
8. Fresnel zone: The area around the line-of-sight that radio waves spread out into after being transmitted by the antenna.
9. Radio Path Survey: In-field wireless communication site survey performed by the radio sub-contractor during the preliminary construction phase of the project.
10. Receiver Sensitivity: The minimum signal power level with an acceptable Bit Error Rate (in dBm or mW) that is necessary for the receiver to accurately decode a given signal.

D. Standards:
   1. American Concrete Institute (ACI):
      a. 318 - Building Code Requirements for Structural Concrete.
   2. ASTM International (ASTM):
      a. A475 - Standard Specification for Zinc-Coated Steel Wire Strand.
      b. A586 - Standard Specification for Metallic-Coated Parallel and Helical Steel Wire Structural Strand.
   3. Code of Federal Regulations (CFR):
      a. Title 47 - Telecommunication.
   4. Institute of Electrical and Electronics Engineers (IEEE):
      a. 802.11 - Wireless LAN Standards.
   5. International Electrotechnical Commission (IEC).
   6. National Fire Protection Association (NFPA):
      a. 79 - Electrical Standard for Industrial Machinery.
   7. Telecommunications Industry Association (TIA):
      a. 222 - Structural Standard for Antenna Supporting Structures and Antennas and Small Wind Turbine Support Structures.
      b. 1019 - Installation, Alteration, and Maintenance of Antenna Supporting Structures and Antennas.
   8. State and Local code requirements.

1.03 DELEGATED DESIGN

A. As specified in Section 01_35_73 - Delegated Design Procedures.

B. Anchoring and bracing for Antenna Mast and equipment installed outdoors.

1.04 SUBMITTALS

A. Furnish submittals as specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Submit product data for all components of the radio communication system:
   1. Radio.
   2. Antenna.
   3. Cables between radio and antenna.

4. All other related accessories.
5. Communication port type and quantity.
6. Installation details for each component indicated above.
7. For each type of radio/antenna:
    a. Provide operating mode setup, encryption, and polling configuration information.
8. Block diagram showing the location of each component of the radio communication system.

C. Furnish commissioning submittals listed below and specified in this Section as specified in Section 01 91 00 - Commissioning:
    1. Manufacturer's representative qualifications.
    Owner training.

1.05 QUALITY ASSURANCE

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. After installation, verify using field-collected data that the installed equipment conforms to reliability benchmark developed as part of the field testing.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.08 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
    1. Coordinate radio configuration and encryption options with the Owner:
        a. Adjust configuration and encryption settings as deemed necessary by the Owner.
        b. Provide radio configuration record files and save the device configuration on a standard SD card if available.
    2. Configure security settings and options as recommended by the radio manufacturer and as deemed necessary by the Owner and Engineer. Provide setup for secure username and password authentication by the Owner.
        a. Alerts shall be sent to defined list of recipients via pre-configured SMS text message.
        b. Alerts shall be sent to defined list of recipients via SMTP (email) message.

B. For licensed radio systems, coordinate and assist the Owner in obtaining and updating all required radio licenses with the FCC.

1.09 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

B. Provide a minimum of 1 year of warranty from substantial completion date for all wireless communication equipment.

1.10 MAINTENANCE

A. Furnish all parts, materials and additional components necessary for maintenance and calibration purposes for 1 year:
   1. Deliver all supplies before Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

A. Furnish and install an industrial wireless communication system that will serve the following sites:

Site Name	Site Coordinates (Latitude N; Longitude W)	Radio/ Antenna Tag	Wireless Technology/ Operational Mode	Radio/ Antenna Mounting Height	Notes
Beltz Well 8	As indicated on the drawings.	Radio-8		30 feet	

B. The wireless radio communication system shall be provided as indicated on the Drawings and as described in this Section.

C. The Contract Documents for the components of the wireless communication system are based on the Owners radio path survey.

D. Verify site conditions and provide a completely functional wireless radio communication system.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. System must be in accordance with the following:
   1. Code of Federal Regulations:
      a. CFR Title 47:
         1) Part 90 - UHF Radio Systems - Subpart C and J.
   2. NFPA 79, Annex “D” Standards.
   3. NEC.
   4. NEMA.
   5. ISA.
   6. IEC.
   7. State and Local code requirements.
   8. TIA 1019.

B. Performance requirements for wireless radio communication:
   1. The following are the radio path requirements for the radio communication system:
      a. Minimum fade margin: 20dB.
      b. Less than 25 percent obstruction within the first 60 percent of the Fresnel zone for 150-900 MHz licensed or unlicensed radios.
      c. Data Rate Capacity.
   2. Minimum antenna mounting heights are described on the following:
      a. As indicated in Section 2.01 above.
   3. Antenna tower location:
      a. As shown in site plan/installation detail in the contract drawings.

2.03 MANUFACTURERS

A. Radio:
   1. Licensed non-microwave radio:
      a. One of the following or equal:
         1) General Electric, Orbit LN Series.

B. Transmission cables:
   1. Manufacturers: One of the following or equal:
      a. Phoenix Contact.
      b. FreeWave.
      c. Esteem Horizon.
      d. Telewave, Inc., ANT Series.
      e. CommScope:
         1) HELIAX Cable Products.
      f. Times Microwave Systems.

C. Surge protectors:
   1. Manufacturers: One of the following or equal:
      a. Polyphasor.
      b. CommScope:
         1) T Series Surge Arrestors.
         2) Gas Tube Surge Arrestors.
      c. Phoenix Contact, Trabtech Series.

D. Antennas:
   1. Radio antennas:
      a. Manufacturers: One of the following or equal:
         1) Phoenix Contact.
         2) FreeWave.
         3) Esteem Horizon.
         4) Telewave, Inc., ANT Series.
         5) Kathrein Scala.
         6) CommScope.
         7) Microwave Data Systems, Clearwave Series.

E. Antenna support structure:
   1. One of the following or equal:
      a. KW Industries.

b. Sabre Industries, Inc.
c. Trylon, Inc.

2.04 MANUFACTURED UNITS

A. Licensed radio system:
1. General:
a. The radio system comprises the following:
1) Wireless radio(s).
2) Antennas.
3) Surge protectors.
4) Transmission cables.
5) Software and other accessories as specified in the Components article.
6) Protocol conversion modules as indicated on the Drawings.
2. Performance requirements:
a. Frequency: 173.2875 MHz .
b. Ambient temperature range: -20 to 60 degrees Celsius.
c. Enclosure protection class:
1) IEC IP20.
d. Bi-directional (2-way) system:
1) Transceiver:
a) Carrier power: 0.1 to 5 W, programmable.
b) Transmission mode: Transparent.
c) I/O interface:
(1) Serial communication ports: RS-232.
(a) Transmission speed for serial protocol: 1.2 to 38.4 kbps.
d) Duty cycle: Continuous.
e) Power supply: 10.5 - FAFA16 VDC.

B. Transmission cables characteristics:
1. 1/2-inch, nominal diameter.
2. Continuous section without splices or connectors other than at the radio and antenna.
3. Rated for outdoor installation.
4. Cable length: As indicated on the Drawings or as indicated in the path study report.
5. Cable characteristics:
a. Attenuation: Less than 1.8 dB at 173 MHz per 100 feet.
b. Characteristic impedance: 50 ohms.
c. Coaxial shield.
d. Dielectric: Foam.

C. Antennas:
1. Radio antenna characteristics:
a. Yagi antenna:
1) Frequency range: 132-174 MHz.
2) Nominal impedance: 50 ohm.
3) Connector: N-Type.
4) Gain: 9 dB.

5) Construction material: All welded aluminum.
6) Operating temperature:
a) Stationary: -40 to 85 degrees Celsius.
b) Cyclic: -40 to 55 degrees Celsius.

3. Antenna support structures:
a. Antenna monopole mast:
1) Mast shall be round steel pole, KW Industries Round Tapered Steel Pole, 14-inch base diameter, gauge 7, or approved equal.
2) Furnish mast as one continuous length for full height without splices.
3) Each mast shall be grounded with dedicated ground rod and grounding conductors.
4) Provide required accessories for complete installation of antenna.

2.05 MATERIALS

A. Anchor bolts:
1. As specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.

2.06 ACCESSORIES

A. Antenna accessories:
1. Provide all required mounting accessories required for installation, such as clamps, brackets adapters, and related hardware for a complete installation.
a. Mounting guidelines shall be provided in the installation details indicated on the Drawings and as recommended by the manufacturer.
2. Provide mounting hardware to meet the wind and seismic requirements at the Project Site as specified in technical sections and as indicated on the Drawings.

B. Provide lightning surge arrestors and data line surge protection for radios or antennas located outdoors.

C. Provide antenna cables, connectors and related hardware for a complete installation.

D. Provide din-rail mounting adapters required for installation of radios in control panels/communication cabinets, as needed for each application.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

A. Anchoring and bracing:
1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
2. Install anchors of type and material indicated on approved anchoring designs.
3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Tag and label terminal blocks, radio system components and associated wiring as indicated in the Drawings and as specified in Section 26_05_53 - Identification for Electrical Systems.

3.04 COMMISSIONING

A. As specified in Section 01 91 00 - Commissioning and Section 40_80_01 - Commissioning for Instrumentation and Controls for communications testing requirements.

B. Functional Testing:
   1. Hardware and communication testing:
      a. Perform tests to show that the integrated system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
      b. Engineer approval of the FAT Communication Testing activities is required before proceeding to FAT Platform Testing.
   2. Failure testing: Demonstrate how the system responds to and recovers from abnormal conditions including, but not limited to:
      a. Equipment failure.
      b. Operator error.
      c. Communications subsystem error.
      d. Communications failure.
      e. Simulated/forced software lockups.
      f. Power failure (both utility power and power to HMI and/or SCADA hardware).
      g. High system loading conditions.

3.05 FIELD QUALITY CONTROL

A. Verify using field-collected data that the installed equipment conforms to reliability benchmarks developed as part of the field testing.

B. Submit a report to document field-verified transmit and receive signal strength and any RF interference after installation of final communication elements.
   1. Troubleshoot issues and assist Owner with FCC coordination if interference is detected during startup and commissioning.

C. The installation shall follow the wireless network manufacturer’s recommended installation practices and comply with all applicable codes.

D. Upon completion of installation, provide the services of a factory-certified local service technician to perform start-up testing. Record test results and compare to factory testing to confirm proper operation of equipment. Submit test results with operation and maintenance manuals.

3.06 ADJUSTING

A. Orient directional antennas as required for maximum receive strength signal intensity during startup.

END OF SECTION

SECTION 40_67_01

CONTROL SYSTEMS: PANELS, ENCLOSURES, AND PANEL COMPONENTS

TABLE OF CONTENTS

PART 1 GENERAL 2

1.01 SUMMARY 2
1.02 REFERENCES 2
1.03 TERMINOLOGY 3
1.04 DELEGATED DESIGN 3
1.05 SUBMITTALS 3
1.06 QUALITY ASSURANCE 4
1.07 PROJECT OR SITE CONDITIONS 4
1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED) 4
1.09 WARRANTY 4

PART 2 PRODUCTS 4

2.01 GENERAL 4
2.02 DESIGN AND PERFORMANCE CRITERIA 5
2.03 MANUFACTURERS (NOT USED) 5
2.04 EXISTING PRODUCTS (NOT USED) 5
2.05 MATERIALS 5
2.06 MANUFACTURED UNITS 6
2.07 ACCESSORIES 20
2.08 FINISHES 22

PART 3 EXECUTION 22

3.01 PREPARATION 22
3.02 INSTALLATION 22
3.03 COMMISSIONING 23

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Design, fabrication and assembly of instrumentation enclosures, control panels and components provided under this Contract, including, but not limited to:
      a. Custom built instrumentation and control panels, including enclosures for hand stations controllers, low voltage power distribution and marshalling panels.
      b. Control panels furnished as part of equipment systems specified in other Divisions, such as vendor control panels (VCPs) and chemical feed panels.
      c. Control components.
      d. Control panel installation.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Standards:
   1. Institute of Electrical and Electronics Engineers (IEEE):
      a. C62.41.1 - Guide on the Surge Environment in Low-Voltage (1,000 V and less) AC Power Circuits.
      b. 802.3af - Standard for Information Technology Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.
      c. 802.3at - Standard for Information Technology -- Local and Metropolitan area networks -- Specific requirements -- Part 3: CSMA/CD Access Method and Physical Layer Specifications Amendment 3: Data Terminal Equipment (DTE) Power via the Media Dependent Interface (MDI) Enhancements.
   2. International Electrotechnical Commission (IEC):
      a. 61643-11 - Low-Voltage Surge Protective Devices - Part 11: Surge Protective Devices Connected to Low-Voltage Power Systems - Requirements and test methods.
      b. 61643-21 - Low-Voltage Surge Protective Devices - Part 21: Surge Protective Devices Connected to Telecommunications and Signaling Networks - Performance Requirements and Testing Methods.
   3. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code (NEC).
   4. Underwriters Laboratories Inc. (UL):
      a. 248-14 - Low-Voltage Fuses - Part 14: Supplemental Fuses.

b. 497B - Standard for Protectors for Data Communications and Fire-Alarm Circuits.
c. 508 - Standard for Industrial Control Equipment.
d. 508A - Standard for Industrial Control Panel.
e. 698A - Standard for Industrial Control Panels Relating to Hazardous (Classified) Locations.
f. 913 - Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations.
g. 1077 - Standard for Supplementary Protectors for Use in Electrical Equipment.
h. 1283 - Standard for Electromagnetic Interference Filters.
i. 1310 - Standard for Class 2 Power Units.
j. 1449 - Standard for Surge Protective Devices.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. The term “panel” in this Section is interchangeable with the term “enclosure.”

1.04 DELEGATED DESIGN

A. As specified in Section 01_35_73 - Delegated Design Procedures.

B. Anchoring and bracing.

1.05 SUBMITTALS

A. Provide Submittals as specified in Section 01 33 00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide a control panel hardware Submittal for each control panel/enclosure being provided on this Project, including, but not limited to:
   1. Product data:
      a. Enclosure construction details and NEMA type.
      b. Manufacturer’s literature and specification datasheets for each type of equipment to be installed within or on the panel or enclosure.
   2. Shop Drawings:
      a. Scaled, detailed exterior panel (front and side views) and interior panel layout showing equipment arrangement and dimensional information:
         1) Provide draft for review and approval by the Engineer. Engineer has the authority to substantially alter initial panel layouts.
      b. Complete nameplate engraving schedule.
      c. Structural details of fabricated panels.
   3. Calculations:
      a. Cooling calculations, including, but not limited to:
         1) Highest expected ambient temperature for the enclosure’s location.
         2) Internal heat load.
         3) Exposure to direct sunlight.
         4) Dimensions of the enclosure in inches.

5) Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.

C. Delegated Design Submittals:
   1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in technical sections and as indicated on the Drawings:
      a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
      b. For equipment installed outdoors.
      c. For wall mounted equipment weighing 125 pounds or more.

1.06 QUALITY ASSURANCE

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Assemble panels, enclosures, and rack systems along with internal and external devices, wiring, equipment, and materials in a facility that is recognized by UL to assemble and certify UL-labeled control panels:
   1. Provide components and equipment with UL 508 listing.
   2. Control panels shall be UL 508A labeled, unless the equipment in the panel and the design in the Contract Documents cannot be reasonably modified to meet the requirements for UL 508A labeling.
   3. Provide fuses for equipment that is not UL or UR listed.
   4. Install intrinsically safe circuits and equipment in accordance with UL 698A.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide control panels identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Panel dimensions:
   1. Minimum dimensions are scalable from or as indicated on the Drawings and are based upon manufacturer's non-certified information. It is the responsibility of the Contractor or manufacturer to design and size panels:
      a. Size panels to provide space for equipment, wiring, terminations, and other items in the panel, including 20 percent of the total back panel area shall remain empty.
      b. Panel sizes that substantially deviate (within 3 inches in any dimension) from the sizes indicated on the Drawings must be approved by the Engineer.
      c. Maximum panel depth: 32 inches, unless otherwise indicated.

B. Provide equipment and components that are fully rated for the Site elevation and operating environment where the equipment will be installed as specified in technical sections and as indicated on the Drawings.

C. Non-conditioned spaces and outdoor installations:
   1. Provide additional temperature conditioning equipment to maintain the equipment temperature within a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature.

D. As listed below in the individual component paragraphs.
   1. Provide conditioning equipment incorporated into the equipment to maintain the enclosures within the equipment manufacturer's specified operating ranges.

2.03 MANUFACTURERS (NOT USED)

2.04 EXISTING PRODUCTS (NOT USED)

2.05 MATERIALS

A. Construct and finish enclosures using materials capable of withstanding the mechanical, electrical, and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service:
   1. Enclosures shall have the following properties:
      a. NEMA Type 1: Steel.
      b. NEMA Type 4: Steel with gasketed door, raintight.
      c. NEMA Type 4X: Type 316 stainless steel (unless Type 304 is indicated on the Drawings).
      d. NEMA Type 4X: Polycarbonate or fiberglass reinforced polyester (FRP) in corrosive areas where stainless steel is incompatible.
      e. NEMA Type 12: Steel with gasketed door, dusttight.
      f. NEMA Type 7: Cast aluminum.

B. Bolting material:
   1. Commercial quality 1/2-inch diameter, stainless steel hex-head Grade 5 bolts, nuts, and washers, with unified coarse (UNC) threads.
   2. Carriage bolts for attaching end plates.

3. Other bolted joints shall have S.A.E. standard lock washers.

2.06 MANUFACTURED UNITS

A. Panels/enclosures:
   1. Manufacturers: One of the following or equal:
      a. nVent/Hoffman.
      b. Rittal.
      c. Saginaw Control & Engineering.
   2. Panel assembly:
      a. General guidelines for panel fabrication include:
         1) Continuous welds ground smooth.
         2) Exposed surfaces free of burrs and sharp edges.
         3) Base formed of heavy channel iron, either galvanized or powder coated, minimum 1/2-inch holes at 12-inch spacing to accommodate anchoring of freestanding enclosures to floor.
      b. Construct enclosure and mounting panel using stretcher-level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
Wall-mounted up to 48	14	14
Up to 57	12	12
57 to 69	12	10
69 to 82	12, except 10 on back	10
82 or more	10	10

         1) Use heavier sheet metal to meet seismic requirements at the Project Site or when required due to equipment requirements.
      c. For Rittal or engineer-approved equal free-standing modular enclosure, construct enclosure and mounting panel using stretcher-level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
Wall-mounted up to 48	16	14
Up to 57	14	13
57 or more	16	11

      d. Construct supporting frame structure with angled, channeled, or folded rigid section of sheet metal, rigidly attached to and having essentially the same outer dimensions as the enclosure surface and having sufficient torsional rigidity to resist the bending moments applied via the enclosure surface when it is deflected.
      e. Provide stiffeners for back mounting or C folded back panels in enclosures larger than 4 feet. In addition, secure the panels in place by collar studs welded to the enclosure.

f. Door construction:
    1) Turned-back edges suitably braced and supported to maintain alignment and rigidity without sagging.
    2) Sufficient width to permit door opening without interference with rear projection of flush-mounted instruments.
    3) Heavy-gauge stainless steel hinges.
    4) For NEMA Type 12, Type 4, and Type 4X, provide oil-resistant neoprene sealing gasket and adhesive to seal cover to enclosure.
    5) Gasket installed to seal against roll lip on the enclosure opening.
g. Latches:
    1) For panels, provide each door with an oil tight 3-point latching mechanism and locking handle with rollers on the ends of the latch rods. Latch rods shall be connected to a common door handle, hold doors securely, and form a compressed seal between door and gasket, at the top, side, and bottom.
        a) Provide padlock for each enclosure with padlock provisions.
        b) Provide 2 keys per panel.
        c) All locks keyed alike.
    2) For Rittal or engineer-approved equal free-standing modular enclosure, provide each door with a 4-point latching mechanism, if available, or a 2-point latching mechanism if a 4-point is not available.
    3) For cabinets not available with 3-point latching hardware, provide multiple clips and padlock hasps.
h. Panel cut-outs:
    1) Cut, punch, or drill cutouts for instruments, devices, and windows. Smoothly finish with rounded edges.
    2) Allow a minimum of 3-inch envelope around displays, controllers, and monitors.
    3) Reinforce around cut-outs with steel angles or flat bars for the following:
        a) Large panel cutouts; for example, openings for local operator interfaces.
        b) Pilot device groupings, where the removed metal exceeds 50 percent of the available metal.

3. In addition to the requirements specified above, the following requirements for NEMA Type 4X powder coated stainless steel enclosures apply:
    a. Minimum 16-gauge, Type 304 stainless steel.
    b. Captive stainless steel cover screws threaded into sealed wells.
    c. Inside finish: White polyester powder coating.
    d. Specifically designed for use with flange-mounted disconnect handles where required or as indicated on the Drawings.
4. Outdoor panels. Supplementary requirements for panels located outdoors are as follows:
    a. Enclosures located outdoors shall be explicitly designed and rated for outdoor service by the manufacturer.
    b. Door hardware: Stainless steel.
    c. Provide factory installed rain canopy and sun shield for enclosures with operator interface panels.
    d. Bases: Heavy channel, gasketed stainless steel bases, flanges up, for anchoring to pad.

B. Arrangement of components:
   1. Arrange panel internal components for external conduit and piping to enter into panel either from above or below.
   2. Arrange panel instruments and control devices in a logical configuration, associating pushbutton and selector switches with related readout devices, or as indicated on the Drawings.
   3. Mount internal control components on an internal back panel. Devices may be mounted on the side panel only by special permission from the Engineer.
   4. Control panel mounted operator interface devices shall be mounted between 3 feet and 5 feet above finished floor.

C. Overcurrent protection:
   1. Main overcurrent device:
      a. Where the electrical power supply voltage to the control panel is more than 120 VAC, provide the panel with a flange-mounted disconnect handle operating a molded-case circuit breaker and provide a control power transformer for 120-VAC circuits:
         1) Door-mounted disconnect handles are not acceptable.
         2) Mechanically interlock the disconnect switch with the control enclosure doors so that no door can be opened unless the power is disconnected, and the disconnect switch cannot be closed until all doors are closed.
         3) Provide means to defeat the interlock.
         4) Lockable in the off position.
      b. Control panels supplied with 120 VAC:
         1) Provide an internal breaker with the line side terminals covered by a barrier.
         2) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.
         3) Provide a nameplate prominently positioned on the control panel stating “CAUTION Risk of Electric Shock - UPS equipment outputs remain energized with main disconnect in off position” for any panel containing a UPS.
   2. Provide circuit breakers as specified in Section 26_28_01 - Low Voltage Molded Case Circuit Breakers.
   3. Selection and ratings of protective devices:
      a. Interrupting ratings: Not less than the system maximum available fault current at the point of application.
      b. Voltage rating: Not less than the voltage of the application.
      c. Select current rating and trip characteristics to be suitable for:
         1) Maximum normal operating current.
         2) Inrush characteristics.
         3) Coordination of the protective devices to each other and to the source breaker feeding the panel.
      d. Circuit breakers, fuses, and motor overcurrent protection devices used for branch circuit protection must be UL 508A compliant.
         1) Circuit breakers listed under UL 1077 Standard for Supplementary Protectors that do not comply with UL 508A requirements are not acceptable.

2) Miscellaneous, miniature, and micro fuses listed under UL 248 Part 14 that do not comply with UL 508A requirements are not acceptable.
3) Manual motor controllers provided with an instantaneous-trip overcurrent mechanism listed under UL 508 that do not comply with UL 508A requirements are not acceptable.

4. Provide a separate protective device for each powered electrical device:
   a. An individual circuit breaker for each 120-VAC instrument installed within its respective control panel and clearly identified for function.
   b. An individual fuse for each PLC discrete output. Provide with individual blown fuse indication external of the I/O card:
      1) Size external fuse to open before any I/O-card-mounted fuses.
   c. Individual discrete inputs shall use a 1/2-amp fuse:
      1) Discrete output:
         a) Size external fuse to open before any I/O-card-mounted fuses.
      2) Analog loop powered from the control panel:
         a) 0.25-amp fuse.
      3) Analog loop powered from the control panel:
         a) 0.25-amp fuse.
   d. Install protective devices on the back mounting panel and identify by a service nameplate in accordance with the wiring diagrams.
5. Fuses for analog and discrete control loops:
   a. Provide durable, readily visible label for each fuse, clearly indicating the correct type, size, and ratings of replacement fuse:
      1) Label shall not cover or interfere with equipment manufacturer's instructions.
   b. Provide fuses rated for the voltage and available short-circuit current at which they are applied.
   c. Manufacturers: One of the following or equal:
      1) Bussmann.
      2) Ferraz Shawmut.
      3) Littelfuse.
6. Fuse holders:
   a. Modular type:
      1) DIN rail mounting on 35-millimeter rail.
      2) Touch-safe design: Connection terminals to be protected against accidental touch.
      3) Incorporates blown-fuse indicator.
      4) Plug-in style fuse terminals and fuse plugs are not acceptable.
   b. Provide nameplate identifying each fuse:
      1) As specified in Section 26_05_53 - Identification for Electrical Systems.
   c. Manufacturers: One of the following or equal:
      1) Allen-Bradley, 1492-FB Series B.
      2) Phoenix Contact, UT4-HESI Series.
7. Control circuit breakers:
   a. DIN rail mounting on 35-millimeter rail.
   b. Manual OPEN-CLOSE toggle switch.
   c. Rated for 250 VAC.
   d. Interrupting rating: 10 kA or available fault current at the line terminal, whichever is higher.
   e. Current ratings: As required for the application.

f. Provide nameplate identifying each circuit breaker:
    1) As specified in Section 26_05_53 - Identification for Electrical Systems.
g. Manufacturers: One of the following or equal:
    1) ABB.
    2) Allen-Bradley.
    3) Phoenix Contact, TMC Series.
    4) Square D.

8. Electronic circuit protectors:
    a. Used where a NEC Class 2 power circuit is required.
    b. Confirms to NEC Class 2 according to UL 1310.
    c. DIN rail mounting on 35-millimeter rail.
    d. Power source:
        1) Operating voltage: 24 VDC.
        2) Output current ratings: As required for the application.
        3) Maximum output current: 4 A.
        4) Maximum nameplate rating: 100 VA.
    e. LED for status indication.
    f. Remote status contact.
    g. When using multi-channel electronic circuit protectors, distribute devices such that a failure is limited to a single network or segment.
    h. Provide nameplate identifying each circuit electronic circuit protector module:
        1) As specified in Section 26_05_53 - Identification for Electrical Systems.
    i. Manufacturers: One of the following or equal:
        1) Single channel:
            a) Allen-Bradley, 1694 series.
            b) Phoenix Contact, PTCB E1 series.
        2) Multi-channel:
            a) Phoenix Contact, CBMC series.
            b) Puls PISA11 series.

D. Conductors and cables:
1. Power and control wiring:
    a. Materials: Stranded, soft annealed copper.
    b. Insulation: 600 VAC type MTW.
    c. Minimum sizes:
        1) Primary power distribution: 12 AWG.
        2) Secondary power distribution: 14 AWG.
        3) Control: 16 AWG.
    d. Color:
        1) AC power (line and load): Black.
        2) AC power (neutral): White.
        3) AC control: Red.
        4) AC control: Orange for foreign voltages.
        5) DC power and control (ungrounded): Blue.
        6) DC power and control (grounded): White with Blue stripe.
        7) Ground: Green.
2. Signal cables:
    a. Materials: Stranded, soft annealed copper.

b. Insulation: 600 VAC, PVC outer jacket.
c. Minimum size: 18 AWG paired triad.
d. Overall aluminum shield (tape).
e. Copper drain wire.
f. Color:
    1) 2-conductor:
        a) Positive (+): Black.
        b) Negative (-): White and red.
    2) 3-conductor:
        a) Positive (+): Black.
        b) Negative (-): Red.
        c) Signal: White.
g. Insulate the foil shielding and exposed drain wire for each signal cable with heat-shrink tubing.

E. Conductor identification:
1. Identify each conductor and cable with unique wire numbers as specified in Section 26_05_53 - Identification for Electrical Systems.
2. Readily identified without twisting the conductor.

F. General wiring requirements:
1. Wiring methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for General Purpose (no open wiring) unless otherwise specified.
2. Install components in accordance with the manufacturer’s instructions included in the listing and labeling.
3. Provide a nameplate on the cover of the control panel identifying sources of power supply and foreign voltages within the control panel.
4. Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.
5. Provide power surge protection for control panels.
6. Provide signal surge protection within control panels for each analog I/O, discrete I/O, and data line (Copper Ethernet, Coax, Fieldbus signals) that originates from outdoor devices.
7. Provide non-metallic ducts for routing and organization of conductors and cables:
    a. Provide wiring separation plan.
    b. Size ducts for ultimate build-out of the panel, or for 20-percent spare, whichever is greater.
    c. Provide separate ducts for signal and low voltage wiring from power and 120 VAC control wiring:
        1) 120 VAC: Grey colored ducts.
        2) 24 VDC: White colored ducts.
8. Cables shall be fastened with cable-mounting clamps or with cable ties supported by any of the following methods:
    a. Screw-on cable tie mounts.
    b. Hammer-on cable-tie mounting clips.
    c. Fingers of the nonmetallic duct.
    d. Adhesive cable tie mounts are not acceptable.
9. Wire ties:
    a. No wire ties inside wire duct.

b. Use Panduit cable tie installation tool, with tension control/cutoff.
c. Verify cut ends are cut flush filed smooth after installed.

10. Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors.
11. Support panel conductors where necessary to keep them in place.
12. Wiring to rear terminals on panel-mount instruments shall be run in nonmetallic duct secured to horizontal brackets run adjacent to the instruments.
13. Conductors and cables shall be run from terminal to terminal without splice or joints. Exceptions:
    a. Factory-applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.
14. Control panel shall be the source of power for 120 VAC devices interconnected with the control panel, including, but not limited to:
    a. Solenoid valves.
    b. Instruments both mounted in the control panel and remotely connected to the control panel.
15. Routing conductors to door-mounted displays and switches:
    a. Use plastic coil wrap to avoid pinching wires and provide sufficient slack to allow doors to open at least 91 degrees.

G. Provide power circuits for Contractor- and vendor-furnished PLC cabinets in accordance with the PLC and instrument power wiring diagrams indicated on the Drawings or as specified.

H. Thermal management:
1. Provide heating, cooling, and dehumidifying devices in order to maintain instrumentation and control devices to within a range as specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation.
2. Heating:
    a. Provide panels located in areas that are not climate controlled with thermostatically controlled strip heaters, except where all of the following conditions apply:
        1) Panel is not supplied with 120 VAC power.
        2) There are no electronics or moisture-sensitive devices in the enclosure.
        3) Panel is smaller than 38-inches high.
3. Heat exchanger:
    a. Closed-loop design ensuring separation of ambient air and clean air inside the cabinet.
    b. Filterless design to facilitate easy cleaning of the core.
    c. Mounting: As indicated on the Drawings.
    d. Manufacturers: One of the following or equal:
        1) ICEqube, Blade series.
        2) Noren, CC Series.
4. Enclosure temperature switch:
    a. Provide wall-mounted bimetallic switch transmitter (to measure internal cabinet temperature in enclosures) containing electrical components such as PLCs, RTUs, RIO, and VFDs.
    b. Sensor and electronic enclosure.
    c. Accuracy: Within 2 degrees Fahrenheit.

d. Single contact:
1) Manufacturers: One of the following or equal:
a) nVent/Hoffman ATEMNC.
b) Pfannenberg FLZ.
c) Rittal.
e. Dual contact:
1) Manufacturers: One of the following or equal:
a) nVent/Hoffman ADLTEMP.
b) Rittal.
5. Status relays and discrete inputs for switches, power supplies, and fieldbus devices (if applicable):
a. Provide as indicated on the Drawings or as specified.
6. Fan ventilation:
a. Provide nVent/Hoffman or Rittal fan speed control:
1) Provide 2 door/cabinet-mounted vent fans for every 72 inches of cabinet width.
2) Provide finger-guard kit.
3) Filter kit with 2 spare filters for each intake fan.
4) Provide bezel and gasket kit.
5) Automatically adjust fan speed depending on remote temperature sensor input.
6) 120 VAC, 60 hertz.
7) NEMA Type 5-15R cord connections.

I. Pilot devices:
1. General:
a. Provide operator pushbuttons, switches, and pilot lights, from a single manufacturer.
b. Size:
1) 30.5 millimeters.
c. Heavy duty.
d. Pushbuttons:
1) Contacts rated:
a) NEMA Type A600.
2) Furnish 1 spare normally open contact and normally closed contact with each switch.
3) Equipment shutdown (ESD): Palm or mushroom-head type with self-latching feature. ESD device will remain in the actuated position until deliberately reset.
e. Selector switches:
1) Contacts rated:
a) NEMA Type A600.
b) Knob type.
2) Furnish 1 spare normally open contact and normally closed contact with each switch.
3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.
f. Pilot lights:
1) Type:
a) LED for interior installations.
2) Push to test.

3) Lamp color:
a) On/Running/Start: Green.
b) Power: White.
c) Alarm: Amber.
d) Opened: Green.
e) Closed: Red.
f) Failure: Amber.

2. Indoor and outdoor areas:
a. NEMA Type 4/13.
b. Manufacturers: One of the following or equal:
1) Allen-Bradley, Type 800T.
2) General Electric, Type CR104P.
3) IDEC, TWND Series.
4) Schneider Electric, Class 9001, Type K.

3. Corrosive areas:
a. NEMA Type 4X.
b. Corrosion resistant.
c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc.
d. Manufacturers: One of the following or equal:
1) Allen-Bradley, Type 800H.
2) Cutler Hammer, Type E34.
3) IDEC, TWND Series.
4) Schneider Electric, Class 9001, Type SK.

4. Hazardous (classified) areas/Class I Division 2:
a. NEMA Type 4X.
b. Corrosion resistant.
c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc:
1) Contacts contained within a hermetically sealed chamber:
a) Pushbuttons.
b) Selector switches.
c) Push-to-test contacts on pilot lights.
2) UL listed and labeled for Class I Division 2 areas.
d. Manufacturers: One of the following or equal:
1) Allen-Bradley, Type 800H.
2) Cutler Hammer, Type E34.

J. Potentiometer and slidewire transmitters:
1. Provide a DC output in proportion to a potentiometer input.
2. Potentiometer input:
a. 100 ohms to 100 K ohms.
b. Impedance greater or equal to 1 M ohms.
c. Zero turn-up: 80 percent of full-scale input.
d. Span turn-down: 80 percent of full-scale input.
3. Field-configurable output:
a. Voltage and current: Conventional current loops and voltage control signals.
4. Accuracy, including linearity and hysteresis, within 0.1 percent maximum at 77 degrees Fahrenheit.
5. Operating temperature: 32 degrees to 131 degrees Fahrenheit.

6. Supply power: 9 to 30 VDC.
7. Manufacturers: One of the following or equal:
    a. Allen-Bradley, Type 800T-U29.
    b. Phoenix Contact, Mini Analog Pro.

K. Signal isolators and converters:
1. Furnish signal isolators that provide complete isolation of input, output, and power input:
    a. Minimum isolation level: 1.0 kilovolts AC/50 hertz for at least 1 minute.
    b. Adjustable span and zero.
    c. Accuracy: Within 1.0 percent of span.
    d. Ambient temperature range: -4 degrees to 149 degrees Fahrenheit.
2. Manufacturers: One of the following or equal:
    a. Acromag, 1500, 600T, 800T, Flat Pack, or ACR Series.
    b. Action Instruments, Q500 Series or Ultra SlimPak II.
    c. AGM Electronics, Model TA-4000.
    d. Moore Industries, MIT 4-Channel.
    e. Phoenix Contact, Mini Analog Pro.

L. Relays:
1. General:
    a. For all types of 120-VAC relays, provide surge protection across the coil of each relay.
    b. For all types of 24-VDC relays, provide a free-wheeling diode across the coil of each relay.
    c. For plug in type relays, provide a relay base from the same manufacturer as the relay manufacturer.
2. Control:
    a. Magnetic style.
    b. For use as standard control relay for motor and starter relay logic.
    c. NEMA ratings:
        1) 300 volts.
        2) 10 amps thermal continuous test current.
        3) 60 amps make.
        4) 6 amps break.
    d. Plug-in type.
    e. LED indication for energization status.
    f. Coil voltages: As required for the application.
    g. Minimum poles: DPDT.
    h. Touch-safe design: Connection terminals to be protected against accidental touch.
    i. Enclose each relay in a clear plastic heat and shock-resistant dust cover.
    j. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
    k. Relays with screw-type socket terminals.
    l. Provide additional relays when the following occurs:
        1) Number or type of contacts shown exceeds the contact capacity of the specified relays.
        2) Higher contact rating is required in order to interface with starter circuits or other equipment.
    m. DIN rail mounting on 35-millimeter rail.

n. Ice-cube-type relays with retainer clips to secure relay in socket.
o. Integrated label holder for device labeling.
p. Manufacturers: One of the following or equal:
1) Allen-Bradley: Type 700 HC.
2) IDEC: R* Series (* = H, J, R, S, U).
3) Potter and Brumfield: Type KRP or KUP.
4) Square D: Type K.

3. Isolation:
a. Electromechanical style.
b. For use as an interposing relay for PLC based discrete I/O signals.
c. NEMA ratings:
1) Switching voltage: 250 volts AC/DC.
2) Limiting current: 6 amps continuous.
3) Interrupt: 1,500 volt-amperes.
d. Plug-in type.
e. LED indication for energization status.
f. Coil voltages: As required for the application.
g. Minimum poles: SPDT.
h. Touch-safe design: Connection terminals to be protected against accidental touch.
i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
j. Relays with screw-type socket terminals.
k. DIN rail mounting on 35-millimeter rail.
l. Integrated label holder for device labeling.
m. Manufacturers: One of the following or equal:
1) Allen-Bradley, Type 700 HL TBR Series.
2) Eaton, XR TBR Series.
3) IDEC, RV8H Series.
4) Phoenix Contact, PLC-INTERFACE Series.

4. Latching:
a. Magnetic-latching control relays.
b. NEMA ratings:
1) 300 volts.
2) 5 amps continuous.
3) 360 volt-amperes make.
4) 320 volt-amperes break.
c. Plug-in type.
d. DIN rail mounting on 35-millimeter rail.
e. Coil voltage: As required for the application.
f. Minimum contacts: DPDT as required for the application. Plus 1 spare contact.
g. Touch-safe design: Connection terminals to be protected against accidental touch.
h. Clear cover for visual inspection.
i. Provide retainer clip to secure relay in socket.
j. Manufacturers: One of the following or equal:
1) IDEC, RR2KP Series.
2) Square D, 8501, Type K.

5. Time delay:
a. Provide time-delay relays to control contact transition time.

b. Contact rating:
    1) 240 volts.
    2) 10 amps continuous.
    3) 3,600 volt-amperes make.
    4) 360 volt-amperes break.
c. Coil voltage: As required for the application.
d. Provide pneumatic or electronic type with on-delay, off-delay, and on/off-delay:
    1) For off-delay, use true power-off time-delay relays. Where the required timing range exceeds capability of the off-delay relay use, signal off-delay where power loss will not cause undesirable operation or pneumatic time-delay relays.
e. Minimum contacts: DPDT.
f. Units include adjustable dial with graduated scale covering the time range in each case.
g. Minimum timing range: 0.1 second to 10 minutes, or as required for the application.
h. Manufacturers: One of the following or equal:
    1) Allen-Bradley, Type 700-HR.
    2) IDEC, RTE Series.
    3) Tyco Electronics, Agastat 7000 Series (pneumatic).

M. Terminal blocks:
1. DIN rail mounting on 35-millimeter rail.
2. Rated for 15 amps at 600 volts.
3. Screw terminal type.
4. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
5. Finger-safe protection for terminals for conductors.
6. Construction: Polyamide insulation material capable of withstanding temperature extremes from -40 degrees to 221 degrees Fahrenheit.
7. Terminals: Plainly identified to correspond with markings on the diagrams:
    a. Permanent machine-printed terminal identification.
8. Disconnect-type field signal conductor terminals with socket/screw for testing.
9. Identify terminals suitable for use with more than 1 conductor.
10. Position:
    a. So that the internal and external wiring does not cross.
    b. To provide unobstructed access to the terminals and their conductors.
11. Manufacturers: One of the following or equal:
    a. Allen-Bradley, 1492 Series.
    b. Phoenix Contact, UT4 Series.

N. DIN rail grounding:
1. Grounding terminal blocks used exclusively for bonding each DIN rail section to panel grounding busbar shall:
    a. Mount to DIN rail via grounding foot with mounting screw.
    b. Connect to the panel grounding busbar shall be via a green insulated conductor sized in accordance with NEC.
    c. Not be used for grounding signal cable shields.
2. Screw terminal type.

3. DIN rail mounting on 35-millimeter rail.
4. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
5. Finger-safe protection for terminals for conductors.
6. Terminals: Plainly identified to correspond with markings on the diagrams:
    a. Permanent machine-printed terminal identification.
7. Manufacturers: One of the following or equal:
    a. Allen-Bradley, 1492-JG Series.
    b. Phoenix Contact, USKLG Series.

O. Wire duct:
1. Provide flame retardant plastic wiring duct, slotted with dust cover.
2. Type:
    a. Wide slot.
    b. Narrow slot.
    c. Round hole.
3. Manufacturers: One of the following or equal:
    a. ABB.
    b. Iboco.
    c. Panduit.
    d. Phoenix Contact.

P. DIN rail:
1. Perforated steel.
2. 35-mm width.
3. 15-mm deep.
4. Provide 2-inch offset using one of the following:
    a. Offset brackets.
    b. Preformed standoff DIN Rail Channel.

Q. Surge protection devices (SPD):
1. 120 VAC control panel power SPD:
    a. Provide SPD for panel 120 VAC power entrances:
        1) Non-faulting and non-interrupting design.
        2) Provide line to neutral and neutral to ground surge protection.
    b. Provide surge protection at secondary of main circuit breaker:
        1) Surge protection is not required for 120 VAC circuits that are only used for panel lights and receptacles.
        2) For panels receiving power at 480 VAC, provide surge protection on the 120 VAC control power transformer secondary.
    c. DIN rail mounting.
    d. Attach wiring to the SPD by means of a screw-type cable-clamping terminal block:
        1) Gastight connections.
        2) Visual status indication of MOV status on the input and output circuits.
        3) Dry contact rated for remote status indication.
    e. Approvals:
        1) Tested in accordance with IEC 61643-11.
        2) Tested in accordance with UL 1283.

3) Tested in accordance with UL 1449.
4) Surge protection minimum requirements: Withstand a minimum 10-kA test current of an 8/20 µs waveform in accordance with IEEE C62.41.1 Category C Area.

f. Manufacturers: One of the following or equal:
1) ASCO, Model 277.
2) Phoenix Contact, Type SFP Filter.
3) Rockwell, 4983-DC series.
4) Sola HD, STFE Elite series.

2. Field device mounted SPD:
a. Conduit entry mounting.
1) Provide parallel or through wiring configurations as required by the application:
a) Use parallel wiring configuration if there is an available cable gland at the device.
b) Use through wiring configuration if there is no available cable gland at the device.
2) Provide screw connections compatible with field device.
b. NEMA 4X stainless steel material housing.
c. Approvals:
1) Tested in accordance with IEC 61643-21.
d. 4-wire field device:
1) Module shall provide simultaneous protection of signal cable, communication bus, or data line, and power supply line.
a) Maximum continuous voltage:
(1) DC:
(a) Signal: 32 VDC.
(b) Power supply: 255 VDC.
(2) AC:
(a) Signal: 22.6 VAC.
(b) Power supply: 255 VAC.
2) Manufacturers: One of the following or equal:
a) Endress+Hauser, HAW569-CB2C.
b) Siemens.
e. 2-wire or 3-wire field device:
1) Module shall provide protection for the signal cable, communication bus or data line.
2) Manufacturers: One of the following or equal:
a) Eaton/MTL, TP Series.
b) Endress+Hauser, HAW569 Series.
c) Phoenix Contact, Surgetrab S-PT Series.

R. Horns and beacons:
1. Beacons/horn combination units:
a. Manufacturers: One of the following or equal:
1) Edwards, Multi-Status LED 108i with tone module.
2) Federal Signals, AV1ST Strobe Combination Audible/Visual Signal.
b. LED Colors: Red, Green, and Amber.
c. Power: 120 VAC.
d. Provide accessories such as pipe mount flange, pipe extensions, corner mount brackets, or wall mount brackets as needed.

e. Horn rated 80 dB minimum at 10 feet.

2. Dedicated beacon unit:
   a. Manufacturers: One of the following or equal:
      1) Allen-Bradley, 855 B *-* 10 Series.
      2) Edwards, 102 Series.
      3) Federal Signal Corp., Starfire Series.
3. Dedicated horn unit:
   a. Electromechanical:
      1) Manufacturers: One of the following or equal:
         a) Edwards, 878EX or 879EX Series.
         b) Federal Signal, 350 or 31X Series.
   b. Electronic:
      1) Manufacturers: One of the following or equal:
         a) Allen-Bradley, 855H or 855XH Series.
         b) Edwards, 5530M or 5533MD Series.
         c) Federal Signal, 300GCX or 300X Series.
   c. Rated for 80 dB minimum at 10 feet.

2.07 ACCESSORIES

A. Provide panels with an inside protective pocket to hold the panel drawings. Ship panels with 1 copy of accepted Shop Drawings, including, but not limited to, schematic diagram, connection diagram, and layout drawing of control wiring and components in a sealed plastic bag stored in the panel drawing pocket.

B. Provide floor stands or legs with a minimum height of 12 inches where needed or as indicated on the Drawings.

C. Provide a folding shelf for enclosures that contain programmable controllers. Shelf shall be mounted on the inside surface of the door, capable of supporting a laptop computer.

D. Provide nameplate to each panel as indicated on the Drawings:
   1. As specified in Section 26_05_53 - Identification for Electrical Systems on internal and external instruments and devices.
   2. With the following markings that is plainly visible after installation:
      a. Manufacturer’s name, trademark, or other descriptive marking by which the organization responsible for the panel can be identified.
      b. Supply voltage, phase, frequency, and full-load current.
      c. Power source or circuit ID.
      d. Short-circuit current rating of the panel based on one of the following:
         1) A listed and labeled assembly.
         2) Established utilizing an approved method.

E. Provide a window kit where indicated on the Drawings or where a transmitter with display is mounted inside a control panel. Window shall meet the following requirements:
   1. Safety plate glass.
   2. Secured by rubber locking seal.
   3. Allow full viewing of devices issuing visual process data or diagnostics.

F. Lighting:
   1. Provide 1 luminaire for each section, on the interior of the panel, spaced evenly along the top-front of the enclosure door opening(s):
      a. Covered or guarded.
      b. Provide On-Off door-activated switches where indicated on the Drawings.
      c. 120-volt, single-phase, 15-amp style plug.
      d. Provide 4,000 K, 900 lumens LED fixture.
         1) Provide additional fixtures for every 36 inches of width.

G. Receptacles:
   1. Provide 1 duplex receptacle located every 6 feet of enclosure width, spaced evenly along the back mounting panels.
   2. GFCI, 120-volt, single-phase, 15-amp style plug.
   3. Provide circuit breaker or fuse to limit receptacle draw to 5 amps.

H. Grounding:
   1. Provide the following:
      a. Grounding strap between enclosure doors and the enclosure.
      b. Equipment grounding conductor terminals.
      c. Provide equipment grounding busbar with lugs for connection of equipment grounding wires.
      d. Bond multi-section panels together with an equipment grounding conductor or an equivalent grounding busbar.
   2. Identify equipment grounding conductor terminals with the word “GROUND,” the letters “GND”, the letter “G”, or the color green.
   3. Signal cable shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
   4. Ensure the continuity of the equipment grounding system by effective connections through conductors or structural members.
   5. Design so that removing a device does not interrupt the continuity of the equipment-grounding circuit.
   6. Provide an equipment-grounding terminal for each incoming power circuit, near the phase conductor terminal.
   7. Size ground wires in accordance with NEC and UL Standards, unless noted otherwise.
   8. Unless otherwise noted, connect exposed, noncurrent-carrying conductive parts, devices, and equipment to the equipment-grounding circuit.
   9. Connect the door stud on the enclosures to an equipment-grounding terminal within the enclosure using an equipment-bonding jumper.
      a. Control panel ground lugs and ground bar shall be copper mechanical or compression connection type. Aluminum connectors or lugs are not acceptable for use with copper conductors.

I. Sunshades:
   1. Where indicated, provide panel-mounted sunshades for outdoor installations.
   2. Provide thermally insulated standoff.
   3. Provide deburred cutouts for access to exterior panel accessories.
   4. Material of sunshade and mounting hardware shall match enclosure.

2.08 FINISHES

A. Finishes:
   1. Metallic (non-stainless):
      a. Metal surfaces of panels shall be prepared by chemical cleaning and mechanical abrasion in accordance with the finish manufacturer's recommendations to achieve a smooth, well-finished surface.
      b. Scratches or blemishes shall be filled before finishing. 1 coat of zinc phosphate shall be applied according to the manufacturer's recommended dry-film thickness and allowed to dry before applying the finish coat.
      c. Finish coat shall be a baked polyester-urethane powder, aliphatic air-dry polyurethane, or epoxy enamel to meet NEMA rating specified application.
      d. Exterior of enclosures located outdoors shall be UV-resistant polyester powder coating. Total dry film thickness shall be 3 mils, minimum.
   2. Stainless steel:
      a. Stainless enclosures shall be provided with a Number 4 brushed finish - not painted.

B. Colors:
   1. Exterior color of panels mounted indoors shall be manufacturer's standard light gray.
   2. Exterior of panels mounted outdoors shall be manufacturer's standard white.
   3. Panel interiors shall be manufacturer's standard white.

PART 3 EXECUTION

3.01 PREPARATION

A. Equipment support and anchoring to structures:
   1. As specified in technical sections and as indicated on the Drawings, including, but not limited to:
      a. Anchor bolt layout.
      b. Equipment templates.
      c. Anchor installation.

3.02 INSTALLATION

A. Install enclosures so that their surfaces are plumb and level within 1/8-inch over the entire surface of the panel: Anchor securely to wall and structural supports at each corner, minimum. Direct attachment to drywall is not permitted.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details.

C. Provide floor stand kits for wall-mounted enclosures larger than 48-inches high.

D. Provide concrete housekeeping pads for freestanding enclosures.
   1. Refer to the structural typical details.

E. Install gasket and sealing material under panels with floor slab cutouts for conduit:
   1. Undercoat floor-mounted panels.

F. Provide a full-size equipment-grounding conductor in accordance with NEC included with the power feeder. Terminate to the incoming power circuit-grounding terminal.

G. Holes for field conduits, etc., shall be cut in the field. No additional holes, factory cut holes, or hole closers allowed. Incorrect holes, additional holes, or miscut holes shall require that the entire enclosure be replaced.

H. Protect wiring from sharp edges and corners.

I. Control panels that are adjacent to motor control centers shall be fully wired to the motor control centers using wireways integral to the motor control center or additional conduits as needed. These interconnections are not shown or reflected on the Conduit Schedule but shall be shown on the loop drawings prepared by the Contractor.

J. Provide individually fused analog input module points with blown-fuse indicator lights, mounted external of the module on the output terminal strip.

K. Side panels:
   1. Side panels shall be kept free of control equipment and devices. Any deviation must be sent to the Engineer in writing asking for a deviation.

3.03 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training.

END OF SECTION

SECTION 40_67_26

CONTROL SYSTEMS: UNINTERRUPTIBLE POWER SUPPLIES 10 KVA AND BELOW

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Single-phase double conversion uninterruptible power supplies rated 10 kVA and below.

1.02 REFERENCES

A. As specified in Section 26_05_00 - Common Work Results for Electrical and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Standards:
   1. Federal Communications Commission (FCC):
      a. FCC Part 15:
         1) Class A.
         2) Class B.
      b. C62.41 - IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.
   2. National Electrical Manufacturers Association (NEMA):
      a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
   3. Underwriters Laboratories, Inc. (UL):
      a. UL 1778 - Standard for Uninterruptible Power Supply Systems and Equipment.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Critical load: Load supplied by the UPS.

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Product data:
   1. Manufacturer and model number.
   2. Catalog data.
   3. Dimensions:
      a. Height.
      b. Width.

c. Depth.
d. Weight.

4. Ratings:
   a. Input voltage.
   b. Output voltage.
   c. Input/output power factor.
   d. Efficiency.
   e. Harmonic distortion.
   f. Runtime.
5. Noise specifications.
6. Heat dissipation.
7. Communications requirements such as software, cards, etc.
8. Alarms and status available for remote monitoring and system health.

C. Shop Drawings:
   1. Power distribution block diagrams.
   2. Front and rear views of equipment enclosures:
      a. Front elevation, including control and indicating devices.
   3. Support points and weight of overall equipment.
   4. Schematic and control wiring diagrams, including, but not limited to:
      a. Line and load terminals.
      b. Alarm and status terminals.
      c. Manual maintenance bypass switch terminals.
      d. External battery or step-down/step-up transformers, if any.
      e. External wiring requirements for communication signals.
   5. Switching and overcurrent protective devices.

D. Calculations:
   1. Include derating for temperature and elevation as necessary.
   2. UPS sizing computation:
      a. Apply safety factors as specified in this Section.
      b. Provide itemized list of critical loads, including individual VA and watt ratings.
   3. Battery time calculation based on specified runtime for total load with the safety factor multiplied to it. Table/graph for back-up time calculation.
   4. Load calculation shall include power for all shown in the power distribution drawing, which includes, but is not limited to, PLC power supply, field instruments (120 VAC and 24 VDC), instrument power, Ethernet switches, and I/O modules. Refer to network drawings for additional information and notes.
   5. Total battery recharge time as a function of capacity utilized.

E. Design data:
   1. Design mounting and anchorage for seismic design criteria specified in technical sections and as indicated on the Drawings:
      a. Provide seismic kits as required to meet design criteria.

F. Record documents:
   1. Provide record drawings of installed unit(s), including layout and wiring.

G. Manufacturer’s field reports.

H. Operation and maintenance manuals:
   1. As specified in Section 01 78 23 - Operation and Maintenance Data.
   2. System instruction manuals that describe troubleshooting, installation, operations, and safety procedures.
   3. Recommendations for maintenance procedures and intervals.
   4. Battery data/replacement information.
   5. Parts list.

1.05 QUALITY ASSURANCE

A. Manufacturer qualifications:
   1. A minimum of 10 years' experience in the design, manufacture, and testing of solid-state UPS systems.
   2. ISO 9001 certified.

B. Regulatory requirements for complete UPS system:
   1. UL listed in accordance with UL 1778.
   2. IEEE C62.41, Category B.
   3. FCC 15:
      a. Greater than 2,000 VA - Class A.
      b. Less than 2,000 VA - Class B.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide complete, factory-assembled, wired, and tested, true on-line double conversion UPS equipment, including, but not limited to, rectifier, DC bus, inverter, battery charger, batteries, automatic bypass, and ancillary components as specified in this Section and as indicated on the Drawings.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Critical loads as indicated on the Drawings.

2.03 MANUFACTURERS

A. Double conversion true online UPS system:
   1. One of the following or equal:
      a. Eaton, 9PX Series.
      b. Vertiv, Liebert GXT5 Series.

2.04 EXISTING PRODUCTS (NOT USED)

2.05 MATERIALS (NOT USED)

2.06 MANUFACTURED UNITS

A. Design requirements:
   1. Minimum VA rating of the UPS shall be greater than or equal to the safety factor (as indicated in the UPS schedule) times the connected load or 700 VA, whichever is greater.
   2. UPS system input:
      a. Voltage:
         1) Less than or equal to 3 kVA UPS:
            a) 120 VAC within 3 percent, single-phase, 2-wire plus ground (L1, N, G).
         2) Greater than 3 kVA UPS:
            a) 208 VAC within 5 percent, single-phase, 3-wire plus ground (L1, L2, N, G).
         3) Frequency: 60 hertz:
            a) Auto sensing on initial power up.
            b) User configurable.
      b. Current harmonic distortion (THDi%):
         1) Less than or equal to 5 percent at full load operation.
      c. Power factor:
         1) Greater than or equal to 0.99 lagging at rated load.
      d. Connections:
         1) As specified and as indicated on the Drawings.
   3. UPS inverter:
      a. Output voltage:
         1) Less than or equal to 3 kVA UPS:
            a) Standard:
               (1) 120 VAC.
            b) User selectable:
               (1) 100 VAC, 110 VAC, 120 VAC, 125 VAC.
         2) Greater than 3 kVA UPS:
            a) Standard:
               (1) 208 VAC.
            b) User selectable: A.
               (1) 200 VAC, 208 VAC, 220 VAC, 230 VAC, 240 VAC.
      b. AC-AC efficiency:
         1) Greater than or equal to 89 percent at full rated resistive linear load.
      c. Transient recovery time:
         1) To nominal voltage within 100 milliseconds.

d. Voltage regulation:
    1) Within 1 percent steady state.
e. Output voltage distortion (THDV%):
    1) Linear load: Less than 2 percent.
    2) Non-linear load: Less than 5 percent.
f. Output power factor:
    1) Load power factor range shall be 0.65 lagging to 1.0 (unity) leading without power derating.
g. Current overload capability:
    1) UPS shall attempt to clear overloads while maintaining normal operation before transferring to bypass.
    2) Bypass transfer thresholds shall follow inverse time-current characteristic that operates when the load exceeds the nameplate rating of the UPS.
    3) Transfer load to bypass when overload capacity is exceeded.

4. Batteries:
    a. Internal battery shall utilize lithium-ion cells.
    b. UPS shall have capability for connection of external battery modules to extend total available run time. External batteries shall match the UPS in aesthetics and color.
5. Mounting:
    a. Configurable for rack and tower mounting applications.
    b. Provide manufacturer's standard mounting kit as required by the application.
6. Cooling:
    a. UPS shall have integral forced air cooling.
7. Output connections:
    a. Receptacles:
        1) Less than or equal to 3 kVA UPS:
            a) Provide a minimum of four NEMA Type 5-15R or Type 5-20R receptacles.
            b) Provide at least one NEMA Type L5-30R receptacle.
        2) Greater than 3 kVA UPS:
            a) Provide a minimum of four NEMA Type 5-20R receptacles.
            b) Provide at least one NEMA Type L14-30R receptacle.
        3) Provide hardwired connections as required and as indicated on the Drawings.

B. Environmental requirements:
    1. Operating ambient temperature:
        a. UPS module: 50 degrees Fahrenheit to 104 degrees Fahrenheit (10 degrees Celsius to 40 degrees Celsius).
        b. Battery: 68 degrees Fahrenheit to 86 degrees Fahrenheit (20 degrees Celsius to 30 degrees Celsius).
    2. Operating altitude:
        a. Project Site conditions as specified in technical sections and as indicated on the Drawings.
    3. Surge protection:
        a. UPS shall be accordance with IEEE C62.41, Category B.
    4. Audible noise:
        a. Less than 46 dB at 1 meter.

C. Communications:
   1. Relay outputs:
      a. Provide low voltage signals for On Battery, Low Battery, Any Mode Shutdown, and Battery Mode Shutdown.
      b. Connections on a terminal block on the rear panel.
   2. Serial:
      a. RS-232 serial connection.
   3. USB:
      a. Provide a USB connection that is HID compliant for network connection.

2.07 ACCESSORIES (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

A. Install equipment in accordance with the manufacturer's instructions.

B. Do not utilize extension cords, adapters, or other electrical connectors for UPS input.

3.03 FIELD QUALITY CONTROL

A. Perform inspections and test procedures before UPS startup:
   1. Inspect equipment for signs of damage.
   2. Verify installation as indicated on the Drawings and specified in the Specifications.
   3. Inspect cabinets for foreign objects.
   4. Verify neutral and ground conductors are properly sized and terminated.
   5. Inspect battery cases.
   6. Inspect batteries for proper polarity.
   7. Check power and control wiring for tightness.
   8. Check terminal connectors for tightness.
   9. Ensure connection and voltage of the battery string(s).

3.04 SCHEDULES

Tag	Minimum Runtime	Input Voltage/Connection	Safety Factor	Notes
UPS-8	15 minutes	120VAC	1.25	

END OF SECTION

SECTION 40_71_15

FLOW MEASUREMENT: MAGNETIC FLOWMETERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Full-body magnetic flowmeters.

1.02 REFERENCES

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Standards:
   1. International Organization for Standardization (ISO):
      a. 9000 - Quality management systems - Fundamentals and vocabulary.
      b. 17025 - General requirements for the competence of testing and calibration laboratories.
   2. National Institute of Standards and Technology (NIST).
   3. NSF International (NSF).

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Include sizing information from the manufacturer that includes:
   1. Chart of the measurement error from zero to maximum measured volumetric flow range indicated in datasheets.
   2. Indication of input parameters and their values used in the calculations.

C. Furnish Commissioning Submittals listed below, as specified in this Section, and Section 01 79 00 - Demonstration and Training:
   1. Manufacturer’s representative qualifications.
   2. Owner Training.

1.04 QUALITY ASSURANCE

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.

b. Location within the process.
c. Accessories: Verify that required accessories are provided and are compatible with the process conditions and physical installation.

C. Manufacture instrument facilities certified to the quality standards of ISO Standard 9001 - Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation and Servicing.

1.05 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.07 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide instruments identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide instruments suitable for the installed Site conditions, including, but not limited to, Site installation conditions (straight pipe runs upstream and downstream of meter), material compatibility, Site altitude, Site seismic conditions, humidity, and process and ambient temperatures.

2.03 MANUFACTURERS

A. One of the following or equal:
1. Endress+Hauser:
a. Promag W (0xDN) flowtube with 300/500 series transmitter.
2. Emerson, Rosemount 8750W (0xDN).

2.04 MANUFACTURED UNITS

A. As specified in this Section, including Attachment A - ISA Datasheet - Flow Measurement: Magnetic Flowmeters.

B. Magnetic flowmeter:
   1. General:
      a. Magnetic flowmeters obtain the flow velocity by measuring the changes of induced voltage of the conductive fluid passing across a controlled magnetic field.
      b. Complete zero stability shall be an inherent characteristic of the flowmeter system.
      c. Include for each magnetic flow metering system:
         1) A metering tube with electrodes (sensor).
         2) Fully welded flanges that are rated for the full pressure class of the piping.
         3) Signal cable if remote mounted.
         4) Transmitter integral or remote as indicated on the Drawings.
         5) Flowmeter grounding rings.
   2. Performance requirements:
      a. Accuracy:
         1) 0.5 percent of flow rate from 10 to 100 percent of full-scale for velocities ranging between 1.9 to 10 feet per second.
         2) Flowmeters shall meet the accuracy requirements for installation conditions shown on the Drawings (limited straight pipe runs upstream and downstream of the meter).
      b. Repeatability:
         1) 0.25 percent of rate.
   3. Element:
      a. Metering tube:
         1) Constructed of Type 304 or 316 stainless steel (unless specifically noted otherwise in the instrument datasheet) with flanged connections to match with piping material.
            a) Carbon steel cannot be used when coils are on the outside of the metering tube, it will not pass the magnetic field.
            b) Coils that are embedded in the liner are not permitted.
         2) Liner material in conformance with:
            a) Manufacturer’s recommendations for the intended service.
            b) NSF certified for drinking water applications.
         3) Electrodes type and material in conformance with:
            a) Manufacturer’s recommendations for the intended service.
            b) Utilize a minimum of 2 self-cleaning electrodes.
         4) As indicated in the datasheets.
         5) Meter terminal housing NEMA Type 4X, unless installed in locations such as vaults that will experience submergence. In those applications NEMA 6P is required.
         6) Meter coating consisting of epoxy painted finish.
         7) Components:
            a) 2 grounding rings:
               (1) Which are in conformance with the manufacturer’s bore and material recommendation for the meter’s intended service.
   4. Transmitter:
      a. Power supply:
         1) As indicated in the datasheets.

b. Outputs:
    1) As indicated in the instrument datasheet.
    2) For instruments with 4 to 20 mA HART or digital bus protocol, provide a Device Type Manager (DTM) certification by FDT group.
c. Microprocessor-based signal converter/transmitter.
d. Utilize DC pulse technique to drive flux-producing coils.
e. Contain a 6-digit display for flow rate, percent of span, and totalizer.
f. Operator keypad interface.
g. Integral zero return to provide consistent zero output signals in response to an external dry contact closure.
h. Integral low flow cut-off zero return.
i. Programmable parameters including:
    1) Meter size.
    2) Full-scale flow rate.
    3) Magnetic field frequency.
    4) Time constant.
j. Data retention for a minimum of 5 years without auxiliary main or battery power.
k. Self-diagnostics and automatic data checking.
l. Protected terminals and fuses in a separate compartment which isolates field connection from electronics.
m. Ambient operating temperature limits of -5 to 140 degrees Fahrenheit (-20 to 60 degrees Celsius).
n. Enclosure:
    1) As indicated in the instrument datasheet.
o. Transmitter should retain all setup parameters and accumulated measurements internally in non-volatile memory in the event of power failure.

2.05 ACCESSORIES

A. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

B. Provide sunshades for transmitters located outdoors.

C. Provide galvanic isolation gaskets, nylon/Teflon™ flange bolt insulation bushings, and nylon washers on meters installed on pipes with cathodic protection.

D. Furnish 1 spool piece for every size of magnetic flow tube being provided.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

A. Factory calibrate each flow metering system at a facility that is traceable to the NIST.
    1. ISO 17025 accredited test facility with certified accuracy traceable to NIST.
    2. Suggestion, the calibration facility be traceable to international standards and ILAC, International Laboratory Accreditation Committee MRA, Mutual Recognition Agreement.
    3. This ensures worldwide accreditation of calibration laboratories.

B. Evidence of accreditation shall originate from a national verification agency such as A2LA ILAC.

C. FM approval certification or equal when installed in classified areas.

D. A real-time computer-generated printout of the actual calibration date indication actual velocities and as read values of the flow tube.
   1. Flow calibration report of the manufacturers flow lab calibration procedure shall be shipped with the meter system.
   2. Minimum calibration shall be a 3 point calibration including 1, 3, and 10 feet per second velocities for every meter and transmitter system. 2 points at 15 to 20 percent and 80 to 100 percent are statistically proven to be sufficient calibration points.
   3. Manufacturer shall archive calibration reports for future reference.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. For instruments located outdoors or where instrument elements and transmitters are separated by conduit located outside the building envelope, provide surge protection devices at the transmitters.

3.03 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training.

B. Owner Training:
   1. Perform Owner Training as specified in Section 01 79 00 - Demonstration and Training.

3.04 FIELD QUALITY CONTROL

A. Field verification:
   1. Verify factory calibration of instruments in accordance with the manufacturer’s instructions.
   2. Transmitter and sensor lude a method to verify flow meter performance to the original manufacturer specifications.
   3. Verification should be traceable to factory calibration using a third party, attested onboard system pursuant to ISO standards.
   4. Verification report should be compliant to common quality systems such as ISO 9000 to prove the reliability of the meter-specified accuracy.
   5. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.05 SCHEDULES

A. Instrument datasheets included in this Section.

B. The provided information does not necessarily include all required instruments.

C. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

ATTACHMENT A - ISA DATASHEET - FLOW MEASUREMENT: MAGNETIC FLOWMETERS

Engineers...Working Wonders With Water®

Magnetic Flow Transmitter

RESERVOIR

PROJECT INFORMATION

PLANT		**CUSTOMER**	CITY OF SANTA CRUZ
PROJECT	202431_08	**LOCATION**	SANTA CRUZ

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG	FIT-9905020 (FE-9905020)	**MEASURING PRINCIPLE**	MAGNETIC
SPECIFICATION NUMBER	40_71_15	**PLC**	PLC-8
DRAWING NUMBER	08N06	**POWER LOCATION**	PCM-8
SERVICE	6" EXTRACTION TO WTP FLOW METER	**TYPICAL DETAIL(S)**	NF130, NF136

CONNECTION

LINE SIZE	6"	**PROCESS CONNECTION**	ANSI 150
LINE MATERIAL	[*]	**PROCESS CONN. MATERIAL**	[*]

FLUID

FLUID	WATER	**PRESSURE**	125 PSI
NOMINAL FLOW	[*]	**TEMPERATURE**	N/A
FLOW RANGE	0-1000 GPM	**VISCOSITY**	N/A
		CONDUCTIVITY	N/A

ELEMENT

ELEMENT TAG NO.	FE-9905020	**PROCESS CONNECTION**	ANSI 150
ENCLOSURE CLASS	NEMA 4X	**LINER MATERIAL**	HARD RUBBER
HAZARDOUS APPROVALS	N/A	**VACUUM POSSIBILITY**	NO
TUBE SIZE	[*]	**ELECTRODE TYPE**	MFR. STD.
TUBE MATERIAL	MFR. STD.	**ELECTRODE MATERIAL**	316 SST

TRANSMITTER

TRANSMITTER TAG NO.	FIT-9905020	**HAZARDOUS APPROVALS**	N/A
MOUNTING	INT	**EMPTY PIPE DETECTION**	YES
ENCLOSURE CLASS	NEMA 4X	**BI DIRECTIONAL FLOW**	NO
POWER	120VAC-1P	**PULSE OUTPUT**	NO
AMBIENT TEMPERATURE	[*]	**RELAY OPTIONS**	YES
OUTPUT	4-20 MA	**POTTED ELECTRONICS**	NO
SURGE PROTECTION	NO	**CATHODIC PROT. LINE**	NO

NOTES

[*]

Engineers...Working Wonders With Water®

Magnetic Flow Transmitter

RESERVOIR

PROJECT INFORMATION

PLANT		**CUSTOMER**	CITY OF SANTA CRUZ
PROJECT	202431_08	**LOCATION**	SANTA CRUZ

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG	FIT-9905030 (FE-9905030)	**MEASURING PRINCIPLE**	MAGNETIC
SPECIFICATION NUMBER	40_71_15	**PLC**	PLC-8
DRAWING NUMBER	08N06	**POWER LOCATION**	PCM-8
SERVICE	6" FLUSH TO STORM DRAIN METER	**TYPICAL DETAIL(S)**	NF130, NF136

CONNECTION

LINE SIZE	6"	**PROCESS CONNECTION**	ANSI 150
LINE MATERIAL	[*]	**PROCESS CONN. MATERIAL**	[*]

FLUID

FLUID	WATER	**PRESSURE**	125 PSI
NOMINAL FLOW	[*]	**TEMPERATURE**	N/A
FLOW RANGE	0-1000 GPM	**VISCOSITY**	N/A
		CONDUCTIVITY	N/A

ELEMENT

ELEMENT TAG NO.	FE-9905030	**PROCESS CONNECTION**	ANSI 150
ENCLOSURE CLASS	NEMA 4X	**LINER MATERIAL**	HARD RUBBER
HAZARDOUS APPROVALS	N/A	**VACUUM POSSIBILITY**	NO
TUBE SIZE	6"	**ELECTRODE TYPE**	MFR. STD.
TUBE MATERIAL	MFR. STD.	**ELECTRODE MATERIAL**	316 SST

TRANSMITTER

TRANSMITTER TAG NO.	FIT-9905030	**HAZARDOUS APPROVALS**	N/A
MOUNTING	INT	**EMPTY PIPE DETECTION**	YES
ENCLOSURE CLASS	NEMA 4X	**BI DIRECTIONAL FLOW**	NO
POWER	120VAC-1P	**PULSE OUTPUT**	NO
AMBIENT TEMPERATURE	[*]	**RELAY OPTIONS**	YES
OUTPUT	4-20 MA	**POTTED ELECTRONICS**	NO
SURGE PROTECTION	NO	**CATHODIC PROT. LINE**	NO

NOTES

[*]

Magnetic Flow Transmitter

PROJECT INFORMATION

PLANT		**CUSTOMER**	CITY OF SANTA CRUZ
PROJECT	202431_08	**LOCATION**	SANTA CRUZ

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG	FIT-9905050 (FE-9905050)	**MEASURING PRINCIPLE**	MAGNETIC
SPECIFICATION NUMBER	40_71_15	**PLC**	PLC-8
DRAWING NUMBER	08N07	**POWER LOCATION**	PCM-8
SERVICE	2" BACKWASH TO STORM DRAIN	**TYPICAL DETAIL(S)**	NF130, NF136

CONNECTION

LINE SIZE	2"	**PROCESS CONNECTION**	ANSI 150
LINE MATERIAL	[*]	**PROCESS CONN. MATERIAL**	[*]

FLUID

FLUID	WATER	**PRESSURE**	125 PSI
NOMINAL FLOW	[*]	**TEMPERATURE**	N/A
FLOW RANGE	0 - 100 GPM	**VISCOSITY**	N/A
		CONDUCTIVITY	N/A

ELEMENT

ELEMENT TAG NO.	FE-9905050	**PROCESS CONNECTION**	ANSI 150
ENCLOSURE CLASS	NEMA 4X	**LINER MATERIAL**	HARD RUBBER
HAZARDOUS APPROVALS	N/A	**VACUUM POSSIBILITY**	NO
TUBE SIZE	[*]	**ELECTRODE TYPE**	MFR. STD.
TUBE MATERIAL	MFR. STD.	**ELECTRODE MATERIAL**	316 SST

TRANSMITTER

TRANSMITTER TAG NO.	FIT-9905050	**HAZARDOUS APPROVALS**	N/A
MOUNTING	INT	**EMPTY PIPE DETECTION**	YES
ENCLOSURE CLASS	NEMA 4X	**BI DIRECTIONAL FLOW**	NO
POWER	120VAC-1P	**PULSE OUTPUT**	NO
AMBIENT TEMPERATURE	[*]	**RELAY OPTIONS**	YES
OUTPUT	4-20 MA	**POTTED ELECTRONICS**	NO
SURGE PROTECTION	NO	**CATHODIC PROT. LINE**	NO

NOTES

[*]

Engineers...Working Wonders With Water®

Magnetic Flow Transmitter

RESERVOIR

PROJECT INFORMATION

PLANT		**CUSTOMER**	CITY OF SANTA CRUZ
PROJECT	202431_08	**LOCATION**	SANTA CRUZ

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG	FIT-9905110 (FE-9905110)	**MEASURING PRINCIPLE**	MAGNETIC
SPECIFICATION NUMBER	40_71_15	**PLC**	PLC-8
DRAWING NUMBER	08N03	**POWER LOCATION**	PCM-8
SERVICE	6" INJECTION FLOW METER	**TYPICAL DETAIL(S)**	NF130, NF136

CONNECTION

LINE SIZE	6"	**PROCESS CONNECTION**	ANSI 150
LINE MATERIAL	[*]	**PROCESS CONN. MATERIAL**	[*]

FLUID

FLUID	WATER	**PRESSURE**	125 PSI
NOMINAL FLOW	[*]	**TEMPERATURE**	N/A
FLOW RANGE	0-1000 GPM	**VISCOSITY**	N/A
		CONDUCTIVITY	N/A

ELEMENT

ELEMENT TAG NO.	FE-9905110	**PROCESS CONNECTION**	ANSI 150
ENCLOSURE CLASS	NEMA 4X	**LINER MATERIAL**	HARD RUBBER
HAZARDOUS APPROVALS	N/A	**VACUUM POSSIBILITY**	NO
TUBE SIZE	6"	**ELECTRODE TYPE**	MFR. STD.
TUBE MATERIAL	MFR. STD.	**ELECTRODE MATERIAL**	316 SST

TRANSMITTER

TRANSMITTER TAG NO.	FIT-9905110	**HAZARDOUS APPROVALS**	N/A
MOUNTING	INT	**EMPTY PIPE DETECTION**	YES
ENCLOSURE CLASS	NEMA 4X	**BI DIRECTIONAL FLOW**	NO
POWER	120VAC-1P	**PULSE OUTPUT**	NO
AMBIENT TEMPERATURE	[*]	**RELAY OPTIONS**	YES
OUTPUT	4-20 MA	**POTTED ELECTRONICS**	NO
SURGE PROTECTION	NO	**CATHODIC PROT. LINE**	NO

NOTES

[*]

Engineers...Working Wonders With Water®

Magnetic Flow Transmitter

RESERVOIR

PROJECT INFORMATION

PLANT		**CUSTOMER**	CITY OF SANTA CRUZ
PROJECT	202431_08	**LOCATION**	SANTA CRUZ

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG	FIT-9905120 (FE-9905120)	**MEASURING PRINCIPLE**	MAGNETIC
SPECIFICATION NUMBER	40_71_15	**PLC**	PLC-8
DRAWING NUMBER	08N03	**POWER LOCATION**	PCM-8
SERVICE	1" FLOW METER	**TYPICAL DETAIL(S)**	NF130, NF136

CONNECTION

LINE SIZE	1"	**PROCESS CONNECTION**	ANSI 150
LINE MATERIAL	[*]	**PROCESS CONN. MATERIAL**	[*]

FLUID

FLUID	WATER	**PRESSURE**	125 PSI
NOMINAL FLOW	[*]	**TEMPERATURE**	N/A
FLOW RANGE	0-25 GPM	**VISCOSITY**	N/A
		CONDUCTIVITY	N/A

ELEMENT

ELEMENT TAG NO.	FE-9905120	**PROCESS CONNECTION**	ANSI 150
ENCLOSURE CLASS	NEMA 4X	**LINER MATERIAL**	HARD RUBBER
HAZARDOUS APPROVALS	N/A	**VACUUM POSSIBILITY**	NO
TUBE SIZE	1"	**ELECTRODE TYPE**	MFR. STD.
TUBE MATERIAL	MFR. STD.	**ELECTRODE MATERIAL**	316 SST

TRANSMITTER

TRANSMITTER TAG NO.	FIT-9905120	**HAZARDOUS APPROVALS**	N/A
MOUNTING	INT	**EMPTY PIPE DETECTION**	YES
ENCLOSURE CLASS	NEMA 4X	**BI DIRECTIONAL FLOW**	NO
POWER	120VAC-1P	**PULSE OUTPUT**	NO
AMBIENT TEMPERATURE	[*]	**RELAY OPTIONS**	YES
OUTPUT	4-20 MA	**POTTED ELECTRONICS**	NO
SURGE PROTECTION	NO	**CATHODIC PROT. LINE**	NO

NOTES

[*]

SECTION 40_71_43

FLOW MEASUREMENT: ROTAMETERS (VARIABLE AREA FLOWMETERS)

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Rotameters (variable area flowmeters).

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.04 QUALITY ASSURANCE

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions, including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that required accessories are provided and are compatible with the process conditions and physical installation.

1.05 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.07 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide instruments identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide instruments suitable for the installed Site conditions, including, but not limited to, material compatibility, Site altitude, Site seismic conditions, humidity, and process and ambient temperatures.

2.03 MANUFACTURERS

A. One of the following or equal:
   1. ABB.
   2. Brooks.
   3. King Instrument Co.

2.04 MANUFACTURED UNITS

A. Rotameters:
   1. General:
      a. Variable area type flowmeters with local flow indication.
      b. Material construction:
         1) As indicated in the datasheet.
   2. Performance requirements:
      a. Flow range:
         1) As specified in instrument datasheets or instrument index.
      b. Accuracy:
         1) Glass tube: Within 2.0 percent of range.
         2) Metal tube: Within 5.0 percent of range.
         3) Repeatability: 0.50 percent of range.

3. Element:
    a. Flow tube:
        1) Glass tube: Borosilicate glass, or as required to be compatible with the process conditions.
    b. Metal tube with magnetic follower:
        1) Type 316 stainless steel.
    c. Turndown: 10 to 1.
    d. Process temperature:
        1) As indicated in the datasheet.
    e. Maximum process pressure:
        1) As indicated in the datasheet.
        2) Range:
            a) As indicated in the datasheet.
    f. Float:
        1) Metal tube rotameters: Float with encapsulated magnet.
4. Components:
    a. Seals: O-rings or packing glands fully compatible with process fluid.
    b. Integral needle valve for flow control.
5. Scale:
    a. Metal tube: Dial indicator with rotatable magnet coupled to magnet encapsulated in rotameter float.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances, including weld-o-lets, valves, etc., for proper installation of instruments.

3.03 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training.

3.04 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
    1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

ATTACHMENT A - ISA DATASHEET - FLOW MEASUREMENT: ROTAMETERS

Rotameter

SPECIFICATION 40_71_43

PROJECT INFORMATION

PLANT

PROJECT 202431_08

CUSTOMER CITY OF SANTA CRUZ

LOCATION SANTA CRUZ

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

TAG	P&ID	SERVICE	TRICKLE FLOW ROTAMETER				
FI-9905120	08N03	**FLUID**	WATER	**TYPICAL DETAILS**	[*]	**FLOW RANGE**	5 GPM, RANGE 0-20 GPM
		MEASURING PRINCIPLE	VARIABLE AREA FLOW	**PRESSURE**	125 PSI	**VISCOSITY**	N/A
		LINE SIZE	[*]	**TEMPERATURE**	N/A	**SEAL MATERIAL**	EPDM
		LINE MATERIAL	[*]	**PROCESS CONN.**	F-NPT	**TUBE MATERIAL**	[*]
		PROCESS CONN. MAT'L	STEEL				

SECTION 40_73_13

PRESSURE/VACUUM MEASUREMENT: GAUGES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pressure/vacuum gauges.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Standards:
   1. American Society of Mechanical Engineers (ASME):
      a. B40.100 - Pressure Gauges and Gauge Attachments.

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Product data:
   1. Accessories.

1.04 QUALITY ASSURANCE

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions, including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that required accessories are provided and are compatible with the process conditions and physical installation.

1.05 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.07 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide instruments specified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide instruments suitable for the installed Site conditions, including, but not limited to, material compatibility, Site altitude, Site seismic conditions, humidity, and process and ambient temperatures.

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Ashcroft:
      a. Maximum pressure less than 10 pounds per square inch: Model 1188.
         1) If a stainless steel dial casing is required:
            a) Model 1009.
      b. Maximum pressure greater than or equal to 10 pounds per square inch: Model 1279.
         1) If a stainless steel dial casing is required:
            a) Model 1009.

2.04 MANUFACTURED UNITS

A. General:
   1. Pressure gauge assembly shall include pressure sensing element, gauge case, and dial mechanism.

B. Performance requirements:
   1. Pressure range:
      a. As specified in the Contract Documents.
   2. Accuracy:
      a. Grade 2A, as defined by ASME B40.100.
      b. Within 1.0 percent of span after friction errors are eliminated by tapping or vibration.
      c. Maximum allowable friction inaccuracy: Within 1.0 percent of span.
   3. Element:
      a. Where the maximum pressure is less than 10 pounds per square inch, provide socket and bellows; for all other pressure ranges, employ a Bourdon® tube.
      b. Socket tips for bellows and Bourdon® tube:
         1) Materials: Type 316 stainless steel.
      c. Overpressure: Minimum 130 percent of maximum range pressure without damage to gauge or sensing element.
      d. Wetted materials:
         1) Type 316 stainless steel.
   4. Dial gauge:
      a. Dial size: 4-1/2 inches.
      b. Dial case material:
         1) As indicated in the datasheets.
      c. Provide safety gauge with safety blow out through the back or top of the unit.
      d. Dial face: Gasketed shatterproof glass or polycarbonate.
      e. Provide gauge locks on pressure gauges directly connected to diaphragm seals.
      f. Provide gauge locks where possible.
      g. Connection and mounting:
         1) Direct mounted and suitable for outdoor installation.
         2) 1/2-inch NPT.
         3) Connection material:
            a) Stainless steel.
      h. Pointer: Externally adjustable.

2.05 ACCESSORIES

A. Pulsation dampeners and snubbers:
   1. As indicated in the datasheets.
   2. Provide with each pressure gauge installed on discharge of positive displacement type pump.
   3. Provide piston-type snubber if pressure spikes will exceed 130 percent of gauge maximum range.
   4. Mount integrally to the pressure gauge.
   5. Connection: 1/2-inch NPT.
   6. Provide diaphragm seals as specified in the Contract Documents and/or as indicated in the datasheets.
   7. Diaphragm seal and pressure gauge shall be assembled by the manufacturer and shipped as an assembly.

B. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

A. Factory calibrate each pressure gauge at a facility that is traceable to the NIST.

B. Provide complete documentation covering the traceability of calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances, including weld-o-lets, valves, etc., for proper installation of instruments.

3.03 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training.

3.04 ADJUSTING

A. Verify factory calibration of instruments in accordance with the manufacturer's instructions:
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.05 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

ATTACHMENT A - ISA DATASHEET - PRESSURE/VACUUM MEASUREMENT: GAUGES

Pressure Gauge

SPECIFICATION 40_73_13

PROJECT INFORMATION

PLANT

PROJECT 202431_08

CUSTOMER CITY OF SANTA CRUZ

LOCATION SANTA CRUZ

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

TAG	P&ID	SERVICE	INJECTION LINE PRESS GAUGE				
PI-9905112	08N03		**FLUID** [*]	**CONNECTION TYPE** [*]	**BOTT. HOUSING MAT.** MFR. STD.
			TEMPERATURE [*]	**ISOLATION SEALS** N/A	**INSTRUMENT VALVES** [*]
			MEASURING PRINCIPLE DIRECT	**CASE MATERIAL** [*]	**DIAPHRAGM MAT.** MFR. STD.
			PRESSURE RANGE: [*]	**TYPICAL DETAILS** [*]	**DIAL SIZE** [*]
			GAUGE RANGE 0-150 PSIG	**OPTIONS** [*]	**AMBIENT TEMP** [*]

SECTION 40_73_23

PRESSURE/VACUUM MEASUREMENT: DIRECT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pressure transmitters and indicators.

1.02 REFERENCES

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning:
   1. Calibrated range: Range that the pressure transmitter is configured to measure.
      a. Low end of the calibrated range must be greater than the lower range value (LRV) of the transmitter.
      b. High end of the calibrated range must be less than or equal to the upper range value (URV).
      c. Calibrated range corresponds to the flow signal sent from the transmitter.
   2. Lower range value (LRV): Lowest pressure that the pressure transmitter is capable of measuring.
   3. Upper range value (URV): Highest pressure that the pressure transmitter is capable of measuring.

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide complete documentation covering the traceability of calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions, including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.

b. Location within the process.
c. Accessories: Verify that required accessories are provided and are compatible with the process conditions and physical installation.

C. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.08 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
1. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.09 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

1.10 MAINTENANCE

A. Furnish parts, materials, fluids, etc., necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver these supplies before Project Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide instruments identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide instruments suitable for the installed Site conditions, including, but not limited to, material compatibility, Site altitude, Site seismic conditions, humidity, and process and ambient temperatures.

2.03 MANUFACTURERS

A. One of the following or equal:
1. ABB, 266 Series.
2. Emerson, Rosemount 2051 Series with high performance option.
3. Emerson, Rosemount 3051 Series.

4. Endress & Hauser, Cerabar S Series.
5. Yokogawa, EJA Series.

2.04 MANUFACTURED UNITS

A. Pressure transmitters - direct:
   1. General:
      a. Pressure transmitter assembly shall include a diaphragm type pressure transducer and microprocessor-based transmitter for measurement of gauge, vacuum, or absolute pressure.
   2. Performance requirements:
      a. Maximum ratio of total instrument range to calibrated span: 10 to 1.
      b. Accuracy:
         1) Reference accuracy: Within 0.075 percent of calibrated span, including effects of hysteresis, nonlinearity, and repeatability.
         2) Total performance accuracy: Within 0.30 percent of calibrated span, including reference accuracy effects, static pressure and ambient temperature effects.
         3) Stability: Within 0.15 percent of upper range limit over 5 years.
   3. Element:
      a. Diaphragm type transducer integral to pressure transmitter.
      b. Diaphragm material: Stainless steel or ceramic.
      c. Process material compatibility:
         1) Verify material compatibilities with the instrument manufacturer.
      d. Process connection: As specified in Attachment A - ISA Datasheet - Pressure/Vacuum Measurement: Direct.
   4. Transmitter:
      a. Power supply:
         1) 24 VDC - 2 wire loop powered.
      b. Outputs:
         1) As indicated in the datasheets.
         2) Isolated 4-20 mA DC with HART communication protocol.
      c. Provided with electronic microprocessor.
      d. Adjustments: Adjustable electronic zero and span, with elevated or suppressed zero as required by application. Adjustment shall be possible without mechanical fulcrum points or handheld configurator.
      e. Local display:
         1) 5-digit LCD.
         2) Scaled in engineering units.
      f. Enclosure:
         1) As indicated in the datasheets.
      g. Over range protection: To maximum process line pressure.
      h. Conduit: 1/2-inch male NPT.
   5. Components:
      a. Transmitter mounting:
         1) As indicated in the datasheets.
         2) Provide necessary hardware for transmitter mounting.

2.05 ACCESSORIES

A. Provide remote or integral diaphragm seals as indicated on the Drawings or as indicated in the datasheets.

B. Provide sunshades for outdoor installations.

C. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

A. Factory calibrate each instrument with a minimum 3-point calibration or according to the manufacturer's standard at a facility that is traceable to the NIST.
   1. Submit calibration datasheets to the Engineer at least 30 days before shipment of the instruments to the Project Site.

B. FM approval certification or equal when installed in classified areas.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances, including weld-o-lets, valves, etc., for proper installation of instruments.

3.03 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training.

3.04 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

ATTACHMENT A - ISA DATASHEET - PRESSURE/VACUUM MEASUREMENT: DIRECT

Engineers...Working Wonders With Water®

Pressure Transmitter

RESERVOIR

PROJECT INFORMATION

PLANT		**CUSTOMER**	CITY OF SANTA CRUZ
PROJECT	202431_08	**LOCATION**	SANTA CRUZ

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG	PIT-9905111 (PE-9905111)		
SPECIFICATION NUMBER	40_73_23	**MEASURING PRINCIPLE**	DIRECT
DRAWING NUMBER	08N03	**PLC**	PLC-8
SERVICE	INJECTION LINE PRESS TRANSMITTER	**TYPICAL DETAILS**	NP501

CONNECTION

CONNECTION TYPE	M-NPT	**INSTRUMENT VALVES**	[*]

FLUID

FLUID	WATER	**PRESSURE RANGE**	0-200 PSI
TEMPERATURE	[*]		

ELEMENT

ELEMENT TAG NO.	PE-9905111	**SEAL TYPE**	N/A
ENCLOSURE CLASS	NEMA 4X	**DIAPHRAGM MATERIAL**	MFR. STD.
HAZARDOUS APPROVALS	N/A	**BOTTOM HOUSING MAT.**	MFR. STD.

TRANSMITTER

TRANSMITTER TAG NO.	PIT-9905111	**AMBIENT TEMPERATURE**	[*]
MOUNTING	INT	**OUTPUT**	4-20 MA
ENCLOSURE CLASS	NEMA 4X	**SURGE PROTECTION**	NO

NOTES

[*]

Engineers...Working Wonders With Water®

Pressure Transmitter

RESERVOIR

PROJECT INFORMATION

PLANT		**CUSTOMER**	CITY OF SANTA CRUZ
PROJECT	202431_08	**LOCATION**	SANTA CRUZ

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG	PIT-9905130A (PE-9905130A)		
SPECIFICATION NUMBER	40_73_23	**MEASURING PRINCIPLE**	DIRECT
DRAWING NUMBER	08N04	**PLC**	PLC-8
SERVICE	NITROGEN REGULATOR PRESS TRANSMITTER	**TYPICAL DETAILS**	NP501

CONNECTION

CONNECTION TYPE	M-NPT	**INSTRUMENT VALVES**	[*]

FLUID

FLUID	[*]	**PRESSURE RANGE**	0 - 500 PSI
TEMPERATURE	[*]		

ELEMENT

ELEMENT TAG NO.	PE-9905130A	**SEAL TYPE**	N/A
ENCLOSURE CLASS	NEMA 4X	**DIAPHRAGM MATERIAL**	MFR. STD.
HAZARDOUS APPROVALS	N/A	**BOTTOM HOUSING MAT.**	MFR. STD.

TRANSMITTER

TRANSMITTER TAG NO.	PIT-9905130A	**AMBIENT TEMPERATURE**	[*]
MOUNTING	INT	**OUTPUT**	[*]
ENCLOSURE CLASS	NEMA 4X	**SURGE PROTECTION**	NO

NOTES

[*]

Engineers...Working Wonders With Water®

Pressure Transmitter

RESERVOIR

PROJECT INFORMATION

PLANT		**CUSTOMER**	CITY OF SANTA CRUZ
PROJECT	202431_08	**LOCATION**	SANTA CRUZ

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG	PIT-9905130B (PE-9905130B)		
SPECIFICATION NUMBER	40_73_23	**MEASURING PRINCIPLE**	DIRECT
DRAWING NUMBER	08N04	**PLC**	PLC-8
SERVICE	VALVE INFLATION PRESS TRANSMITTER	**TYPICAL DETAILS**	NP501

CONNECTION

CONNECTION TYPE	M-NPT	**INSTRUMENT VALVES**	[*]

FLUID

FLUID	[*]	**PRESSURE RANGE**	0 - 500 PSI
TEMPERATURE	[*]		

ELEMENT

ELEMENT TAG NO.	PE-9905130B	**SEAL TYPE**	N/A
ENCLOSURE CLASS	NEMA 4X	**DIAPHRAGM MATERIAL**	MFR. STD.
HAZARDOUS APPROVALS	N/A	**BOTTOM HOUSING MAT.**	MFR. STD.

TRANSMITTER

TRANSMITTER TAG NO.	PIT-9905130B	**AMBIENT TEMPERATURE**	[*]
MOUNTING	INT	**OUTPUT**	[*]
ENCLOSURE CLASS	NEMA 4X	**SURGE PROTECTION**	NO

NOTES

[*]

SECTION 40_73_29

PRESSURE/VACUUM MEASUREMENT: DIFFERENTIAL

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Differential pressure transmitters and indicators.

1.02 REFERENCES

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Calibrated range: Range that the pressure transmitter is configured to measure.
      a. Low end of the calibrated range must be greater than the lower range value (LRV) of the transmitter.
      b. High end of the calibrated range must be less than the upper range value (URV).
      c. Calibrated range corresponds to the pressure signal sent from the transmitter.
      d. When a Low-Flow Cut-Off is considered, the calibration set points need to be 10 percent, 25 percent, 50 percent, 75 percent, and 100 percent of the output flowrate rather than starting form 0 percent.
   2. Lower range value (LRV): Lowest pressure that the pressure transmitter is capable of measuring.
   3. Upper range value (URV): Highest pressure that the pressure transmitter is capable of measuring.

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Product data:
   1. Accessories.

C. Provide complete documentation covering the traceability of calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions, including:
    1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
    2. Physical conditions:
        a. Installation and mounting requirements.
        b. Location within the process.
        c. Accessories: Verify that required accessories are provided and are compatible with the process conditions and physical installation.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT CONDITIONS

A. Project environmental conditions as specified in technical sections and as indicated on the Drawings.

1.08 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
    1. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.09 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

1.10 MAINTENANCE

A. Furnish parts, materials, fluids, etc., necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver these supplies before Project Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide instruments specified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide instruments suitable for the installed Site conditions, including, but not limited to, material compatibility, Site altitude, Site seismic conditions, humidity, and process and ambient temperatures.

2.03 MANUFACTURERS

A. One of the following, no equal:
   1. Emerson, Rosemount 3051S Series.
   2. Endress + Hauser, Deltabar S Series.
   3. SMAR, LD300 Series.

2.04 MANUFACTURED UNITS

A. As specified in this Section, including Attachment A - ISA Datasheet - Pressure/Vacuum Measurement: Differential.

B. Pressure transmitters - differential:
   1. General:
      a. Differential pressure transmitter assembly shall include a diaphragm-type pressure transducer and microprocessor-based transmitter for measurement of differential pressure.
      b. Differential pressure transmitters shall be used for differential pressure, flow, or liquid level measurement as indicated on the Drawings.
   2. Performance requirements:
      a. Maximum ratio of total instrument range to calibrated span: 10 to 1.
      b. Accuracy:
         1) Reference accuracy: Within 0.075 percent of calibrated span, including effects of hysteresis, nonlinearity, and repeatability.
         2) Stability: Within 0.30 percent of upper range limit over 5 years.
   3. Element:
      a. Diaphragm-type transducer integral to differential pressure transmitter.
      b. Diaphragm/wetted material: As indicated in Attachment A - ISA Datasheet - Pressure/Vacuum Measurement: Differential.
      c. Wetted materials: As indicated in the datasheets.
      d. Process material compatibility:
         1) Verify material compatibilities with the instrument manufacturer.
      e. Diaphragm fill fluid: Silicon oil.
      f. Process connection: As indicated in the datasheets.
   4. Transmitter:
      a. Power supply:
         1) 24 VDC - 2 wire loop powered.
      b. Outputs:
         1) Isolated 4-20 mA DC with HART communications protocol.
      c. Provided with electronic microprocessor.
      d. Adjustments: Adjustable electronic zero and span, with elevated or suppressed zero as required by application. Adjustment shall be possible without mechanical fulcrum points or handheld configurator.
      e. Square root extraction for flow calculation.
      f. Local display:
         1) 5-digit LCD.
         2) Scaled in engineering units.
      g. Enclosure:
         1) As indicated in the datasheets.
         2) Non-hazardous area:
            a) NEMA Type 4X.

3) Class I, Division 1 area:
a) Explosion-proof/Class I, Division 1 rated.
4) Class I, Division 2 area:
a) Class I, Division 2 rated.
h. Overrange protection: To maximum process line pressure.
i. Conduit connection: 1/2-inch male NPT.
5. Components:
a. Transmitter mounting:
1) As indicated in the datasheets.
2) Provide necessary hardware for transmitter mounting.

2.05 ACCESSORIES

A. Provide seals as indicated on the Drawings and as indicated in the datasheets.
1. Diaphragm seals and instrument shall be assembled by the manufacturer and shipped as an assembly.

B. Furnish device isolation as indicated in the datasheets and specified in Section 40_73_64 - Pressure/Vacuum Measurement: Instrument Valves:
1. Mount isolation device integrally to the instrument.
2. Isolation device and instrument shall be assembled by the manufacturer and shipped as an assembly.

C. Provide flanged diaphragm for tank or vessel level measurement:
1. Flanged diaphragm and transmitter shall be assembled by the manufacturer and shipped as an assembly.

D. Provide sunshades for outdoor installations.

E. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

F. Sensing (impulse) lines:
1. Provide sensing lines for each instrument.
2. Seamless stainless steel.
3. Pressure rated for the actual field service conditions.
4. Diameter based on the overall length:
a. Up to 10 feet: 3/8-inch.
b. From 10 feet to 20 feet: 1/2-inch.
c. From 20 feet to 40 feet: 1-inch.
d. Increase the diameter 1 increment for medium to heavy viscosity fluids, very dirty fluids and sludges.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

A. Each differential pressure transmitter shall be factory calibrated with 5-point calibration at a facility that is traceable to the NIST.

B. Provide complete documentation covering the traceability of calibration instruments.

C. FM approval certification or equal when installed in classified areas.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances, including weld-o-lets, valves, etc., for proper installation of instruments.

C. Install sensing lines in accordance with the Contract Documents and the line manufacturer.

3.03 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training.

3.04 ADJUSTING

A. Verify factory calibration of instruments in accordance with the manufacturer's instructions:
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.05 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

ATTACHMENT A - ISA DATASHEET - PRESSURE/VACUUM MEASUREMENT: DIFFERENTIAL

Pressure Transmitter

PROJECT INFORMATION

PLANT		**CUSTOMER**	CITY OF SANTA CRUZ
PROJECT	202431_08	**LOCATION**	SANTA CRUZ

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG	PDIT-9905110 (PE-9905110)		
SPECIFICATION NUMBER	40_73_29	**MEASURING PRINCIPLE**	DIFFERENTIAL
DRAWING NUMBER	08N03	**PLC**	PLC-8
SERVICE	INJECTION LINE PRESSURE DIFFERENTIAL	**TYPICAL DETAILS**	NP189

CONNECTION

CONNECTION TYPE	M-NPT	**INSTRUMENT VALVES**	[*]

FLUID

FLUID	WATER	**PRESSURE RANGE**	0-150 PSIG
TEMPERATURE	[*]		

ELEMENT

ELEMENT TAG NO.	PE-9905110	**SEAL TYPE**	N/A
ENCLOSURE CLASS	NEMA 4X	**DIAPHRAGM MATERIAL**	MFR. STD.
HAZARDOUS APPROVALS	N/A	**BOTTOM HOUSING MAT.**	MFR. STD.

TRANSMITTER

TRANSMITTER TAG NO.	PDIT-9905110	**AMBIENT TEMPERATURE**	[*]
MOUNTING	INT	**OUTPUT**	4-20 MA
ENCLOSURE CLASS	NEMA 4X	**SURGE PROTECTION**	NO

NOTES

[*]

SECTION 40_73_36

PRESSURE/VACUUM MEASUREMENT: SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pressure/vacuum switches.

1.02 REFERENCES

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Product data:
   1. Accessories.

1.04 QUALITY ASSURANCE

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions, including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that required accessories are provided and are compatible with the process conditions and physical installation.

1.05 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.07 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

1.09 MAINTENANCE

A. Furnish parts, materials, fluids, etc., necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver these supplies before Project Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide instruments specified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide instruments suitable for the installed Site conditions, including, but not limited to, material compatibility, Site altitude, Site seismic conditions, humidity, and process and ambient temperatures.

2.03 MANUFACTURERS

A. Mechanical type pressure switch: One of the following or equal:
   1. Allen-Bradley, Model 836.
   2. Ashcroft, GP Series.

B. Electronic type pressure switch: One of the following or equal:
   1. Allen-Bradley.
   2. Emerson, P Series.

2.04 MANUFACTURED UNITS

A. As specified in this Section, including Attachment A - ISA Datasheet - Pressure/Vacuum Measurement: Switches.

B. Mechanical type pressure switches:
   1. General:
      a. Diaphragm or diaphragm-sealed piston type.
   2. Performance requirements:
      a. Pressure range:
         1) As indicated in the datasheets.
      b. Accuracy:
         1) Within 1.0 percent of range.

c. Repeatability:
    1) Within 1.0 percent of range.
3. Element:
    a. Type: Diaphragm, diaphragm-sealed piston, or Bourdon® tube.
    b. Overpressure:
        1) Minimum 130 percent of maximum range pressure without damage to switch or sensing element.
        2) Minimum 400 percent of nominal range without leakage or rupture.
    c. Sensing element shall not require ambient temperature compensation.
    d. Wetted materials:
        1) As indicated in the datasheets.
    e. Setpoint:
        1) Single.
        2) Switch shall activate at setpoint on increasing pressure for high-pressure alarm applications and on decreasing pressure for low-pressure alarm applications.
    f. Deadband:
        1) As indicated in the datasheets.
    g. Switch elements:
        1) As indicated in the datasheets.
        2) Rated at 5 A, 125/250 VAC.
        3) Resets:
            a) As indicated in the datasheets.
    h. Enclosure: Epoxy coated:
        1) As indicated in the datasheets.
        2) Non-hazardous area:
            a) NEMA Type 4X.
        3) Class I, Division 1 area:
            a) Explosion-proof/Class I, Division 1 rated.
            b) NEMA Type 4X with intrinsic safe circuits.
        4) Class I, Division 2 area:
            a) Explosion-proof/Class I, Division 1 rated.
            b) Class I, Division 2 rated.
            c) NEMA Type 4X with intrinsic safe circuits.
    i. Switch mounting:
        1) As indicated in the datasheets.
        2) Process connection: 1/2-inch NPT.
4. Components:
    a. Provide necessary hardware for pressure switch mounting.

2.05 ACCESSORIES

A. Pulsation dampeners and snubbers:
    1. Provide with each pressure switch installed on discharge of positive displacement type pump.
    2. Materials: Stainless steel.
    3. Mount integrally to the pressure switch.
    4. Connection: 1/2-inch NPT.

B. Provide diaphragm seals as specified in the datasheets or as indicated on the Drawings and as specified:
   1. Diaphragm seal and pressure switch shall be assembled by the manufacturer and shipped as an assembly.

C. Furnish instrument isolation as indicated in the datasheets and specified in Section 40_73_64 - Pressure/Vacuum Measurement: Instrument Valves:
   1. Mount isolation device integrally to the instrument.
   2. Isolation device and instrument shall be assembled by the manufacturer and shipped as an assembly.

D. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

A. Factory calibrate each instrument with a minimum 3-point calibration or according to the manufacturer's standard at a facility that is traceable to the NIST.
   1. Submit calibration datasheets to the Engineer at least 30 days before shipment of the instruments to the Project Site.

B. FM approval certification or equal when installed in classified areas.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances, including weld-o-lets, valves, etc., for proper installation of instruments.

3.03 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training.

3.04 ADJUSTING

A. Verify factory calibration of instruments in accordance with the manufacturer's instructions:
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.05 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments specified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

ATTACHMENT A - ISA DATASHEET - PRESSURE VACUUM MEASUREMENT: SWITCHES

Pressure Switch

SPECIFICATION 40_73_36

PROJECT INFORMATION

PLANT

PROJECT 202431_08

CUSTOMER CITY OF SANTA CRUZ

LOCATION SANTA CRUZ

ELEMENT/SWITCH

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

TAG	P&ID	SERVICE	PRESSURE TRANSMITTER				
PIT-9905010A	08N05	**FLUID**	WATER	**HAZARDOUS APP**	N/A	**POWER**	[*]
PE-9905010A		**FLUID TEMPERATURE**	N/A	**ELEM. ENCL. CLASS**	NEMA 4X	**POWER LOCATION**	LOOP
		MEASURING PRINCIPLE	PRESSURE	**ELEMENT MATERIAL**	MFR. STD.	**OUTPUT**	4-20 MA
		SET POINT	RANGE 0-150 PSI	**SWITCH ENCL. CLASS**	NEMA 4X	**RELAY FORM**	SPDT
		ADJUSTABLE RANGE	[*]	**ENCL. MATERIAL**	MFR. STD.	**PLC**	PLC-8
		TYPICAL DETAILS	NP501	**SURGE PROTECTION**	NO	**MANUAL RESET**	NO
		CONN. MOUNTING	BOTTOM	**BOTT. HOUSING MAT.**	MFR. STD.	**SEAL TYPE**	N/A
		CONNECTON TYPE	M-NPT	**INSTRUMENT VALVES**	INSTRUMENT VALVE TREE	**DIAPHRAGM/WET MAT**	MFR. STD.

TAG	P&ID	SERVICE	PRESSURE SWITCH HIGH				
PSH-9905010B	08N05	**FLUID**	WATER	**HAZARDOUS APP**	N/A	**POWER**	[*]
PE-9905010B		**FLUID TEMPERATURE**	N/A	**ELEM. ENCL. CLASS**	NEMA 4X	**POWER LOCATION**	LOOP
		MEASURING PRINCIPLE	PRESS SW	**ELEMENT MATERIAL**	MFR. STD.	**OUTPUT**	RELAY
		SET POINT	~110 PSI (RANGE 0-150	**SWITCH ENCL. CLASS**	NEMA 4X	**RELAY FORM**	SPDT
		ADJUSTABLE RANGE	[*]	**ENCL. MATERIAL**	MFR. STD.	**PLC**	PLC-8
		TYPICAL DETAILS	NP501	**SURGE PROTECTION**	NO	**MANUAL RESET**	NO
		CONN. MOUNTING	BOTTOM	**BOTT. HOUSING MAT.**	MFR. STD.	**SEAL TYPE**	N/A
		CONNECTON TYPE	M-NPT	**INSTRUMENT VALVES**	INSTRUMENT VALVE TREE	**DIAPHRAGM/WET MAT**	MFR. STD.

SECTION 40_73_63

PRESSURE/VACUUM MEASUREMENT: DIAPHRAGM SEALS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Diaphragm seals.

1.02 REFERENCES

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Standards:
   1. American National Standards Institute (ANSI).

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Additional requirements:
   1. Product data:
      a. Manufacturer’s installation instructions.
      b. Seal type.
      c. Body materials.
      d. Diaphragm material.
      e. Fill fluid type.
      f. Seal size.
      g. Options.
      h. Process connection.

1.04 QUALITY ASSURANCE

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify the compatibility with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that required accessories are provided and are compatible with the process conditions and physical installation.

1.05 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.07 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Notify the Engineer if any installation condition does not meet the manufacturer's recommendations or specifications.

1.08 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide seals identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

2.03 MANUFACTURERS

A. Diaphragm seals:
   1. For chemical applications, liquids containing solids, and liquids with pulsating flow having pressures greater than or equal to 15 pounds per square inch gauge: One of the following or equal:
      a. Ashcroft:
         1) Flushing connection: Type 201.
         2) Without flushing connection: Type 200.
      b. Mansfield and Green:
         1) Flushing connection: Type SG.
         2) Without flushing connection: Type SB.
      c. Wika:
         1) Type L990.10.

2.04 MANUFACTURED UNITS

A. Diaphragm seals:
   1. General:
      a. Diaphragm seal and pressure instrument shall be assembled by pressure instrument manufacturer and shipped as an assembly.
   2. Requirements:
      a. Seal type:
         1) Metallic diaphragm: Welded to upper housing.
         2) Elastomer diaphragm: Bonded to upper housing.
      b. Process connection:
         1) As indicated in the instrument datasheets.
      c. Instrument connection: 1/2-inch NPT.
      d. Material Construction:
         1) As indicated in the instrument datasheets.
         2) Type 316 stainless steel.
      e. Provide fill/bleed connection.
      f. Mounting: As indicated in the Contract Documents.
      g. Provide Type 316 stainless steel armored capillary for remote installations.
      h. Nuts and bolts: Type 316 stainless steel.
      i. Materials of construction:
         1) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 pounds per square inch:
            a) Diaphragm: Type 316 stainless steel.
            b) Lower housing: Type 316 stainless steel.
            c) Upper housing: Manufacturer's standard.
            d) Fill fluid: Silicone oil.
         2) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures greater than 15 pounds per square inch:
            a) Diaphragm: Type 316 stainless steel.
            b) Lower housing: Type 316 stainless steel.
            c) Upper housing: Manufacturer's standard.
            d) Fill fluid: Silicone oil.
         3) Chlorine:
            a) Diaphragm: Tantalum.
            b) Lower housing: Hastelloy C.
            c) Upper housing: Manufacturer's standard.
            d) Fill fluid: Halocarbon.
         4) Ferric chloride:
            a) Diaphragm: PTFE or tantalum.
            b) Lower housing: PVC or titanium.
            c) Upper housing: Manufacturer's standard.
            d) Fill fluid: Silicone oil.
         5) Fluorosilicic acid:
            a) Diaphragm: Viton™.
            b) Lower housing: PVC.
            c) Upper housing: Manufacturer's standard.
            d) Fill fluid: Silicone oil.

6) Hydrochloric acid:
    a) Diaphragm: PVDF or tantalum.
    b) Lower housing: Hastelloy B2.
    c) Upper housing: Manufacturer's Standard.
    d) Fill fluid: Fluorolube.
7) Ozone:
    a) Diaphragm: Type 316 stainless steel.
    b) Lower housing: Type 316 stainless steel.
    c) Upper housing: Manufacturer's standard.
    d) Fill fluid: Halocarbon.
8) Potassium permanganate:
    a) Diaphragm: PTFE or tantalum.
    b) Lower housing: PVDF or titanium.
    c) Upper housing: Manufacturer's standard.
    d) Fill fluid: Halocarbon.
9) Sodium permanganate:
    a) Diaphragm: PTFE.
    b) Lower housing: PVDF.
    c) Upper housing: Manufacturer's standard.
    d) Fill fluid: Halocarbon.
10) Sodium bisulfite:
    a) Diaphragm: Tantalum.
    b) Lower housing: Titanium.
    c) Upper housing: Manufacturer's standard.
    d) Fill fluid: Silicone oil.
11) Sodium hydroxide:
    a) Diaphragm: Monel.
    b) Lower housing: Monel.
    c) Upper housing: Manufacturer's standard.
    d) Fill fluid: Silicone oil.
12) Sodium hypochlorite:
    a) Diaphragm: Tantalum.
    b) Lower Housing: Titanium.
    c) Upper Housing: Manufacturer's standard.
    d) Fill Fluid: Halocarbon.
13) Sulfur dioxide:
    a) Diaphragm: PTFE or tantalum.
    b) Lower housing: PVDF or titanium.
    c) Upper housing: Manufacturer's standard.
    d) Fill fluid: Halocarbon.
14) Sulfuric acid:
    a) Diaphragm: PTFE or tantalum.
    b) Lower housing: Hastelloy B2.
    c) Upper housing: Manufacturer's Standard.
    d) Fill fluid: Halocarbon.
15) Engineer's approval.

2.05 ACCESSORIES (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation System.

B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances including weld-o-lets, valves, etc., for proper installation of instruments.

C. Do not use Teflon™ thread seal tape on pressure instruments with silicone oil fill fluid.

3.03 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training.

END OF SECTION

SECTION 40_73_64

PRESSURE/VACUUM MEASUREMENT: INSTRUMENT VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Instrument valve tree.
   2. Valve manifolds.
   3. Level sensor isolation valves.

1.02 REFERENCES

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Additional requirements:
   1. Product data:
      a. Instrument valve type.
      b. Body material.
      c. Size.
      d. Options.
   2. Shop Drawings:
      a. Mounting details for instrument valves.

1.04 QUALITY ASSURANCE

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify that the valves are compatible with the installed conditions, including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that required accessories are provided and are compatible with the process conditions and physical installation.

C. Provide valves manufactured at facilities certified to the quality standards of ISO 9001.

1.05 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Protect valve manifolds and protective coatings from damage during handling and installation. Repair coating where damaged.

1.06 PROJECT OR SITE CONDITIONS

A. As specified in technical sections and as indicated on the Drawings.

1.07 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Notify the Engineer if any installation condition does not meet the manufacturer's recommendations or specifications.

1.08 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

1.09 MAINTENANCE

A. Furnish parts, materials, fluids, etc., necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver these supplies before Project Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide valves and valve manifolds identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide valves and valve manifolds suitable for the installed Site conditions, including, but not limited to, material compatibility, process, and ambient temperatures.

2.03 MANUFACTURERS

A. Instrument valve tree as indicated in the Contract Documents.

B. Valve manifolds:
   1. One of the following or equal:
      a. Anderson Greenwood.
      b. Emerson, Rosemount.
      c. Hex Valve.
      d. Noshok.

C. Level sensor isolation valves:
   1. One of the following or equal:
      a. DeZURIK.
      b. Indu-Tech.
      c. PBM.

2.04 MANUFACTURED UNITS

A. Instrument valve tree as indicated in the Contract Documents.

B. Valve manifolds:
   1. General:
      a. Provide 2-valve, 3-valve, blowdown type 5-valve, or metering type 5-valve manifolds, as indicated in the datasheets.
      b. Valve manifolds shall have 1-piece bonnet with a metal-to-metal seal to the valve body below the bonnet threads.
   2. Requirements:
      a. Bonnet lock pin to prevent accidental loosening.
      b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
      c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
      d. Manifold valves shall have straight through portion for bi-directional flow and easy roddable cleaning.
      e. Manifold valves shall allow for direct or remote instrument mounting.
      f. Shall be able to withstand pressures up to 6,000 psi for soft seat valves and 10,000 psi for hard seat valves at maximum 200 degrees Fahrenheit.
      g. Materials of construction:
         1) Body material: Type 316 stainless steel.
         2) O-ring: Teflon™.
      h. 2-valve manifolds:
         1) 1 isolation valve and 1 drain/vent and calibration valve.
      i. 3-valve manifolds:
         1) 2 isolation valves and 1 equalizing valve for differential pressure applications.
         2) Plugged vent connections used for vent/drain or calibration.
      j. Blowdown 5-valve manifold:
         1) 2 isolation valves, 1 equalizing valve, 2 blowdown valves for differential pressure applications.
      k. Metering 5-valve manifold:
         1) 2 isolation valves, 2 equalizing valves, 1 vent/drain and calibration valve for differential pressure applications.

C. Level sensor isolation valves:
   1. General:
      a. Valve shall provide process isolation from level diaphragm.
      b. Gas leak tested, metal-to-metal hard seat design for hard seat valves.
      c. Gas leak tested, soft seat design with replaceable seat for soft seat valves.
   2. Requirements:
      a. Materials of construction:
         1) Body material: Type 316 stainless steel.
         2) Flange diameter size: 3 inches.

2.05 ACCESSORIES

A. Provide tube fitting, female NPT, or pipe butt weld connections if necessary.

B. Provide stainless steel concentric or eccentric pipe nipples when necessary.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location and verify the valve will work properly when installed.

3.02 INSTALLATION

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances, including weld-o-lets, valves, etc., for proper installation of valves.

3.03 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training.

END OF SECTION

SECTION 40_73_65

PRESSURE MEASUREMENT: SUBMERSIBLE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Submersible pressure transmitters.

1.02 REFERENCES

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures, and Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide complete documentation covering the traceability of calibration instruments.

1.04 QUALITY ASSURANCE

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions, including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that required accessories are provided and are compatible with the process conditions and physical installation.

C. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.05 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in technical sections and as indicated on the Drawings.

1.07 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

1.09 MAINTENANCE

A. Furnish parts, materials, fluids, etc., necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver these supplies before Project Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide instruments identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide instruments suitable for the installed Site conditions, including, but not limited to, material compatibility, Site altitude, Site seismic conditions, humidity, and process and ambient temperatures.

2.03 MANUFACTURERS

A. Submersible level measurement with 2-wire integral transmitter:
   1. One of the following or equal:
      a. Druck, PTX-1830.
      b. Endress+Hauser, Waterpilot FMX21.
      c. Siemens, SITRANS LH100.

2.04 MANUFACTURED UNITS

A. As specified in this Section, including Attachment A - ISA Datasheet - Pressure Measurement: Submersible.

B. Submersible level measurement with 2-wire integral transmitter:
   1. General:
      a. Pressure is measured through a diaphragm-type measuring cell and converted to linear pressure measurement.
      b. Each submersible pressure transmitter system shall include:
         1) Signal cable, including pressure compensation tube.
         2) Transducer probe with integral transmitter.
         3) Transmitter cable termination housing.

2. Performance requirements:
    a. Accuracy:
        1) 0.3 percent of range.
    b. Repeatability:
        1) 0.25 percent of full scale.
    c. Rangeability:
        1) 3:1.
    d. Range:
        1) As indicated on the Drawings or in the datasheet.
3. Element:
    a. Sensor housing shall be Type 316L stainless steel or titanium with ceramic, Teflon™-coated, or titanium diaphragm.
    b. Protective cap shall be the manufacturer's recommended material, chemically resistant to process fluid.
    c. Pressure reference/compensation:
        1) Slip resistant extension cable with pressure compensation tube.
    d. Enclosure for probe and transmitter assembly shall be NEMA Type 6P.
4. Transmitter:
    a. Power supply:
        1) 24 VDC: 2-wire loop powered.
    b. Outputs:
        1) Isolated 4 to 20 mA DC with HART communication protocol.
    c. Ambient operating temperature limits of -10 to 70 degrees Celsius (14 to 158 degrees Fahrenheit).
5. Transmitter cable termination housing:
    a. As indicated in the datasheets.
    b. NEMA Type 4X.
    c. Equipped with filter or desiccant chamber to eliminate moisture from the pressure compensation tube.
    d. Termination for signal wires and/or pressure compensation tube.

2.05 ACCESSORIES

A. Type 316L stainless steel mounting clamp with Type 304 stainless steel mounting screws.

B. Provide cable clamp and strain relief.

C. Provide sunshade for outdoor installations.

2.06 FINISHES (NOT USED)

2.07 SOURCE QUALITY CONTROL

A. Factory calibrate each instrument with a minimum 3-point calibration or according to the manufacturer's standard at a facility that is traceable to the NIST.
    1. Submit calibration datasheet to the Engineer at least 30 days before shipment of the instruments to the Project Site.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances, including weld-o-lets, valves, etc., for proper installation of instruments.

3.03 COMMISSIONING

A. As specified in Section 01 91 00 - Commissioning.

3.04 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

ATTACHMENT A - ISA DATASHEET - PRESSURE MEASUREMENT: SUBMERSIBLE PRESSURE TRANSMITTER

Submersible Pressure Transmitter

PROJECT INFORMATION

PLANT
PROJECT 202431_08
CUSTOMER CITY OF SANTA CRUZ
LOCATION SANTA CRUZ

GENERAL NOTE: FIELDS SHOWN WITH THE [*] SYMBOL ARE NOT SHOWN ON THE DATASHEET BUT MAY BE REQUIRED BY THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL SUBMIT COMPLETE ISA DATASHEETS FOR EACH INSTRUMENT PER ALL SPECIFIED REQUIREMENTS.

GENERAL

TAG LIT-9905010 (LE-9905010)
SPECIFICATION NUMBER 40_73_65
DRAWING NUMBER 08N05
SERVICE LEVEL TRANSMITTER
MEASURING PRINCIPLE DIRECT
PLC PLC-8
TYPICAL DETAILS NL132

CONNECTION

CONNECTION TYPE SUSPENDED
ISOLATION SEALS N/A
INSTRUMENT VALVES [*]

FLUID

FLUID WATER
TEMPERATURE [*]
INSTRUMENT RANGE 0-300 FT

ELEMENT

ELEMENT TAG NO. LE-9905010
ENCLOSURE CLASS NEMA 6P
HAZARDOUS APPROVALS N/A
HOUSING MATERIAL MFR. STD.
MEMBRANE MATERIAL MFR. STD.
DIAPHRAGM MATERIAL MFR. STD.

TRANSMITTER

TRANSMITTER TAG NO. LIT-9905010
ENCLOSURE CLASS NEMA 4X
TRANS. MOUNTING INT
SURGE PROTECTION NO
SIGNAL OUTPUT AI
OUTPUT 4-20 MA
AMBIENT TEMPERATURE [*]

NOTES

[*]

SECTION 40_80_01

COMMISSIONING FOR INSTRUMENTATION AND CONTROLS

TABLE OF CONTENTS

PART 1 GENERAL 2

1.01 SUMMARY 2
1.02 REFERENCES 2
1.03 TERMINOLOGY 2
1.04 SUBMITTALS 2
1.05 QUALITY ASSURANCE 4

PART 2 PRODUCTS (NOT USED) 4

PART 3 EXECUTION 4

3.01 EXAMINATION (NOT USED) 4
3.02 INSTALLATION 4
3.03 COMMISSIONING 4
3.04 SCHEDULES 24

ATTACHMENT A - FACTORY ACCEPTANCE TEST - CONTROL PANELS

ATTACHMENT B - INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION

ATTACHMENT C - SWITCHES INSTALLATION AND CALIBRATION CHECKLIST

ATTACHMENT D - TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST

ATTACHMENT E - ANALYZERS INSTALLATION AND CALIBRATION CHECKLIST

ATTACHMENT F - CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Testing requirements that apply to process control and instrumentation systems for the entire Project.

1.02 REFERENCES

A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

B. Abbreviations:
   1. PTO: Profibus Trade Organization.

C. Standards:
   1. Telecommunications Industry Association (TIA).

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning:
   1. Complete End-to-End Testing (CEET) - Signals are tested from the field device through the PLC program, the network, and all the way to the operator's HMI graphic screens.
   2. Loop validation tests - Signals are tested from the field device to the PLC.
   3. Permanent link: Fixed portion of cabling installed between an equipment outlet and its immediate distributor or between 2 distributors.
   4. Platform testing: Testing of the PLC and SCADA/HMI at the manufacturer's shop to demonstrate the program's functionality based upon specified and designed control requirements.

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. General:
   1. Reference additional detailed test Submittal scheduling and prerequisite requirements as specified in the sequencing article of Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

C. Overall test plan:
   1. Develop the PCIS system test Submittals in consultation and cooperation with applicable Subcontractors.
   2. Develop and submit an overall testing plan for the PCIS. Overall test plan to be reviewed and approved by the Engineer before detailed test plans, procedures, and forms will be reviewed.
   3. Describe the test phases as they apply specifically to this Project and each process system.

4. Provide a preliminary testing schedule to show the sequence of tests and commissioning as they apply to each process system and each PLC.
5. Provide a description of factory tests. Describe what equipment will be included, what testing equipment will be used, and the simulator that will be used.
6. Provide examples of proposed forms and checklists.

D. Test procedures:
1. Develop and submit detailed test procedures to show that the integrated SCADA system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
2. Provide a statement of test objectives for each test.
3. Prepare specific procedures for each process system.
4. Describe sequentially the steps to be followed in verifying the correct operation of each process system, including features described in the loop descriptions, control strategies, and shown in the P&IDs. Implied or generic test procedures are not acceptable.
5. Specify who will perform the tests, specifically what testing equipment will be used (including serial numbers and NIST-traceable calibration), and how the testing equipment will be used.
6. Describe the expected role of the Engineer, as well as any requirements for assistance from the Owner's staff.
7. Provide the forms and checklists to be used.

E. Test forms:
1. Submit completed calibration forms, test forms, and checklists.
    a. Test forms shall include the detailed test procedures or shall include clear references to separate pages containing the complete test procedure applicable to each form. If references to procedures are used, the complete procedure shall be included with each test binder.
    b. Every page of each test form shall include Project name, date, time, name of person conducting the test, signature of person conducting the test, and for witnessed tests, place for signature of person (Engineer and Owner) witnessing the test.
    c. Sample test forms at the end of this Section show the minimum required content:
        1) Sample test forms have not been customized for this Project.
        2) Develop and submit test forms customized for the Project and meeting the specified test and Submittal requirements.

F. FAT procedure additional minimal requirements:
1. Prepare and submit a FAT procedure which includes:
    a. Control system testing block diagram.
    b. Estimated test duration.
    c. Details on the simulator construction, components, and operation.

G. Testing binders:
1. Sub-system to be tested: Provide and submit a test binder containing test procedures and individual forms for the test. References to other documents for test procedures and requirements are not acceptable.
2. Fill out in advance, headings and all other information known before the test.

3. Include applicable test plan information, as well as a list of test prerequisites, test personnel, and equipment.
4. Include or list reference material and provide separately at the time of the test.
5. Record test results and verify that all test requirements and conditions have been met.

H. Furnish Commissioning Submittals listed below, as specified in this Section, and Section 01 79 00 - Demonstration and Training:
1. Manufacturer's representative qualifications.
2. Owner Training.

I. Test reports:
1. At the conclusion of each test, submit a complete test report, including test results and certifications.
2. Include completed test binders, forms, and checklists.
3. Submission, review, and acceptance of each test report is required before the start of the sub-system.

J. Furnish 4 CD/DVD copies of the following:
1. Application software:
a. Finalized fully annotated copy of programmed PLC logic in its native format.
b. Cross-referenced index of PLC registers or points.

1.05 QUALITY ASSURANCE

A. Test personnel:
1. Furnish qualified technical personnel to perform calibration, testing, and verification. Test personnel are required to be familiar with this Project and the equipment, software, and systems before being assigned to the test program.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 INSTALLATION

A. Installation supervision:
1. Provide as specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

3.03 COMMISSIONING

A. As specified in Section 01 79 00 - Demonstration and Training.

B. Testing and training phase:
1. Source Testing:
a. Manufacturer services: Provide as specified in the table below.

Section Number	Section Title	Source Testing (Witnessed or Non-Witnessed)
40_61_15 - Control Strategies	Control Strategies	Witnessed
40_61_16.08 - Specific Control Strategies - Beltz 8	Specific Control Strategies	Witnessed
40_67_01 - Control Systems - Panels, Enclosures, and Panel Components	Control Systems - Panels, Enclosures, and Panel Components	Witnessed
40_80_01 - Commissioning for Instrumentation and Controls	Commissioning for Instrumentation and Controls	Witnessed

b. Prerequisite requirements:
1) Engineer approval of the hardware and equipment Source Testing Submittal is required before proceeding to preliminary FAT.
c. Preliminary FAT (pre-FAT):
1) The purpose of the pre-FAT is to provide assurance that the HMI/SCADA system is ready for the full, witnessed FAT, in terms of both stability and functionality:
a) Debugging of software and troubleshooting of hardware shall occur during and before the pre-FAT, not during the FAT.
b) Fully test the HMI/SCADA system and fix deficiencies found before the FAT.
2) Conduct utilizing test procedures approved by the Engineer.
3) Owner shall have the right to witness any or all of the pre-FAT testing and shall be notified in writing 20 days before the start of the pre-FAT.
4) Submit a letter, signed by the Contractor's Project manager or company officer, certifying that integrated system hardware and software has been tested and confirmed to be fully operational and in compliance with the requirements specified in the Contract Documents and is fully ready for the full, witnessed FAT:
a) Attach the completed pre-FAT test forms, signed by the Contractor's staff.
5) Engineer approval of the pre-FAT Submittal is required before proceeding to FAT.
d. FAT hardware and communications testing:
1) Perform tests to show that the integrated system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
2) Complete PCIS system, including operator stations, servers, network equipment, printers, PCMs, PLCs, RTUs, LCPs, CCS, peripherals, communications equipment, and other HMI/SCADA equipment, shall be assembled, connected, and software loaded for a fully functional FAT of the integrated system.

3) For any fault tolerant networks such as ring topology networks, disconnect each segment of the network individually to demonstrate proper failover and alarming at the HMI.
4) Testing simulation:
    a) Inputs and outputs shall be simulated, and proper control and system operation shall be validated.
    b) Whenever supplied equipment is available, such as devices internal to the control panel, test input and output signals using the equipment. Simulation is not acceptable.
    c) FAT shall make use of simulators that contain switches, pilot lights, variable analog signal generators, and analog signal level displays, which shall be connected to the I/O points within the HMI/SCADA system:
        (1) Simulator may consist of a PLC, operating under an HMI/SCADA software package, or other approved software that has its I/O points wired to the PLC's I/O points.
        (2) Software operating on a PC may then act as the switches, pilot lights, variable analog signal generators, and analog signal level displays.
5) Additional source tests are specified in other sections of the instrumentation and control Specifications.
6) Owner shall have the right to witness any or all of the FAT testing and shall be notified in writing 20 days before the start of the FAT.
7) Verify communications between the hardware and the programmer's software comply with specified requirements:
    a) For systems that contain RTUs or remote communications with other devices, the complete communications system must be factory tested, including actual interfacing with telephone company equipment and/or the actual radios used for radio-based telemetry systems.
8) Panel inspections:
    a) Engineer will inspect each control panel for completeness, workmanship, fit and finish, and compliance with the Contract Documents and the accepted Shop Drawings:
        (1) Inspection to include, as a minimum: Layout, mounting, wire and data cable routing, wire tags, power supply, components and wiring, I/O components layout (including terminals, wiring and relays), device layout on doors and front panels, and proper ventilation operation.
    b) Inspection forms:
        (1) Provide panel inspection forms as part of the FAT procedures Submittal.
        (2) A sample FAT control panel form has been provided at the end of this Section.
9) I/O test:
    a) Engineer will verify that I/O is properly wired to field terminals and is properly mapped into the PLC and the rest of the SCADA system, including operator interface devices.

b) Test methodology:
   (1) Discrete inputs:
      (a) Apply appropriate input from simulator at panel terminal, observe input card indicator, observe data value at each indicated data address, and observe data received at field wiring terminals or operator interface screen.
   (2) Discrete outputs:
      (a) Issue commands from operator interface screen or PLC, verify output card indicator light, and measure response at field wiring terminals or multimeter.
   (3) Analog inputs:
      (a) Apply appropriate analog input signal at panel terminals on simulator, observe data value at each indicated data address, and observe data properly received at field wiring terminals or operator interface screen.
      (b) Check each point at 0 percent, 50 percent, and 100 percent of scale.
   (4) Analog outputs:
      (a) Enter scaled values in the output buffer file, observe the output data file value, and measure appropriate response at field wiring terminals or multimeter.
      (b) Check each point at 0 percent, 50 percent, and 100 percent of scale.

c) Test forms to include, but not be limited to, the following data:
   (1) PLC and panel number.
   (2) I/O type.
   (3) I/O tag name.
   (4) Rack/slot/number of I/O point.
   (5) Check-off for correct response for each I/O point.
   (6) Comments field.
   (7) Initials of individual performing test.
   (8) Date test was performed.
   (9) Witness signature lines.

10) System configuration test:
   a) Demonstrate and test the setup and configuration of operator stations, servers, development stations, and peripherals.
   b) Demonstrate utility software and functions, such as virus protection, backup, optical drive burning, network monitoring, etc.
   c) Demonstrate the proper operation of peripheral hardware.
   d) Demonstrate general HMI/SCADA functions.
   e) Demonstrate proper operation of log-on and other security access functions.
   f) Demonstrate the proper operation of historical data storage, trend, display, backup, and report functions.
   g) Test automatic fail over of redundant equipment.
   h) Demonstrate the proper operation of the alarm display and acknowledgement functions.
   i) For any fault tolerant networks, such as ring topology networks, disconnect each segment of the network individually to demonstrate proper failover and alarming.

j) Test forms:
(1) For each test, list the specification page and paragraph of the function demonstrated, and provide a description of the function.
(2) List the specific tests and steps to be conducted.
(3) For each function, list all of the different sub-functions or ways the function can be used, and provide a test check-off for each:
(a) Include signature and date lines.

11) Engineer approval of the FAT Communication Testing activities is required before proceeding to FAT Platform Testing.

e. FAT Platform Testing - Control logic test:
1) Verify the PLC, HMI, and SCADA, provides monitoring and control functionality based upon specified and designed control requirements.
2) Testing requirements:
a) Demonstrate each function described in the Control Strategies.
b) Demonstrate in detail how each function operates under a variety of operating scenarios:
(1) Test to verify the application of each general control strategy function to each specific control strategy or loop description.
c) Demonstrate the proper operation of the programming and configuration for each control strategy or loop description:
(1) Test each strategy or loop description on a sentence by sentence and function by function basis.
(2) Loops with similar or identical logic must each be tested individually.
(3) Test the boundaries of each numeric operator input by entering values outside of the allowable range.
d) Demonstrate the proper operation of digital communication links and networks:
(1) Verify each digital communication I/O point.
e) Failure testing: Demonstrate how the system responds to and recovers from abnormal conditions, including, but not limited to, equipment failure, operator error, communications subsystem error, communications failures, simulated/forced software lockups, power failure (both utility power and power to HMI and/or SCADA hardware), process equipment failure, and high system loading conditions.
3) Test forms:
a) Submit completed test forms for each loop, including, but not limited to, the fully revised and approved control strategy.
b) Identify the cause and effect as each I/O point is toggled through the simulator:
(1) Identify and track proper and/or improper operation of the loop.
c) Note any deficiencies or operational changes on the forms for correction and documentation:
(1) Include signature and date lines.
4) Engineer approval of the FAT Submittal is required prior to shipment of system components.

2. Owner Training:
   a. Perform Owner Training as specified in Section 01 79 00 - Demonstration and Training.

Course Title	Minimum Course Length (Hours per Session)	Personnel (Estimated Number of Students)	Minimum Number of Sessions
System Overview	8	10	1
Operator Training - Basic	24	10	2
Operator Training - Advanced	16	5	2
PLC Hardware	16	4	1
PLC Software	32	6	1
LOI Hardware and Software	16	5	1

3. Training course requirements:
   a. System overview training:
      1) Furnish training courses that give the Owner's supervisory level personnel and overview of all elements of the PCIS system that focus on the overall functional aspect of elements of the control system and provide an understanding of the interaction of the various components.
      2) Furnish a training course that gives the Owner's supervisory level personnel and overview of the new Contractor-provided elements of the PCIS system. Focus on the overall functional aspects of each new elements of the control system, particularly the mechanical system vendor-provided control packages.
   b. Operator training:
      1) Furnish training courses that instruct system operators in the efficient operation of all aspects of the PCIS that include not only the general operation of the control system but also the operation of specific system features.
      2) Furnish training courses that instruct system operators in the efficient operation of Contractor-provided aspects of the PCIS that include not only the general operation of each control system but also the operation of specific system features.
      3) Operator's training shall include the following for each vendor package and programmable device:
         a) Control system overview: Architecture, equipment functions, software components, etc.
         b) Display navigation, overview, and types of displays.
         c) Process and equipment monitoring and control: Basic principles and operation.
         d) Logging ON and OFF the system and description of the security and access system.
         e) Alarm subsystem.
         f) Trending: Provide a thorough session on how to use trending functions.
         g) Reports: How to access, print, and review content.

h) Control strategies: Present an average 15-minute review of each control strategy, including a hands-on demonstration of screens and operator functions for each.
i) Instruction on the use of operational functionality alarm logging, trending, displays, database, reports, and control software developed for the Project and incorporated in the installed PCIS system.

c. PLC software training:
1) Furnish training on PLC software.
2) 2 types of training are required: basic and project-specific:
a) Basic PLC software training covers the principles of PLC programming and the specific features and function of the PLC products used on this Project, provided by one of the PLC manufacturer's certified trainers.
b) Project-specific PLC software training covers the programming conventions, new standardized software modules, specific control strategy programs, and documentation created for the Work performed under this Contract.
(1) This training includes the specific knowledge needed to modify, expand, duplicate, troubleshoot, and repair the PLC programs provided under this Contract, provided by a qualified individual who is thoroughly familiar with the delivered system, and is one of the senior programmers who programmed the PLCs for this Project.

d. LOI hardware and software training:
1) Provide the following:
a) Overview of hardware and firmware, including starting, stopping, and PLC interface.
b) Configuration of tag database.
c) Creating, editing, and saving display screens.
d) Troubleshooting.

e. Follow-up training:
1) Provide a series of on-site follow-up training classes beginning after process Start-up of the SCADA/PCIS system. The intent for these classes is to provide the Owner's personnel the opportunity for a review and "refresher" of the training topics and material after they have had some experience using the system.
2) Mutually schedule and develop the content of these classes with the Owner no later than 1 month before the beginning of the first session:
a) Schedule at the Owner's discretion on non-consecutive days spaced out over the process Start-up and warranty period.

4. Installation testing:
a. Calibration:
1) Performed by the Contractor and ICSC.
2) Calibrate and adjust instruments, devices, valves, and systems, in accordance with the component manufacturer's instructions and as specified in these Contract Documents.

3) Replace either individually or within a system, defective elements that cannot achieve proper calibration or accuracy.
    a) Discrete devices:
        (1) Calibrate and adjust devices for reliable operation and to avoid nuisance tripping.
    b) Ultrasonic and radar level devices:
        (1) Provide echo transmission and signal quality on level transmitters, including guided and unguided units.
            (a) Submit printout of the actual transmission and parameters.
        (2) Adjust mounting as required to obtain accurate readings.
        (3) Post mounting: Provide any additional calibration required by the manufacturer.
    c) Analog transmitters:
        (1) Components having adjustable features are to be set accurately for the specific conditions and applications of this installation.
        (2) Test and verify that components and/or systems are within the specified limits of accuracy.
        (3) Calibration points:
            (a) Calibrate each analog instrument at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span, using test instruments with accuracies traceable to NIST.
        (4) Field verify calibration of instruments, including units that have been factory-calibrated to determine whether any of the calibrations are in need of adjustment.
    d) Analyzer:
        (1) Calibrate and test each analyzer system as a workable system after installation. Follow the testing procedures directed by the manufacturers' technical representatives.
        (2) Submit completed instrument calibration sheets for every field instrument and analyzer.
        (3) Calibration tags:
            (a) Attach a calibration and testing tag to each instrument, piece of equipment, or system.
            (b) Sign the tag when calibration is complete.
    e) Industrial networking test equipment:
        (1) Submit calibration documentation.

b. Loop check:
    1) Performed by the Contractor.
    2) Cabling installed, terminated, and labeled.
    3) Perform continuity check of wiring to each field device through intermediate devices to field terminals in the cabinet.
    4) Complete loop check form for each device.
    5) Submit loop check test results before proceeding to the next step.
c. Loop validation tests:
    1) Performed by the Contractor, ICSC, and the manufacturer's representative, working together, and witnessed by the Owner or City's Representative.

2) Perform tests on the signal from each field device through intermediate devices to the I/O module on the PLC.
    a) PLC may or may not be connected to the network.
3) Engineer approval of the loop validation test Submittal is required before proceeding to CEET.

d. Copper Ethernet cable acceptance testing:
1) Testing procedures and field-test instruments shall comply with applicable requirements of:
    a) TIA-1152 - Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling.
    b) TIA-568.0-E - Generic Telecommunications Cabling for Customer Premises.
    c) TIA-568.1-E - Commercial Building Telecommunications Infrastructure Standard.
    d) TIA-568.2-D - Balanced Twisted-Pair Telecommunications Cabling and Components Standard.
    e) Copper Ethernet cable installation testing as specified in Section 26_08_50 - Field Electrical Acceptance Tests.
2) Testing shall be performed by trained technicians who have successfully completed an appropriate training program and have obtained a certificate as proof thereof shall execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization:
    a) Manufacturer of the connectors or cable.
    b) Manufacturer of the test equipment used for the field certification.
    c) Training organizations (e.g., BICSI).
3) Submit the following information before testing begins:
    a) Manufacturer’s catalog sheets, specifications, and the most recent calibration report for the test equipment.
    b) Certificate of testing technician’s training.
    c) A schedule of balanced twisted-pair copper links to be tested, including:
        (1) Cable identification as it appears on the cable records.
        (2) Cable identification as it appears on the individual test reports.
        (3) Cable identification as specified in Section 26_05_53 - Identification for Electrical Systems.
    d) Sample test reports.
    e) Installed cabling Permanent Links shall be field-tested and pass the test requirements and analysis as described below:
        (1) Any Permanent Link that fails these requirements shall be diagnosed and corrected.
        (2) Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected Permanent Link meets performance requirements.
        (3) Final and passing result of the tests for Permanent Links shall be provided in the test results documentation in accordance with the testing requirements.
    f) Acceptance of the test results shall be given in writing after the Project is fully completed and tested in accordance with the Contract Documents and to the satisfaction of the Engineer.

4) Cable field-test instruments:
    a) Field-test instrument shall be within the calibration period recommended by the manufacturer, typically 12 months.
    b) Certification tester requirements:
        (1) Level III in accordance with TIA-1152.
        (2) Independent verification of accuracy.
        (3) Must be capable of storing more than 10,000 results for all required measurements.
        (4) Manufacturers: The following or equal:
            (a) Fluke CableAnalyzer Industrial Ethernet Kit, DSX2-5-IE-K1.
    c) Permanent Link adapters:
        (1) Use the manufacturer's adapter for connecting to tested equipment.
            (a) Patch cables shall not be used for testing.
        (2) RJ45 plug must meet the requirements for NEXT, FEXT, and return loss in accordance with TIA-568.2-D Annex C.
    d) Measurement capabilities:
        (1) Wire map.
        (2) Length.
        (3) Propagation delay.
        (4) Delay skew.
        (5) DC loop resistance.
        (6) DC resistance unbalance.
        (7) Insertion loss.
        (8) NEXT (near-end crosstalk).
        (9) PS NEXT (power sum near-end crosstalk).
        (10) ACR-N (attenuation to crosstalk ratio near-end).
        (11) PS ACR-N (power sum attenuation to crosstalk ratio near-end).
        (12) ACR-F (attenuation to crosstalk ratio far-end).
        (13) PS ACR-F (power sum attenuation to crosstalk ratio far-end).
        (14) Return loss.
        (15) TCL (transverse conversion loss).
        (16) ELTCTL (equal level transverse conversion transfer loss).
        (17) Time domain reflectometer.
        (18) Time domain crosstalk analyzer.
5) Testing requirements:
    a) Field-test instruments shall have the latest software and firmware installed.
    b) Permanent Link test results, including the individual frequency measurements from the tester shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC in which the administrative documentation (reports) may be generated.
    c) Testing shall be performed on each cabling segment from connector to connector:
        (1) Sampling is not acceptable.

d) Installer shall build a reference link:
   (1) Components shall be anchored so it is not possible to disturb them.
   (2) Technician is to conduct a Permanent Link test each day, for each type of category cable used, to ensure no degradation of the tester or its Permanent Link adapters.
e) Unless noted otherwise tests shall use the following frequency resolution:
   (1) 1 to 31.25 MHz: 150 kHz.
   (2) 31.25 to 100 MHz: 250 kHz.
   (3) 100 to 250 MHz: 500 kHz.
f) Wire map measurement:
   (1) Wire map test is intended to verify pin-to-pin termination at each end and check for installation connectivity errors. For each of the 8 conductors in the cabling, the wire map indicates:
      (a) Continuity to the remote end.
      (b) Shorts between any 2 or more conductors.
      (c) Reversed pairs.
      (d) Split pairs.
      (e) Transposed pairs.
      (f) Distance to open on shield.
      (g) Any other miss-wiring.
      (h) Correct connectivity of telecommunications outlets/connectors is defined in TIA-568.2-D:
         - 2 color schemes are permitted.
         - User shall define which scheme is to be used.
         - Field tester shall document which color scheme was used.
g) Length measurement:
   (1) Record the length of each cable. Use the physical length of the link calculated using the pair with the shortest electrical delay for reporting and to determine pass/fail.
   (2) Pass or fail criteria is based on the maximum length allowed for the Permanent Link as specified in TIA-568.2-D plus the nominal velocity of propagation (NVP) uncertainty of 10 percent. For a Permanent Link, the length measurement can be 325 feet before a fail is reported.
h) Propagation delay measurement:
   (1) Is the time it takes for a signal to reach the end of the link?
   (2) Measurement shall be made at 10 MHz in accordance with TIA-1152.
   (3) Propagation delay of each balanced twisted pair shall be recorded.
   (4) Is not to exceed 498 ns in accordance with TIA-568.2-D Section 6.4.21.
i) Delay skew measurement:
   (1) Is the difference in propagation delay at 10 MHz between the shortest delay and the delays of the other wire pairs?

(2) Delay skew of each balanced twisted pair shall be recorded.
(3) Is not to exceed 44 ns in accordance with TIA-568.2-D Section 6.4.22.

j) DC resistance:
(1) Often reported as resistance, is the loop resistance of both conductors in the pair.
(2) Is not specified in TIA-1152 but shall be recorded for all 4 pairs.

k) DC resistance unbalance:
(1) Often reported as resistance unbalance, is the difference in resistance of the 2 wires within the pair.
(2) Is not specified in TIA-1152 for a Permanent Link but shall be recorded for all 4 pairs.

l) Insertion loss:
(1) Is the loss of signal strength over the cabling (in dB).
(2) Worst case shall be reported for all 4 pairs in one direction only.
(3) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk.
(4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.10.

m) NEXT (near-end crosstalk):
(1) Is the difference in amplitude (in dB) between a transmitted signal and the crosstalk received on other wire pairs at the same end of the cabling?
(2) Shall be measured in both directions (12 pair to pair possible combinations).
(3) Both worst case and worst margins shall be reported.
(4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.11.
(5) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
(6) Time domain crosstalk data shall be stored for any marginal or failing NEXT results.

n) PS NEXT (power sum near-end crosstalk):
(1) Is the difference (in dB) between the test signal and the crosstalk from the other pairs received at the same end of the cabling.
(2) Shall be measured in both directions (8 pair possible combinations).
(3) Both worst case and worst margins shall be reported.
(4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.12.
(5) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
(6) Time domain crosstalk data shall be stored for any marginal or failing PS NEXT results.

o) ACR-N (attenuation crosstalk ratio near-end):
(1) Is a calculation of NEXT minus insertion loss of the disturbed pair in dB.

(2) Shall be calculated in both directions.
(3) Is not specified in TIA-1152 but shall be recorded for all 12 possible combinations.

p) PS ACR-N (power sum attenuation crosstalk ratio near-end):
(1) Is a calculation of PS NEXT minus insertion loss of the disturbed pair in dB.
(2) Shall be calculated in both directions.
(3) Is not specified in TIA-1152 but shall be recorded for all 8 possible combinations.

q) ACR-F (attenuation crosstalk ratio far-end):
(1) Is a calculation of FEXT minus insertion loss of the disturbed pair in dB.
(2) Shall be measured in both directions (24 pair to pair possible combinations).
(3) Both worst case and worst margins shall be reported.
(4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.14.
(5) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).

r) PS ACR-F (power sum attenuation crosstalk ratio far-end):
(1) Is a calculation of PS FEXT minus insertion loss of the disturbed pair in dB.
(2) Shall be measured in both directions (8 pair possible combinations).
(3) Both worst case and worst margins shall be reported.
(4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.16.
(5) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).

s) Return loss:
(1) Is the difference (in dB) between the power of a transmitted signal and the power of the signals reflected back.
(2) Shall be measured in both directions (8 pair possible combinations).
(3) Both worst case and worst margins shall be reported.
(4) Shall be ignored at all frequencies where the insertion loss is less than 3 dB for that pair.
(5) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.9.
(6) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
(7) Time domain reflectometer data shall be stored for any marginal or failing return loss results.

t) TCL (transverse conversion loss):
(1) Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the near-end on the same wire pair.
(2) Shall be measured in both directions.
(3) Is not specified in TIA-1152 for a Permanent Link but shall be recorded for all 8 possible combinations.

u) ELTCTL (equal level transverse conversion transfer loss):
(1) Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the far end on the same wire pair minus the insertion loss of that pair.
(2) Shall be measured in both directions.
(3) Is not specified in TIA-1152 for a Permanent Link but shall be recorded for all 8 possible combinations.

6) Test results documentation:
a) Detailed test results documentation data is to be provided in an electronic database for each tested balance twisted pair and shall contain the following information:
(1) Overall pass/fail evaluation of the link-under test.
(2) Date and time the test results were saved in the memory of the tester.
(3) Identification of the customer site as specified by the end user.
(4) Name of the test limit selected to execute the stored test results.
(5) Name of the personnel performing the test.
(6) Version of the test software and the version of the test limit database held within the test instrument.
(7) Manufacturer, model, and serial number of the field-test instrument.
(8) Adapters used.
(9) Factory calibration date.
(10) Wire map.
(11) Propagation delay values, for all 4 pairs.
(12) Delay skew values, for all 4 pairs.
(13) DC resistance values, for all 4 pairs.
(14) DC resistance unbalance, values for all 4 pairs.
(15) Insertion loss, worst case values for all 4 pairs.
(16) NEXT, worst case margin and worst case values, both directions.
(17) PS NEXT, worst case margin and worst case values, both directions.
(18) ACR-F, worst case margin and worst case values, both directions.
(19) PS ACR-F, worst case margin and worst case values, both directions.
(20) Return loss, worst case margin and worst case values, both directions.
(21) TCL, worst case values both directions.
(22) ELTCTL, worst case values, both directions.
(23) Time domain crosstalk data if the link is marginal or fails.
(24) Time domain reflectometer data if the link is marginal or fails.
b) Maintain a set of “red-line” throughout during construction:
(1) Drawings shall be available for review at any time as requested by the Owner or Engineer.

(2) Provide record copy drawings at the end of the Project:
(a) Shall be in CAD format and include notations reflecting the as-built conditions of any additions to or variation from the drawings provided, such as, but not limited to, cable paths and termination point.
(3) As-built drawings shall include, but are not limited to, block diagrams, frame and cable labeling, cable termination points, equipment room layouts and frame installation details.
(4) As-builts shall include field changes made up to construction completion:
(a) Field directed changes to pull schedule.
(b) Horizontal cable routing changes.

e. Associated detail drawings. Engineer approval of the copper Ethernet cable acceptance-testing Submittal is required before proceeding to CEET.

f. Complete End-to-End Testing (CEET):
1) Performed by the Contractor, ICSC, and programmer working together, with assistance from the Owner or the inspection staff, as needed:
a) Participants need to be dedicated full-time to CEET.
b) Programmer will provide staff to verify input signals at, and create output signals from, an HMI or engineering workstation.
c) Contractor and ICSC will be responsible for creating field signals and verifying proper operation of final control elements.
2) Prerequisites:
a) CEET cannot begin until the successful completion of the preceding tests:
(1) Calibration.
(2) Loop check.
(3) Loop validation tests.
(4) Copper Ethernet cable acceptance testing.
3) Testing description:
a) This testing is to ensure I/O signals operate to the intent of the design from the field device to the HMI and all other auxiliary controls and indicators in the PCS.
b) Connect PLC to the network to test signals from the field device through the PLC program, the network, and to the operator's HMI graphic screens. Outputs will be energized for a duration long enough to verify proper operation of the final control element.
c) SCADA screens:
(1) Test and record operator commands and signal readouts to each operator device where there is more than one operator interface point.
(2) For each signal, perform separate tests for SCADA computer screens, local operator interface (LOI) screens, and local control panels.
(3) Retest any loop following any necessary corrections.
4) Check control loops under simulated operating conditions by causing a range of input signals at the primary control elements and observing appropriate responses of the respective control and

monitoring elements, final control elements, and the graphic displays associated with the HMI/SCADA system:

a) Use actual process inputs wherever available.
b) Issue commands from the HMI/SCADA system and verify proper responses of field devices:
    (1) Test SCADA system inputs from field device to SCADA system operator workstations:
        (a) Track responses through trend charts in the HMI/SCADA system.
    (2) Test SCADA system outputs from SCADA operator workstations to field devices and equipment.

5) Discrete device testing:
    a) Exercise each field device providing a discrete input to the HMI/SCADA system in the field and observe the proper operation shall be observed at the operator workstation:
        (1) Test limit switches, set limits mechanically, and observe proper operation at the operator workstation.
        (2) Exercise starters, relay contacts, switch contacts, and observe proper operation.
        (3) Calibrate and test instruments supplying discrete inputs and observe proper operation.
    b) Test each device accepting a discrete output signal from the HMI/SCADA. Perform the appropriate operator action at the SCADA operator stations (including LOIs, if present) and confirm the proper operation of the field device:
        (1) Stroke valves through outputs from the HMI/SCADA system and confirm proper directional operation. Confirm travel limits and any feedback signals to the HMI/SCADA system.
        (2) Exercise motors starters from the HMI/SCADA system and verify proper operation through direct field observation.
        (3) Exercise solenoids and other field devices from the HMI/SCADA system and verify proper operation through direct field observation.
6) Analog device testing:
    a) Apply continuously variable up and down analog inputs to verify the proper operation and setting of discrete devices (signal trips, etc.).
    b) Apply provisional settings on controllers and alarm setpoints.
    c) Specified accuracy tolerances for each analog network are defined as the square-root of the sum of the squares of individual component accuracy.
7) Analog input:
    a) Exercise each field device monitoring the analog signal, through the HMI/SCADA system:
        (1) Apply simulated sensor inputs corresponding to 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span for networks that incorporate analog elements and monitor the resulting outputs to verify compliance to accuracy tolerance requirements.

8) Analog output:
    a) Exercise each field device requiring an analog command signal, through the HMI/SCADA system:
        (1) Vary the output from the PLC HMI/SCADA system and measure the end device position, speed, etc., to confirm the proper operation of the device for the supplied analog signal.
        (2) Manually set the output from the HMI/SCADA screen at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent and measure the response at the final device and at any intermediate devices.
9) Submit completed test forms:
    a) Discrete instrument input devices:
        (1) Switch setting, contact action, and dead band.
        (2) Valve position switches:
            (a) Response in the PLC as the valve is stroked from the PLC.
            (b) Field observed actual valve position, and valve indicator position as the valve is stroked from the PLC.
        (3) Operator interface switches (control stations and other pilot devices) and associated response.
        (4) Starter and drive auxiliary device contact response.
        (5) Response of all other discrete inputs to the PLC.
        (6) Test equipment used and associated serial numbers.
    b) Discrete output devices:
        (1) Observed response of field device to the discrete output from the PLC.
        (2) Observe the proper operation of Open, Close, Start, Stop, On, Off, etc.
        (3) Test equipment used and associated serial numbers.
    c) Analog input devices:
        (1) Calibration range.
        (2) Calibration data: Input, output, and error at each test value.
        (3) Analog input associated PLC register address.
        (4) Value in PLC register at each test point.
        (5) Value displayed at each operator interface station (local operator interface displays and SCADA workstations).
        (6) Test equipment used and associated serial numbers.
    d) Analog output devices:
        (1) Calibration range.
        (2) Test value at each test point.
        (3) Analog output associated PLC register address.
        (4) Control variable value at field device at each test point.
        (5) Physical device response at each test point:
            (a) Response to be actual valve position, or motor speed, etc.
        (6) Test equipment used and associated serial numbers.
10) Failure testing:
    a) Demonstrate how the system reacts and recovers from abnormal conditions, including, but not limited to:
        (1) Equipment failure.

(2) Communications sub-system error.
(3) Power failure.
(4) Process equipment failure.
(5) High system loading conditions.

11) Engineer approval of the CEET Submittals is required before proceeding to Functional Testing.

5. Functional Testing:
   a. General:
      1) Testing to demonstrate proper operation of systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.
      2) Performed by the Contractor, ICSC and programmer working together, with assistance from the Owner or the inspection staff, as needed.
      3) Additional tests are specified in other instrumentation and control Sections.
      4) Follow approved detailed test procedures and check lists for Functional test activities.
   b. Control logic operational validation:
      1) The purpose of control logic validation is to field test the operation of the complete control system, including all parts of the HMI/SCADA system, control panels (including vendor control panels), control circuits, control stations, monitored/controlled equipment, and final control elements.
      2) Demonstrate control functionality shown on the P&IDs, control schematics, and other drawings, and specified in the loop descriptions, control strategies, electrical Specifications, and mechanical equipment Specifications.
      3) Test in detail on a function-by-function and sentence-by-sentence basis.
      4) Thoroughly test hardware and software functions, including hardwired and software control circuit interlocks and alarms.
      5) Test final control elements, controlled equipment, control panels, and ancillary equipment under startup, shut down, and steady-state operating conditions to verify logic and control is achieved.
      6) Control logic validation tests to include, but not be limited to, a repeat of control logic tests from the FAT, modified and expanded to include field instruments, control panels, circuits, and equipment.
   c. Loop tuning:
      1) Optimally tune electronic control stations and software control logic incorporating proportional, integral, or derivative control. Apply control signal disturbances at various process variable levels and adjusting the gain, reset, or rate settings as required to achieve proper response.
      2) Verify the transient stability of final control elements operating over the full range of operating conditions, by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations and making necessary controller adjustments

as required to eliminate excessive oscillatory amplitudes and decay rates.
a) As a minimum, achieve 1/4-wave amplitude decay ratio damping (subsidence ratio of 4) under the full range of operating conditions.

3) If excessive oscillations or system instability occur, as determined by the Engineer, continue tuning and parameter adjustments, or develop and implement any additional control algorithms needed to achieve satisfactory control loop operation.
4) Functional validation sheets:
a) Document each Functional test on an approved test form.
b) Document loop tuning with a report for each loop, including two-pen chart recordings showing the responses to step disturbance at a minimum of three setpoints or process rates approved by the Engineer. Show tuning parameters on the charts, along with time, date, and sign-off by the Contractor and Engineer.
c) Include on the form, functions which can be demonstrated on a loop-by-loop basis:
(1) Loop number and P&ID number.
(2) Control strategy, or reference to specification tested.
(3) Test procedures: Where applicable, use the FAT function-by-function, sentence-by-sentence loop test checklist forms modified to meet the requirements of the Functional test. Otherwise, create new forms.
d) For functions that cannot be demonstrated on a loop-by-loop basis (such as overall plant power failure), include on the test form a listing of the specific steps and tests to be conducted. Include with each test description the following information:
(1) Specification page and paragraph of function demonstrated.
(2) Description of function and/or text from specification.
(3) Test procedures: Use the FAT loop test checklist forms modified to meet the specific testing conditions of the Functional test.
5) Functional certification:
a) Including test forms with test data entered, submitted to the Engineer with a clear and unequivocal statement that Functional test requirements have been satisfied.

C. Process Start-up Phase:
1. Process Start-up:
a. ICSC shall be on site to support process Start-up activities and provide functional changes as required.
2. Process operation period:
a. Programmer shall be available to support process operational period and provide functional changes as required:
1) ICSC shall be available as needed.
b. ICSC shall be available to support process operational period and provide functional changes as required.

3. PCIS optimization and fine-tuning:
    a. General:
        1) After the process operational period, test PCIS system for additional 60 days as specified in this Section to identify issues and make corrections, as needed.
        2) This is part of the Work that must be completed as a condition of substantial completion and final completion for the entire Project.
        3) Complete PLC control and HMI/SCADA system must run continuously for the duration of the PCIS optimization and fine-tuning.
        4) Test and use the entire process control system under standard operating conditions.
        5) Exercise system functions.
        6) Log failure, any system interruption and accompanying component, subsystem, or program failure, including time of occurrence, duration of each failure, failure classification, and cause:
            a) Provide a competently trained technician or programmer on call for the Project Site during normal working days and hours from the start of the PCIS optimization and fine-tuning until final acceptance of the system:
                (1) Response time to the Project Site: 24 hours or less, for a major failure.
    b. SCADA system testing:
        1) Exercise each system function, e.g., status report, alarms, logs, and displays several times at a minimum, and in a manner that approximates “normal” system operation.
        2) Failure of the HMI/SCADA system during testing shall be considered as indicating that the programs and operating system do not meet the requirements of the specifications:
            a) Corrective action is required before restarting the PCIS optimization and fine-tuning.
        3) Only those components, sub-systems, and systems covered in this Section and supplied under this Contract shall be considered for this acceptance test. Problems and failures of other systems shall not be considered as part of this test, except as they display the capabilities of this system to detect failures.
        4) Failures:
            a) Classify failures as either major or minor:
                (1) Minor failure:
                    (a) A small and non-critical component failure or software problem that can be corrected by the Owner’s operators.
                    (b) Log this occurrence but this is not a reason for stopping the test and is not grounds for non-acceptance.
                    (c) Should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance.
                    (d) Failure of 1 printer or operator station is considered a minor failure providing all functions can be provided by backup equipment, i.e., alternate printers and operator

station, and repairs can be made, and equipment returned to service within 3 working days.

(2) Major failure:

(a) Considered to have occurred when a component, subsystem, software control, or program fault causes a halt in or improper operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system.

(b) Cause termination of the PCIS optimization and fine-tuning.

(c) Start a new acceptance test when the causes of a major failure have been corrected.

(d) A failure is also considered major when failure of any control system that results in an overflow, underflow, overdose, or underdose condition occurs.

5) Technician report:

a) Each time a technician is required to respond to a system malfunction, they must complete a report, which includes details concerning the nature of the complaint or malfunction and the resulting repair action required and taken.

b) If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report is required or logged as specified above.

c) If a technician has performed work but no report is written, then a major failure is considered to have occurred.

d) Each report shall be submitted within 24 hours to the Engineer and the Owner, or its representative.

3.04 SCHEDULES

A. Example test forms:

1. Attached at the end of this Section. They may be used as a starting point for the development of project-specific test forms for this Project.
2. Not intended to be complete or comprehensive. Edit and supplement the forms to meet the requirements for testing and test forms specified in this Section and other Contract Documents.

END OF SECTION

ATTACHMENT A - FACTORY ACCEPTANCE TEST - CONTROL PANELS

	FACTORY ACCEPTANCE TEST - CONTROL PANELS	

1. GENERAL INSPECTION

A. Structural Inspection

- ☐ Verify lifting lugs installed.
- ☐ Verity enclosure has lock and lock is functional.
- ☐ Confirm that seismic bracing components are provided in accordance with manufacturer's installation instructions.

B. Exterior Inspection

- ☐ Cabinet exterior is clean, scratch, and dent free.
- ☐ Inspect externally for corrosion and damage.
- ☐ Verify enclosure door opens and closes easily.
- ☐ Verify enclosure has a 3-point latch.
- ☐ Verify enclosure has a flange mounted disconnect (where voltages greater than 120 VAC enter the cabinet).
- ☐ Verify enclosure has the appropriate NEMA rating (1, 1G, 12, 3R, 4, 4X, etc.).
- ☐ Verify enclosure is the appropriate size (not grossly larger than design and will still fit in the plant).

Nameplates

- ☐ Cabinet has identification nameplate.
- ☐ All door labels are straight, spelled correctly, and match the tagging defined in the Contract.
- ☐ Cabinet has a nameplate that includes the following:
  - ☐ Power source(s).
  - ☐ Integrator's logo.
  - ☐ Circuit ID(s).
  - ☐ Short Circuit KAIC ratings.
- ☐ If labels are screwed to door, silicone was utilized to cover screw holes. (Labels screwed to the door of a NEMA 4/4X panel technically violates the NEMA rating.)

Door Devices

- ☐ All devices penetrating the outside of panel have gaskets, silicone or both.
- ☐ All door devices are installed (HMIs, Pilot Devices, etc.).
- ☐ Door mounted equipment is mounted straight and square.
- ☐ All exterior or door mounted equipment present and accounted for, installed and securely fastened.
- ☐ NEMA classification has not been violated due to penetrations.
- ☐ Door mounted equipment has the same NEMA rating as the panel.
- ☐ All door mounted equipment installed at the correct height.
- ☐ All door mounted equipment installed in the correct positions and order (layout of door mounted equipment is grouped properly and in a logical manner).
- ☐ Doors with multiple penetrations have adequate bracing (if needed).
- ☐ Visually check condition of indicators, controllers, and annunciators.
- ☐ Check that pilot lights illuminate correctly.
- ☐ Check the Push-To-Test function.
- ☐ Ensure correct pilot light color.

Peripheral Devices

- ☐ Horn/Beacon is installed (where required).
- ☐ Silence and Reset pushbutton.

PROJECT NAME:	_____	TEST DATE:	_____
FACILITY NAME:	_____	TESTED BY:	_____
PROCESS AREA:	_____	COMPANY:	_____
NETWORK ID:	_____	PAGE:	_____
WITNESSED BY:	_____	SIGNATURE:	_____

	FACTORY ACCEPTANCE TEST - CONTROL PANELS	

1. GENERAL INSPECTION (continued)

C. Interior Inspection

- ☐ Cabinet is cleaned of marks and dirt.
- ☐ Inspect internally for corrosion and damage.
- ☐ Back panel is clean of marks and dirt.
- ☐ Interior of panel vacuumed and shall be free of all debris.
- ☐ Check that the panel roof is clean and clear of foreign materials.
- ☐ Bottom of panel has been cut out (where bottom entry is required), with angle iron welded around the bottom perimeter. Re-painting has been performed.
- ☐ If internal light door limit switch is provided, ensure the light automatically turns “on” when the doors are open.
- ☐ Check that a document pocket has been provided.
- ☐ Intrusion alarms (where required).

Interior Labeling

- ☐ All panel mounted equipment has identification labeling, by using either a Brothers or Phenolic type tags.
- ☐ Verify that door mounted components are mounted square and symmetrical.
- ☐ Verify that nameplates are straight, legible, and spelled correctly.
- ☐ All terminal blocks are identified/labeled with permanent labels, including tight end blocks and caps.
- ☐ All wiring shrink labeled and or phased correctly to the specifications.
- ☐ All wire labels shrunk completely rotated and aligned alike for easy identification.
- ☐ All fuses and circuit breakers are labeled with ID and current rating.
- ☐ System Integrator’s label or labels installed on door.
- ☐ Panel manufacturer model/serial number tag is present.
- ☐ All required safety/warning tags installed and straight.
- ☐ Correct UL (typically UL 508) or cUL tag installed and registered and all other associated tags installed and straight. (The UL tag might not be installed in the panel at the factory test. If the panel is modified due to changes during the factory test or a punch list generated from the factory test, the UL labeling would need to be re-applied. Some UL shops do not apply the UL label until the panel is released to be shipped.)

Wireways

- ☐ Plastic wire way covers installed properly.
- ☐ Plastic wireways have no sharp edges.
- ☐ No wire ties inside the wireways.
- ☐ No sharp edges on wire ties.
- ☐ Separation: White duct is used for DC voltages; Gray duct is used for AC voltages.
- ☐ Ensure wiring duct is not over-full, includes provision for 20% more wiring and the cover may easily be installed. Panduit recommends 50% duct fill, but 40% is a better practice.

PROJECT NAME:	_____	TEST DATE:	_____
FACILITY NAME:	_____	TESTED BY:	_____
PROCESS AREA:	_____	COMPANY:	_____
NETWORK ID:	_____	PAGE:	_____
WITNESSED BY:	_____	SIGNATURE:	_____

	FACTORY ACCEPTANCE TEST - CONTROL PANELS	

1. GENERAL INSPECTION (continued)

C. Interior Inspection (continued)

Wiring

- ☐ Visually check terminals and condition of internal wirings.
- ☐ Verify that the control panel has been assembled and wired as designed.
- ☐ Verify that all components are operational and perform the functions intended.
- ☐ Verify that all components are sized appropriately for the application.
- ☐ Verify that equipment control circuits function as intended.
- ☐ Back of door wiring is labeled and neatly formed.
- ☐ Back panel to door wiring has sufficient bending radius with spiral wrap.
- ☐ Wire connection has been verified wired to correct points within the panel.
- ☐ Individual wires have been given a pull test to verify a good terminal connection.
- ☐ Wire and cable minimum bending radius have not been violated.
- ☐ All equipment installed straight and square to back panel.
- ☐ Wire colors are correct:
  - ☐ Black and White > AC hot and neutral, respectively.
  - ☐ Red > AC control signals.
  - ☐ Blue > DC power and control (Blue w/White stripe for DC ground).
  - ☐ Yellow > Foreign voltages (those still present when panel power is disconnected).
  - ☐ Green > AC equipment ground.
  - ☐ Black > TSP (+).
  - ☐ White > TSP(-).
- ☐ Analog wiring shields are continuous (connected by a dedicated terminal block for such shields).
- ☐ Analog shield wires are grounded within the panel, where not otherwise grounded at the transmitter itself.
- ☐ Discrete inputs are separately fused or protected by a circuit breaker on a “per loop” basis.
- ☐ Intrinsic Safety Wiring.
  - ☐ Ensure wiring associated with intrinsic safety circuits or intrinsic safety barriers is kept away from all other wiring by UL minimum distances or by a physical (grounded metal) barrier preventing non-intrinsically safe wiring from coming in contact with intrinsically safe circuits or wiring.
- ☐ Verify all spare terminals are installed according to the percentage listed in the specifications.

Grounding

- ☐ Equipped with “Blackburn” or other grounding type lug.
- ☐ Lug is securely fastened to the panel structure.
- ☐ Verify grounding bar is installed.
- ☐ Verify isolated ground bar is installed.

PROJECT NAME:	_____	TEST DATE:	_____
FACILITY NAME:	_____	TESTED BY:	_____
PROCESS AREA:	_____	COMPANY:	_____
NETWORK ID:	_____	PAGE:	_____
WITNESSED BY:	_____ SIGNATURE:		_____

	FACTORY ACCEPTANCE TEST - CONTROL PANELS	

2. POWER TEST

A. AC Power

- ☐ AC power is routed correctly within the panel and is isolated from DC and network wiring.
- ☐ All fuses are installed and sized properly.
- ☐ All breakers are installed and sized properly.
- ☐ 24 VDC Power Supplies are functional.
- ☐ 24 VDC Power fail contacts are functional.
- ☐ 24 VDC power supplies are redundant and have diode modules enabling the hot swap-over between supplies.
  - ☐ 24 VDC supplies are equipped with dry contact failure alarms, wired as PLC inputs to signal failure of any DC power supply. Such alarm inputs to the PLC have been tested as being functional.
- ☐ Dedicated receptacle is wired to receive a dedicated AC supply.
- ☐ Verify continuity for all DC commons, ground and AC neutrals.
- ☐ Verify that the CP temporary input power is connected correctly and is the correct voltage.
- ☐ Close the CP main circuit breaker(s).
- ☐ Verify that voltages at subsequent circuit breakers are correct.
- ☐ Close circuit breakers.
- ☐ Verify that power feeding interruptible and uninterruptible power supplies is correct.
- ☐ Turn on power supplies if they are not already on.
- ☐ Verify that voltages at distribution terminals are correct.
- ☐ Energize any remaining hardware such as the PLC.

B. Uninterruptible Power Supply (UPS)

- ☐ Mounted appropriately within the cabinet, on a dedicated shelf, or rear of a swing-out sub panel.
- ☐ Is equipped with maintenance bypass switch (or at least plug/receptacle means for bypassing the unit).
- ☐ Test all UPS alarms (on inverter, failure, battery failure etc.).
- ☐ Turn off the AC power supply and verify that the UPS will be switched on to supply the designated vital loads in the control panel.

3. CONTROLS & AUXILIARY DEVICES TEST

- ☐ Verify all interposing and auxiliary relays are functioning.
- ☐ Verify panel lights are functioning.

Ventilation and Heating

- ☐ If ventilation fans are fitted, check the fans operate correctly any associated air filters are clean and not blocked.
- ☐ Verify components are installed in the correct orientation for proper air flow.

4. HARDWIRED INTERLOCK AND SAFETY TEST

- ☐ Verify that hardwired interlocks through the control panel as shown on schematic drawings are functioning. For example, outlet high pressure switch interlock to a pump.
- ☐ Verify that all hardwired safety devices through the control panel is functioning. For example, the pull cord emergency stops of conveyors.

PROJECT NAME:		TEST DATE:	
FACILITY NAME:		TESTED BY:	
PROCESS AREA:		COMPANY:	
NETWORK ID:		PAGE:	
WITNESSED BY:		SIGNATURE:	

	FACTORY ACCEPTANCE TEST - CONTROL PANELS	

5. PLC TEST

A. Components

☐ PLC interior High Temperature alarm is installed, wired to the PLC, and is shown to be functional.

☐ Relays have transient suppression across their coils. This is particularly important for DC coil relays, where diodes in reverse polarity are often used.

☐ TVSS is installed across the main incoming 120 VAC.

PLC and PLC Rack

☐ Verify all cards are securely seated.

☐ Ensure clearance around PLC rack has been met, such that convective heat transfer is not impeded by devices erroneously mounted in the “no encroachment” area. Confirm with manufacturer clearance recommendations.

B. PLC I/O Test

☐ Furnish **I/O test forms** and test all the listed input and output points as follows:

☐ Discrete Inputs: Simulate a field contact closure by “shorting” across the appropriate terminal blocks. Observe the transition between a logical “0” and “1” in the PLC software.

☐ Discrete Outputs: Force the output bit to toggle between logical “0” and logical “1” using the PLC software. Measure contact resistance at the wired terminal blocks using a digital meter selected for the “ohms” setting.

☐ Analog Inputs: Connect a signal generator to the appropriate terminal blocks. Tailor the connection depending on whether a 2-wire or 4-wire simulation is required. Modulate the 4-20mA signal. Observe the associated PLC internal memory register to transition between 0-65535 or if scaled in engineering units, between 0 and the maximum scaled engineering unit. The latter method is preferred.

☐ Analog Outputs: Force the output register to a value between 0-65535 or 0-100%, if the scaling block can be manipulated. Observe the measured 4-20mA value increment and decrement using a digital ammeter.

C. Redundant Controllers (where required) Test

☐ Remove Communication cable from primary PLC to verify switching to backup PLC.

☐ Remove Communication cable from backup PLC to verify switching back to primary PLC.

☐ Remove Power cable from primary PLC to verify switching to backup PLC.

☐ Remove Power cable from backup PLC to verify switching back to primary PLC.

D. PLC Control Logic Verification

☐ The PLC control strategy is verified by following the Control Logic Verification Form based on the specifications. Each control strategy will be verified by simulating the process and checking the state or value of PLC outputs. The results of equipment status and alarms and process instrument values and trends shall also be verified on the Plant SCADA graphic screens stored in a temporary SCADA computer. Since all PLC input and output wiring has been verified and some field devices are not available during Factory Acceptance Testing, certain inputs will be simulated either by means of additional hardware and/or software as described below.

☐

☐

☐ DI states are either simulated by hardwired switches or forced inputs using a programming terminal.

☐ For example, when starters and drives are not provided as part of the Contract, jumpers may be installed from the output call relays to the running confirmation inputs to simulate the running state of the motors.

PROJECT NAME:	_____	TEST DATE:	_____
FACILITY NAME:	_____	TESTED BY:	_____
PROCESS AREA:	_____	COMPANY:	_____
NETWORK ID:	_____	PAGE:	_____
WITNESSED BY:	_____ SIGNATURE:		_____

5. PLC TEST (continued)

D. PLC Control Logic Verification (continued)

Typical Fault Logic

- ☐ If the fault input is high and the disable (if applicable) for the fault is not high and the common disable (if applicable) is not high begin timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output. If the fault alarm is a shutdown alarm stop the associated motor and latch the alarm so that it remains present even if the condition clears.
- ☐ The fault condition must return to normal, and the alarm must be reset for a latched alarm to clear.

Typical Fail to Start Logic

- ☐ If the motor is called to run (call output high) and no running feedback is received (running input is low) and the fail to start and common alarm disables (if applicable) are not high start timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output, stop calling the motor and latch the alarm.

6. HMI OR OIT TEST

HMI/OIT Functionality

- ☐ Communication with PLC.
- ☐ Screen Layouts.
- ☐ Screen Navigation.
- ☐ Set Point Entry.
- ☐ Animation.
- ☐ Color Correctness (Green=Run, Red=Off, Amber=Alarm, or the agreed upon convention).
- ☐ Alarms.
- ☐ Acknowledge and Reset.
- ☐ Security/Access Levels/Passwords.

7. NETWORK COMMUNICATION TEST

A. Network Components

- ☐ Fiber optic cabling terminates in a patch panel.
- ☐ Media converters are installed and functional.
- ☐ Terminating resistors have been installed for trunk/tap topologies or where required.
- ☐ Wire and cable bending limitations have not been violated.

B. Networking Functions

- ☐ Verify data transfer via the network to different PLCs as shown on the Network Block Diagrams.
- ☐ Verify network traffic rate and error margin is acceptable.

PROJECT NAME:	_____	TEST DATE:	_____
FACILITY NAME:	_____	TESTED BY:	_____
PROCESS AREA:	_____	COMPANY:	_____
NETWORK ID:	_____	PAGE:	_____
WITNESSED BY:	_____	SIGNATURE:	_____

	FACTORY ACCEPTANCE TEST - CONTROL PANELS	

8. FAT DOCUMENTATION AND RECORD

Panel Documentation

- ☐ As-built panel drawings showing actual panel construction and devices arrangement and c/w Bill of Material.
- ☐ Panel schematic and interconnection drawings.
- ☐ P&ID drawings and schematic drawings for the process area controlled by the panel that is to be tested.
- ☐ I/O list test forms of the process area to be tested.
- ☐ FAT procedure of the process area to be tested.
- ☐ Test record forms of the process area to be tested. Forms shall include area for signature of responsible test personnel.
- ☐ Hard copy of the PLC application program of the process area to be tested.
- ☐ Hard copy of the HMI/OIT graphic screens of the process area to be tested.

9. FAT TOOLS AND SOFTWARE

- ☐ Simulation software if required.
- ☐ Digital volt meter Fluke 87.
- ☐ Process meter Fluke 787.
- ☐ Laptop computer with PLC application program.
- ☐ Temporary SCADA computer with HMI software and applicable graphic screens.
- ☐ Jumper wires.

PROJECT NAME:	_____	TEST DATE:	_____
FACILITY NAME:	_____	TESTED BY:	_____
PROCESS AREA:	_____	COMPANY:	_____
NETWORK ID:	_____	PAGE:	_____
WITNESSED BY:	_____	SIGNATURE:	_____

ATTACHMENT B - INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION

	INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

A COPY OF LATEST ISSUE OF THE FOLLOWING DOCUMENTS ARE INCLUDED IN THIS INSTRUMENT INSTALLATION CERTIFICATION FILE:

☐ INSTRUMENT SPECIFICATION SHEETS (FOR ALL INSTRUMENTS IN THE LOOP)

☐ INSTRUMENT INSTALLATION DETAILS (FOR ALL INSTRUMENTS IN THE LOOP)

☐ INSTRUMENT LOOP WIRING DIAGRAMS

☐ INSTRUMENT INSTALLATION CERTIFICATION CHECKLIST

☐ SIZING CALCULATIONS

☐ INSTRUMENT INSTALLATION SCHEDULE (APPLICABLE PART)

☐ NAMEPLATE SCHEDULE (APPLICABLE PART)

☐ VENDOR LITERATURE CALIBRATION INFORMATION

	☐ No	☐ Yes
INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?		

REMARKS: _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

ATTACHMENT C - SWITCHES INSTALLATION AND CALIBRATION CHECKLIST

	SWITCHES INSTALLATION AND CALIBRATION CHECKLIST	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, WHEN COMPLETED:

☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER DETAIL NO. _____

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

	☐ No	☐ Yes
INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?		

FIELD CALIBRATION CHECK

CONTACT NO.	FUNCTION	FOR SIGNAL	CONTACT IS TO	AT SPECIFIED VALUE FOR		ACTUAL TRIP POINT WAS	
1	☐ ALARM	☐ INCR	☐ OPEN	SET PT =		SET PT =	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =		RESET =	
2	☐ ALARM	☐ INCR	☐ OPEN	SET PT =		SET PT =	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =		RESET =	
3	☐ ALARM	☐ INCR	☐ OPEN	SET PT =		SET PT =	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =		RESET =	
4	☐ ALARM	☐ INCR	☐ OPEN	SET PT =		SET PT =	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =		RESET =	

NOTE: PERM IS ABBREVIATION FOR PERMISSIVE

	SWITCHES INSTALLATION AND CALIBRATION CHECKLIST	

REMARKS: _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

ATTACHMENT D - TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST

	TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	

☐ No ☐ Yes

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

INSTRUMENT TYPE ☐ TRANSMITTER ☐ CONTROLLER ☐ INDICATOR

☐ OTHER DESCRIPTION _____

INSTRUMENT TAG NO. _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

BENCH CALIBRATION CHECK

INPUT RANGE = _____ OUTPUT RANGE = _____

HEAD CORRECTION = _____ ☐ LINEAR

CALIBRATED SPAN = _____ ☐ SQUARE ROOT

% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

CHECK BELOW, WHEN COMPLETED:

☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER DETAIL NO. _____

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

FIELD CALIBRATION CHECK

INPUT RANGE = _____ OUTPUT RANGE = _____

% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

	TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	

☐ DIRECT ☐ REVERSE

☐ ACTION VERIFIED AT 50% SPAN

☐ ACTION VERIFIED AT _____ SPAN

CONTROLLER SETTINGS								
SETTING	**GAIN**	**PB**	**RESET (INTEGRAL)**	**DERIV. (RATE)**	**HIGH LIMIT**	**LOW LIMIT**	**ELEV. ZERO**	**ZERO SUPP**
PRE-TUNE								
POST-TUNE								

PRE-TUNE SETTINGS					
	GAIN	**PB**	**RESET (REPEAT/MIN)**	**RESET (MIN/REPEAT)**	**DERIVATION (MINUTES)**
FLOW	1.0	100	10	0.1	N/A
LEVEL	1.0	100	MIN.	MAX.	N/A
PRESSURE	2.0	50	2.0	0.5	N/A
TEMP.	4.0	25	0.1	10	OFF

REMARKS _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

ATTACHMENT E - ANALYZERS INSTALLATION AND CALIBRATION CHECKLIST

	ANALYZERS **INSTALLATION AND CALIBRATION CHECKLIST**	

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS? ☐ No ☐ Yes

TYPE OF INSTRUMENT _____

INSTRUMENT TAG NO. _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, IF TRUE

☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER DETAIL NO. _____

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

REMARKS _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

ATTACHMENT F - CONTROL VALVES
INSTALLATION AND CALIBRATION CHECKLIST

	CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST	

☐ No ☐ Yes

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

☐ VALVE TAG NO. _____ SERIAL NO. _____

☐ TRANSDUCER TAG NO. _____ SERIAL NO. _____

☐ SOLENOID TAG NO. _____ SERIAL NO. _____

☐ VOLUME BOOSTER TAG NO. _____ SERIAL NO. _____

☐ POSITIONER _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

TRANSDUCER CHECK					
INPUT RANGE =			OUTPUT RANGE =		
CALIBRATED SPAN =			CALIBRATED SPAN =		
BENCH					
SPAN	**DESIRED**	**ACTUAL**	**SPAN**	**EXPECTED**	**ACTUAL**
0%			0%		
50%			50%		
100%			100%		
FIELD					
SPAN	**DESIRED**	**ACTUAL**	**SPAN**	**EXPECTED**	**ACTUAL**
0%			0%		
50%			50%		
100%			100%		

CHECK BELOW, IF TRUE:

☐ BENCH CALIBRATED PER ABOVE _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

- ☐ VALVE SPECIFICATION NO. _____
- ☐ TRANSDUCER SPECIFICATION NO. _____
- ☐ SOLENOID SPECIFICATION NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER INSTRUMENT INSTALLATION DETAILS _____

- ☐ VALVE DETAIL NO. _____
- ☐ TRANSDUCER DETAIL NO. _____
- ☐ SOLENOID DETAIL NO. _____

	CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST	

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

VALVE CHECK			
FLOW CHECK	☐ PROCESS FLOW DIRECTION THROUGH THE VALVE IS CORRECT		
SAFETY CHECK	ON LOSS OF AIR VALVE FAILS ☐ OPEN ☐ CLOSE	ON LOSS OF POWER SOLENOID FAILS ☐ TO VENT ☐ TO VALVE	
TRAVEL CHECK	FULL OPEN AT _____ PSI	FULL CLOSED AT _____ PSI	MEASURED TRAVEL _____ INCHES
SEATING CHECK	☐ ON BENCH ☐ IN-LINE	RESULTS	ACTUATOR BENCH SET
POSITIONER CHECK			
VALVE FULL OPEN AT _____ PSI TO POSITIONER _____			
VALVE FULL CLOSED AT _____ PSI TO POSITIONER _____			
VOLUME BOOSTER CHECK			
BYPASS VALVE (GAIN) ADJUSTING SCREW BACKED OUT _____ TURNS FROM CLOSED TO ENSURE QUICK BUT STABLE OPERATION (TYPICALLY 1-1/2 TO 2 TURNS)			

REMARKS _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

SECTION 43_25_20.02

SUBMERSIBLE WELL PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Submersible well pumps.
   2. Tag numbers: As specified in the Pump Schedule.

B. American Iron and Steel Compliance: Contractor is advised that the funding for this project includes “American Iron and Steel (AIS)” requirements. Refer to Section 00 45 46.4 and Section 00 73 74 for additional information. All shop drawing submittals for products containing iron and/or steel shall indicate if the product is AIS compliant, if a product-specific waiver has been obtained, or if the product qualifies for the National De Minimis Waiver for incidental products.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C654 - Disinfection of Wells.

B. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   3. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   4. A283 - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
   5. A516 - Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service.
   6. A536 - Standard Specification for Ductile Iron Castings.
   7. A582 - Standard Specification for Free Machining Stainless Steel Bars.
   8. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
   9. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
   10. F594 - Standard Specification for Stainless Steel Nuts.

C. The Hydraulic Institute (HI):
   1. 9.1-9.5 - Pumps - General Guidelines.
   2. 11.6 - Rotodynamic Submersible Pump Test.
   3. 14.1-14.2 - Rotodynamic Pumps for Nomenclature and Definitions.
   4. 14.3 - Rotodynamic Pumps for Design and Application.
   5. 14.4 - Rotodynamic Pumps for Installation Operation and Maintenance.

D. NSF International (NSF):
   1. Standard 61 - Drinking Water System Components - Health Effects.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Pump head (total dynamic head, TDH), flow capacity, pump efficiency, net positive suction head available (NPSHa), and net positive suction head required (NPSHr) as defined in HI 9.1-9.5, 11.6, 14.1-14.2, 14.3, 14.4, and as modified in the Specifications.
   2. Pump head and efficiency are evaluated at the outlet of the discharge head and include the net losses in the pump column and discharge.
   3. Suction head: Gauge pressure available at pump intake flange or bell in feet of fluid above atmospheric.
   4. Tolerances: This Section and related sections contain tolerances that may be more stringent than Hydraulic Institute Standard tolerances. Where tolerances are not mentioned, Hydraulic Institute Standards 9.1-9.5, 14.1-14.2, 14.3, and 14.4 shall apply.

1.04 DELEGATED DESIGN

A. As specified in Section 01_35_73 - Delegated Design Procedures.

B. Anchoring and bracing.

C. Rotordynamic analysis.

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01 33 00 - Submittal Procedures.

B. Delegated Design Submittals:
   1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in technical sections and as indicated on the Drawings:
      a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
      b. For equipment installed outdoors.
      c. For wall mounted equipment weighing 125 pounds or more.

C. Commissioning Submittals:
   1. As specified in Section 01 91 00 - Commissioning, including the following:
      a. Manufacturer’s representative qualifications.
      b. Certificates:
         1) Requirements as specified in this Section.
      c. Test Plans:
         1) Test requirements as specified in this Section.
      d. Test Reports.
      e. Manufacturer’s representatives field notes and data.
      f. Owner Training.

D. Product Submittals:
   1. As specified in Section 01 61 00 - Common Product Requirements.
   2. Product data:
      a. For pumps in contact with drinking water, submit one of the following:
         1) Pump lead free certification.
         2) Weighted average lead calculations.
   3. Shop Drawings.
   4. Manufacturer's instructions.
   5. Calculations.
   6. Schedules.

E. Operation and maintenance manuals:
   1. As specified in Section 01 78 23 - Operation and Maintenance Data.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01 61 00 - Common Product Requirements, Section 46_05_10 - Common Work Results for Mechanical, and the manufacturer's instructions.

1.07 WARRANTY

A. As specified in Section 01 78 36 - Warranties.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:
   1. Grundfos, SP Series No. 625S400-2.
   2. Fairbanks Morse.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Product requirements: As specified in Section 01 61 00 - Common Product Requirements and Section 46_05_10 - Common Work Results for Mechanical Equipment:

2.03 MATERIALS

A. General:
   1. Materials in the Pump Schedule shall be the type and grade as specified in this Section.

B. Drinking water pumps: Provide materials as specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.

C. Type 304 stainless steel: In accordance with ASTM A276.

D. All materials shall be NSF 61 approved.

2.04 GENERAL PUMP CONSTRUCTION

A. Pumps shall be NSF 61 certified.

B. Impeller: Type 304 stainless steel.
   1. Each impeller shall be fitted with a NBR/PPS seal ring around its eye or skirt to prevent hydraulic losses.
   2. Single keyed and securely fastened to the shaft by a Type 416 stainless steel collets or by a smooth shaft with split-cone and nut design.

C. Motor:
   1. Type 304 stainless steel.
   2. Motor shroud: Furnish integral flow sleeve for motor cooling.

D. Intermediate Bearings:
   1. Material: NBR.
   2. Lubricated by the pumped liquid.
   3. Provide a Carbon/Graphite upthrust disc to protect the pump against upthrust.

E. Check Valve:
   1. Check valve integrally designed into the pump discharge housing.
   2. The check valve and check valve housing shall be Type 304 stainless steel.
   3. The check valve seat shall be NBR/316 stainless steel.
   4. The discharge shall have internal NPT-type pipe thread connections.

F. Fasteners: Type 304 stainless steel fasteners in accordance with ASTM F593 or ASTM F594.

2.05 COLUMN PIPE

A. Material: Seamless 304L stainless steel casing pipe, 6.625-inch OD x 0.312-inch wall thickness.

B. Size: As scheduled in the Pump Schedule.

C. Head connection: Design with and flange bolted connection to discharge head and flange bolted connection to impeller assembly.

D. Design working pressure: Design to withstand a design working pressure not less than 1.20 times the maximum shutoff total dynamic head with the maximum diameter impeller at the maximum operating speed plus the maximum suction static head.

E. Pressure test: Design to withstand a 5 minute hydrostatic test pressure not less than 1.5 times the design working pressure; perform test at source.

F. Lengths and connections:
   1. Design with maximum 20-foot length.
   2. Threaded and coupled.

2.06 DRIVERS

A. Horsepower:
   1. As scheduled.
   2. Listed driver horsepower is the minimum to be supplied.
      a. Increase driver horsepower if required to prevent driver overload while operating at any point of the supplied pump operating head-flow curve including runout.
      b. When scheduled driver is a motor, increase motor horsepower if required to prevent operation in the service factor.
      c. Make structural, mechanical, and electrical changes required to accommodate increased horsepower.
      d. Coordinate available power and space with the Engineer prior to providing a submittal with increased motor horsepower.

B. Motors:
   1. Manufacturers: Same as pump manufacturer.
   2. Water filled for cooling and lubrication. No oils or grease lubrication shall be allowed.
   3. A Nitrile Rubber or Type 100 Hydrin shaft seal shall be provided to ensure the internal motor fluid is not mixed with the pumped fluid.
   4. A Nitrile Rubber or Type 100 Hydrin diaphragm shall be provided to permit expansion and contraction of the internal motor fluid when the motor heats and cools during operation.
   5. NSF Standard 61 certified.
   6. Revolutions per minute: 3,600.
   7. Enclosure: NEMA Type R Submersible.
   8. Motor shroud: Furnish integral flow sleeve for motor cooling.
   9. Electrical characteristics: As scheduled in the Pump Schedule.
   10. Motor construction:
      a. Motor: Type 304 stainless steel.
      b. Thrust bearing: Kingsbury type.
      c. Upper and lower radial bearings: Carbon sleeve.
      d. Motor coupling: Type 316/329/416 stainless steel either keyed or splined as required to fit the motor shaft.
      e. Temperature rating: Continuous duty in water at 30 degrees Celsius.

C. Cables:
   1. Flat cable shall be shielded and comprised of 4 separate conductors or a single cable assembly with 4 conductors.
   2. Each conductor shall be insulated by synthetic rubber or plastic insulation suitable for continuous immersion in water.
   3. Protected with steel guard where it passes the bowl assembly to prevent damage from contact with the well casing.
   4. Type 304 stainless steel bands shall be provided to support the cable along the column pipe at intervals of not more than 20 feet.
   5. Power cable shall be sized such that the voltage drop will not exceed 5 percent at the motor rated full load current and voltage.
   6. Cable shall be NSF 61 certified.

D. Variable frequency drives (VFD): As scheduled and as specified in Section 26_29_24 - Variable Frequency Drives 0.50 - 50 Horsepower.

2.07 SPARE PARTS AND SPECIAL TOOLS

A. Vendor to provide spare parts that are required to provide uninterrupted operation for a minimum of 2 years.

B. Special tools: Deliver 1 set for each furnished pump type and size needed to assemble and disassemble pump system.

C. Additional spare part requirements as specified in the Contract Documents.

PART 3 EXECUTION

3.01 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

B. Sterilization:
   1. Disinfection procedures shall be in accordance with AWWA C654.
   2. Samples for bacteriological analysis shall be collected in a sterile container at the pump discharge, and a test made for coliform organisms.
      a. After sterilization, the well shall be pumped at open discharge until at least 100,000 gallons of water have been pumped before the samples are collected.
      b. Water samples shall be collected from the well on 3 successive days and analyzed for coliform organisms with each sample showing that no organisms were found before the well is accepted for showing the water is coliform free.
      c. Samples shall be collected by a laboratory approved by the Owner and the test for coliform organisms shall be made by the laboratory, and the Owner shall be furnished a copy of the laboratory report.
      d. If any coliform organisms are found present in the samples, re-sterilize the pump and have the water resampled as stated above until such time as no coliform organisms are found present in a water samples collected after at least 100,000 gallons of water have been pumped from the well following sterilization, or until such time as the Owner becomes convinced that coliform organisms exist naturally in the water-bearing formation and are not present in water produced from the well as a result of the operations of the Contractor.
      e. All expenses of sterilization of the pump and laboratory analyses for coliform organisms shall be borne by the Contractor.
   3. Water discharged by the pump following disinfection shall be dechlorinated to a level of 0.02 or less milligrams per liter chlorine before it is allowed to leave the site.

3.02 INSTALLATION

A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

3.03 COMMISSIONING

A. As specified in Section 01 91 00 - Commissioning.

B. Source Testing (Factory Acceptance Tests):
   1. Not witnessed.
   2. Furnish test reports and Manufacturer's Certificate of Source Testing.
   3. Equipment testing:
      a. Pump:
         1) Performance test: Test level as scheduled; test as specified in Section 46_05_94 - Mechanical Equipment Testing.
         2) Vibration test: Test level as scheduled; test as specified in Section 46_05_94 - Mechanical Equipment Testing.
         3) Noise test: Test level as scheduled; test as specified in Section 46_05_94 - Mechanical Equipment Testing.
         4) Pump casing: Hydrostatic pressure tests if specified in this Section.

C. Installation Verification:
   1. Furnish Manufacturer's Certificate of Installation Verification.

D. Functional Testing:
   1. Equipment testing:
      a. Pump:
         1) Performance test: Test level as scheduled; test as specified in Section 46_05_94 - Mechanical Equipment Testing.
         2) Vibration test: Test level as scheduled; test as specified in Section 46_05_94 - Mechanical Equipment Testing.
         3) Noise test: Test level as scheduled; test as specified in Section 46_05_94 - Mechanical Equipment Testing.

E. Owner Training:
   1. Perform Owner Training as specified in Section 01 91 00 - Commissioning.
   2. Number of sessions:
      a. Operations 1.
      b. Maintenance 1.

3.04 PUMP SCHEDULE

Tag Numbers	PMP-9905010
Application	Treated and Raw Groundwater
Well No.	Beltz 8
Quantity	1
Nominal Diameter, Inches	6
Estimated Static Water Level, Feet	See Dwg 00G05

Tag Numbers	PMP-9905010
Estimated Pumping Water Level, Feet	See Dwg 00G05
Column Pipe, Air Line and Pressure Transducer Setting, Feet	See Dwg 00G05
Maximum Pumped Fluid, Degrees Fahrenheit	90
Rotordynamic Analysis Level	None
Vibration Analysis Expert	Not Required
Number of Stages	Per Manufacturer
Column Pipe Internal Diameter, Inches	6
Speed Control	Variable Frequency Drive
Maximum Pump Speed, rpm	3,600
Minimum Pump Speed (for VFD applications), rpm	1,200
Design Condition 1 – Extraction (Long-Term)	
Flow, gpm	565
Head, Feet	129
Minimum Efficiency, Percent	60
Design Condition 2 – Extraction (Short-Term)	
Flow, gpm	730
Head, Feet	135
Minimum Efficiency, Percent	70
Design Condition 3 – Well Backflush	
Flow, gpm	750
Head, Feet	140
Minimum Efficiency, Percent	70
Minimum Shut Off Head, Feet	260
Maximum NPSHr at Every Specified Flow, Feet	40
Driver Horsepower, Maximum	50
Motor Voltage/Phase/Hertz	460/3/60
Motor Shroud/Cooling Sleeve Required	Yes
Service Factor	1.15
Motor Control	Variable Frequency Drive
Performance Test Level	3
Vibration Test Level	Not Required
Noise Test Level	Not Required

END OF SECTION

SECTION 46_05_10

COMMON WORK RESULTS FOR MECHANICAL EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Mechanical equipment requirements for:
      a. Basic design and performance criteria.
      b. Prescriptive requirements for common components.
      c. Installation requirements.

1.02 REFERENCES

A. American Bearing Manufacturers Association (ABMA):
   1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
   2. 11 - Load Ratings and Fatigue Life for Roller Bearings.

B. American Gear Manufacturers Association (AGMA) Standards.

C. American Petroleum Institute (API):
   1. 682 - Pumps—Shaft Sealing Systems for Centrifugal and Rotary Pumps.

D. ASTM International (ASTM):
   1. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   2. A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   3. A320 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
   4. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
   5. F594 - Standard Specification for Stainless Steel Nuts.

E. Hydraulic Institute (HI):
   1. 9.6.8 - Guideline for Dynamics of Pumping Machinery.

F. International Concrete Repair Institute (ICRI):
   1. Guideline No. 310.2R, Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.

G. International Organization for Standardization (ISO):
   1. 21940 - Mechanical Vibration - Rotor Balancing - Part 1: Introduction.

H. National Electrical Manufacturers Association (NEMA):
   1. MG-1 - Motors and Generators.

I. Society for Protective Coatings (SSPC):
    1. SP-1-Solvent Cleaning.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning:
    1. Definitions used in this specification and equipment Submittals for terms related to rotor-dynamic pumps shall be in accordance with HI 9.6.8, Appendix A, as clarified below.
    2. These definitions shall be applied to equipment other than pumps, unless otherwise specified in technical sections.
    3. Resonant frequency:
        a. Frequency of a periodic excitation force that is close to the natural frequencies of an object. Also known as critical frequency, critical speed, or resonant speed.
        b. An undamped resonant frequency within the separation margin is always considered harmful under Level 1 analysis.
        c. A resonant frequency that occurs within a separation margin of 15 percent above or below the operating speed range and has a log decrement greater than +0.3 is considered harmful under Level 2 and Level 3 analysis.
    4. Rotordynamic analysis level:
        a. Level of detail required for rotordynamic analysis is indicated in the technical section schedules as None (no analysis required), Analysis Level 1, Analysis Level 2, or Analysis Level 3, which correlate to increasing levels of required detailed equipment design analysis. Analysis Levels 1, 2, and 3 are based on HI 9.6.8.
        b. Where these specifications differ from HI the more stringent shall apply.
    5. Separation margin:
        a. Span of operating speeds within which interference between excitation orders and resonant frequencies indicate the possibility of harmful vibrations.
        b. Separation margin for a specific application extends 15 percent above and 15 percent below the span of operating speed required for the specified performance conditions.

1.04 ADMINISTRATIVE REQUIREMENTS

A. Roof coordination:
    1. Show roof penetrations for mechanical equipment on roof drawing Submittal and include mechanical equipment information:
        a. Type.
        b. Size.
        c. Location.
        d. Configuration of penetration and the surround.
        e. Weight.
        f. Anchoring and support details.

1.05 SUBMITTALS

A. Items in this Section are components of equipment or systems specified in other Sections:
   1. Include data for this Section's components with the equipment or system Submittal.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. General:
   1. Equipment manufacturer's responsibility extends to selection and mounting of gear drive units, motors or other prime movers, accessories, and auxiliaries to provide a complete, operable unit.
   2. Manufacturer shall analyze rubber-bearing vertical-column pumps and equipment identified as non-reversing in the technical sections for reverse rotation and provide non reversing motor ratchets.
   3. Equipment that prevents reverse rotation shall be capable of both:
      a. Handling 150 percent of the maximum torque at maximum operating speed.
      b. 150 percent of torque that will be generated in reverse direction due to equipment shutoff head as calculated by the manufacturer.
   4. Motor shall be designed to run safely in the reverse direction at up to 140 percent times the reverse runaway speed under shutoff head conditions.

B. Rotordynamic analysis and vibration testing:
   1. Submit information for the rotordynamic analysis level specified for each piece of equipment as shown in the technical sections prior to manufacture of the equipment.
   2. Rotordynamic analysis shall be performed on "like-new" and "as-worn" conditions, representing conditions when first installed and conditions when parts wear to the manufacturer's maximum allowable operating tolerances:
      a. Conditions assumed for the "as-worn" condition shall be 2 times the "like-new" tolerances unless specified otherwise.
   3. Rotordynamic analysis criteria:
      a. Torsional excitation forcing function magnitudes shall be no less than 1 percent of the maximum transmitted torque at given speed.
      b. Motor mass elastic information in accordance with NEMA MG-1 shall be obtained from the original equipment manufacturer and included in the analysis. Motors shall be precision balanced to ISO 21940 Grade G2.5.
      c. Bearings:
         1) At maximum bearing loads an L-10 life of 100,000 hours in accordance with ABMA 9-11 to be proven.
   4. Submit factory and field testing requirements as specified in the technical sections and specified in Section 46_05_94 - Mechanical Equipment Testing after manufacture and installation respectively.

5. Repair, replace, and modify equipment exhibiting vibration performance that does not meet criteria specified in this Section at no additional cost to the Owner:
    a. Acceptable remedies include adjustments to equipment component geometry, materials, energy absorbing couplings, etc.
    b. Locking out speed interval(s) within equipment specified operating range is unacceptable.
6. Vibration analysis expert:
    a. Provide when specified in the equipment technical sections:
        1) Must be a 3rd party, unaffiliated with the equipment vendor or Contractor.
    b. Analysis shall be provided by one of the following or equal:
        1) Engineering Dynamics Inc. (EDI, Texas).
        2) Mechanical Solutions, Inc. (MSI, New Jersey).
    c. Analysis shall be:
        1) Stamped by a registered professional mechanical engineer.
        2) Verified in-situ by the vibration analysis expert, including certification that installation conforms to field conditions assumed in the reports.
        3) Verified in-situ by the vibration analysis expert, including witness of at least 1 field vibration test, and certification that vibration measurements corroborate the rotordynamic analysis.
        4) Supplemented with additional field investigation and analysis should conditions during field vibration testing activity indicate non-compliance with these specifications; supplemental field investigation and analysis shall indicate remedies to comply with the specifications and shall be stamped by a registered professional mechanical engineer.
7. Rotordynamic Analysis Level 1:
    a. Before the equipment is released for manufacture it shall be determined that the equipment/motor structures do not have any harmful resonant frequencies in the lateral and torsional modes. Representative analysis results for identical equipment may be submitted.
    b. Calculate rotor lateral and torsional and equipment structural components' lateral frequencies with a spreadsheet calculation or finite element analysis software:
        1) Equipment structure lateral frequency shall include the motor.
        2) Speed changing drive systems (belt, gear) effects on rotational inertia and stiffness shall be incorporated.
    c. Determine the equipment system components (rotor and structure) resonant frequencies.
    d. An intersection of an equipment component resonant frequency with the 1x run speed excitation order that occurs within separation margin is unacceptable.

2.02 BEARINGS

A. Oil or grease lubricated, ball or roller antifriction type, of standard manufacture.
   1. Design lubrication system based on the equipment location to operate in the temperatures as specified in technical sections and as indicated on the Drawings.

B. Ratings: In accordance with ABMA 9 or ABMA 11 L10 life for bearings rating life of not less than 50,000 hours.

2.03 FLANGED PIPING CONNECTIONS

A. Unless specified otherwise in the technical sections or indicated on the Drawings, provide flat face flanges.

2.04 ASSEMBLY FASTENERS

A. General service: Stainless steel, Type 316:
   1. Bolts: In accordance with ASTM F593, Alloy Group 2.
   2. Nuts: In accordance with ASTM F594, Alloy Group 2.
   3. Washers: Alloy group matching bolts and nuts.

2.05 SHOP FINISHES

A. Manufacturer's standard primer and finish coatings:
   1. Primer only if field coatings are to be applied.

2.06 MOUNTING AND LIFTING PROVISIONS FOR EQUIPMENT

A. Equipment bases and base plates:
   1. Provide equipment bases with machined support pads, dowels for alignment for mating of adjacent items, openings for electrical conduits, and openings to facilitate grouting.
   2. Provide jacking screws in bases and supports for equipment and for equipment weighing 500 pounds or more.
   3. Materials:
      a. Match equipment material or steel.
      b. Coating: Match equipment.

B. Steel support frames:
   1. Carbon steel:
      a. At exterior locations and at interior wet or moist locations, provide continuous welds on both sides to close seams and edges between steel members.
      b. Grind closure welds smooth.

C. Lifting lugs or eyes:
   1. Equipment units weighing 50 pounds or more:
      a. Provide with lifting lugs or eyes to allow removal with lifting device.

2.07 NAMEPLATES

A. Fastened to equipment at factory in an accessible and visible location.

B. Metal engraved or stamped with text, holes drilled or punched for fasteners.

C. Material: Aluminum or stainless steel.

D. Fasteners: Number 4 or larger oval head stainless steel screws or drive pins.

E. Text:
   1. Manufacturer's name, equipment model number, equipment serial number, and identification tag number.
   2. Additional items indicated in the technical sections.
   3. Indicate the following additional information as applicable:
      a. Maximum and normal rotating speed.
      b. Service class in accordance with applicable standards.
   4. Include for pumps:
      a. Rated total dynamic head in feet of fluid.
      b. Rated flow in gallons per minute.
      c. Impeller, gear, screw, diaphragm, or piston size.
   5. Include for motors:
      a. Drive speed.
      b. Motor horsepower with rated capacity.
   6. Include for gear reduction units:
      a. AGMA class of service.
      b. Service factor.
      c. Input and output speeds.

2.08 SHIPPING

A. Prior to shipment of equipment:
   1. Bearings (and similar items):
      a. Pack separately or provide other protection during transport.
      b. Greased and lubricated.
   2. Gear boxes:
      a. Oil filled or sprayed with rust preventive protective coating.
   3. Fasteners:
      a. Inspect for proper torques and tightness.

PART 3 EXECUTION

3.01 PRE-INSTALLATION

A. Field measurements:
   1. Prior to Shop Drawings preparation, take field measurements and verify dimensions indicated on the Drawings.
   2. Ensure equipment and ancillary appurtenances fit within available space.

B. Sequencing and scheduling:
   1. Coordinate details of equipment with other related parts of the Work, including verification that structures, piping, wiring, and equipment components are compatible.
   2. Equipment anchoring: Obtain anchoring material and setting drawings from equipment manufacturers in adequate time for templates to be constructed and anchors to be cast-in-place.

3.02 LUBRICATION LINES AND FITTINGS

A. Support and protect lines from source to point of use.

B. Fittings:
   1. Bring fittings to outside of equipment in manner such that they are readily accessible from outside without necessity of removing covers, plates, housings, or guards.
   2. Mount fittings together wherever possible using factory-mounted multiple fitting assemblies securely mounted, parallel with equipment lines, and protected from damage.
   3. For underwater bearings: Bring fittings above water surface and mount on edge of structure above.

3.03 ALIGNMENT OF DRIVERS AND EQUIPMENT (NOT USED)

3.04 EQUIPMENT SUPPORT AND ANCHORING TO STRUCTURES

A. Anchor equipment to structures as indicated on the Drawings and as specified.

B. Obtain final anchor bolt layouts for equipment prior to:
   1. Detailing reinforcement for equipment pads.
   2. Preparation of Shop Drawings for metal structures supporting equipment.

C. Anchor bolt templates:
   1. Provide templates as specified in the technical sections.
   2. Use final anchor bolt layout to construct templates for setting anchor bolts.
   3. Make templates:
      a. Rigid, and non-deformable during use.
      b. With longitudinal axes of anchors parallel.
      c. With longitudinal axes of anchors perpendicular to surface supporting the equipment.
   4. Templates may be reused for multiple locations of the same equipment only if:
      a. Templates are in “like-new” condition prior to each reuse.
      b. Anchor layout has not been deformed or damaged by previous installation, removal, or handling of templates.
   5. Sequence:
      a. Set and support templates prior construction of structures surrounding anchors.

b. Position anchors in templates to provide designated embedment in supporting structure, with required projection for installation of grout, base plates, and hardware for tightening.
c. Construct concrete or masonry around anchors using methods that preserve required anchor positions and alignment, and clearances to edges of supports or structures.

D. Anchor adjustment sleeves:
1. Use of adjustment sleeves around anchors:
a. Is at the option of the Contractor.
b. Does not relieve the Contractor of obligation to construct and use templates for setting of anchors.
c. May required increased anchor embedment length to develop the strength of the anchor in the embedded length below the adjustment sleeve.
2. Submittal requirements for anchor adjustment sleeves:
a. Provide within sufficient time for Engineer approval and not less than 10 working days before setting those items.
b. Proposed locations of sleeves.
c. Details and dimensions of sleeves.
d. Sleeve materials of construction, and coatings.
e. Information on sleeve filler material and means of filler removal.
f. Type, details, and dimensions of anchor bolts or anchor rods to be used with sleeves.
g. Calculations showing development of anchor load capacity below the bottom of the sleeve.
h. Plan for removal of sleeve fillers, if any.
i. Plan for placement and consolidation of flowable grout inside sleeves and to a level equal to top of concrete slab or equipment pad surrounding the sleeve.

3.05 GROUTING UNDER EQUIPMENT BASES, BASE PLATES, SOLE PLATES, AND SKIDS

A. General:
1. Comply with the equipment manufacturer’s installation instructions, including:
a. Tolerances for level.
b. Tolerances for vertical and horizontal alignment.
c. Requirements or recommendations for grouting spaces and grout installation.
d. Recommendations for tightening of equipment anchors after grout has cured.
2. Install equipment over grout as indicated on the Drawings or specified only after:
a. Equipment is leveled and in proper alignment.
b. Piping connections are complete and in alignment with no strain transmitted to equipment.
3. Install flowable grout, as specified in Section 03_60_00 - Grouting, placed with forms and head boxes:
a. Use flowable, non-shrink grout.

b. Use flowable, non-shrink epoxy grout, only where indicated on the Drawings, where specified in Technical Sections, or when approved in advance by the Engineer.
c. Grouting with dry-pack materials is not permitted.

B. Prepare equipment bases, base plates, soleplates, and skids for grouting:
1. Concrete equipment bases:
a. Roughen surface in accordance with ICRI, Guideline No. 310.2R, Surface Preparation Profiles CSP-3 and CSP-4.
b. Clean roughened concrete surfaces.
2. Base plates, soleplates, and skids:
a. Clean surfaces in accordance with SSPC-SP-1-Solvent Cleaning, to remove dirt, dust, oil, grease, paint, and other material.

C. Level equipment for grouting:
1. Use removable jack screws, or removable steel wedges and shims to support and level equipment bases, base plates, sole plates, and skids:
a. Do not use leveling nuts placed on equipment anchors to support or level equipment bases, base plates, sole plates, and skids.
2. Removable jack screws:
a. Provide number, size, and locations of jack screws required to support and level equipment in accordance with the manufacturer's recommendations.
b. Drill and tap equipment base plates, sole plates, and skids for jack screws.
c. Support jack screws on circular steel plates that have been epoxy bonded to the equipment foundation:
1) Provide plates fabricated from Type 316 stainless steel where edges of support plates will have grout side cover of 3 inches or less in the finished Work.
d. Make provision for removal of jack screws after grouting:
1) Prevent grout from bonding to jack screws by wrapping jack screw threads that will be in contact with grout with multiple layers of tape or other material acceptable to the Engineer.
e. Place and cure grout.
f. After grout is placed and cured:
1) Remove jack screws and material used to prevent grout from bonding to jack screws.
2) Provide jack screws to the Owner for future use.
3) Fill jack screw holes with grout.
4) Cure grout as specified.
3. Removable steel wedges and shims:
a. Use for equipment bases, base plates, sole plates, and skids where it is not practical to use jack screws.
b. Provide number, size, and locations of wedges and shims required to support and level equipment in accordance with the manufacturer's recommendations.
c. Make provision for removal of wedges and shims after grouting:
1) Prevent grout from bonding to wedges and shims by wrapping wedges and shims that contact grout with multiple layers of tape or other material acceptable to the Engineer.
2) Locate and orient wedges and shims to allow for removal after grouting, and to facilitate placement of grout in the remaining voids.

d. Place and cure grout.
e. After grout is placed and cured:
    1) Remove wedges and shims, and material used to prevent grout from bonding to them.
    2) Fill jack screw holes with grout.
    3) Cure grout as specified.

D. Construct grout forms:
1. Provide forms:
    a. Rigid with adequate strength to withstand placement of grout.
    b. With surfaces that will produce a smooth, uniform finish for grout edges exposed in the finished Work.
    c. That allow grout to flow horizontally beyond the perimeter of the equipment base plate a distance not less than the thickness of the grout, and not less than 1 inch.
2. Install forms:
    a. Seal form cracks and joints with elastomeric sealant to make form watertight.
    b. Line form surfaces in contact with grout with polyethylene film, or coat with 2 coats of heavy-duty paste wax.
3. Construct grout “head box” over entire length of one side of form:
    a. Make head box height sufficient to force grout to flow under full dimensions of equipment base and to the surrounding form faces.

E. Pre-grouting procedures:
1. Concrete surfaces receiving flowable, non-shrink grout:
    a. Saturate concrete surface in contact with grout and concrete surfaces extending not less than at least 6 inches beyond limits of grout with clean water for a minimum of 24 hours prior to grouting.
    b. Just prior to grout placement, remove standing water using clean rags or oil-free compressed air. Provide saturated surface dry (SSD) concrete for grout placement.
2. Concrete surfaces receiving flowable, non-shrink epoxy grout:
    a. Do not saturate concrete prior to grout placement.

F. Grout placement and curing:
1. Place and cure grout as specified in Section 03_60_00 - Grouting and in this Section.
2. Grouting:
    a. Keep level of grout in head box above bottom of equipment bases, base plates, sole plates, and skids always to drive flow under base.
    b. Maintain continuous grout flow from head box to opposite sides of forms without trapping air or forming voids.
    c. Vibrate, rod, or chain grout to facilitate grout flow, to consolidate grout, and to remove entrapped air.
3. After grout sets, remove forms and trim grout edges at 45-degree angle from bottom edge of equipment bases, base plates, sole plates, and skids.
4. Cure grout as specified in Section 03_60_00 - Grouting.

G. After grout is cured:
   1. Remove jack screws or wedges and shims, and material used to prevent grout from bonding to leveling devices.
   2. Fill pockets from removed leveling devices with grout.
   3. Cure filled voids as specified in Section 03_60_00 - Grouting.
   4. Tighten equipment anchors in accordance with the equipment manufacturer's requirements.

3.06 FIELD FINISHES

A. When touchup or repair is required, apply primer and coating systems as recommended by the equipment manufacturer.

END OF SECTION

SECTION 46_05_94

MECHANICAL EQUIPMENT TESTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Testing of mechanical equipment and systems.

1.02 REFERENCES

A. American Gear Manufacturers Association:
   1. AGMA 6000-B96 - Specification for Measurement of Linear Vibration on Gear Units.

B. American National Standards Institute (ANSI):
   1. S1.4 - Specification for Sound Level Meters.

C. Hydraulic Institute (HI).

D. National Institute of Standards and Technology (NIST).

1.03 SUBMITTALS

A. Provide Source Test Plans as specified in Section 01 79 00 - Demonstration and Training.

B. Provide Installation and Functional Testing Plans as specified in Section 01 79 00 - Demonstration and Training.

C. Operation and maintenance manuals:
   1. As specified in Section 01 78 23 - Operation and Maintenance Data.
   2. Include motor rotor bar pass frequencies for motors larger than 500 horsepower.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Commissioning of equipment as specified in:
   1. This Section.
   2. Section 01 79 00 - Demonstration and Training.
   3. Equipment sections:
      a. If testing requirements are not specified, provide Level 1 tests.

B. Test and prepare piping as specified in Section 40_05_00.09 - Piping Systems Testing prior to equipment testing.

C. Operation of related existing equipment:
   1. Owner will operate related existing equipment or facilities necessary to accomplish the testing.
   2. Schedule and coordinate testing as specified in Section 01 79 00 - Demonstration and Training.

D. Provide necessary test instrumentation that has been calibrated within 1 year from date of test to recognized test standards traceable to the NIST or approved source.
   1. Properly calibrated field instrumentation permanently installed as a part of the Work may be utilized for tests.
   2. Prior to testing, provide signed and dated certificates of calibration for test instrumentation and equipment.

E. Test measurement and result accuracy:
   1. Use test instruments with accuracies as recommended in the appropriate referenced standards. When no accuracy is recommended in the referenced standard, use 1 percent or better accuracy test instruments.
      a. Improved (lower error tolerance) accuracies specified elsewhere prevail over this general requirement.
   2. Do not adjust results of tests for instrumentation accuracy.
      a. Measured values and values directly calculated from measured values shall be the basis for comparing actual equipment performance to specified requirements.

3.02 SUBMERSIBLE WELL PUMP TESTING REQUIREMENTS

A. In addition to requirements listed in individual technical sections, Contractor shall test the existing well pump following completion of the Work.

B. The existing well pump shall be tested prior to demolition in accordance with the Level 1 Performance Test described in this Section at the Target Extraction Rate as indicated on the Drawings.

C. The existing well pump shall be tested prior following Step 2: Temporary Shutdown (see Drawing 00G05) in accordance with the Level 1 Performance Test described in this Section at the Target Extraction Rate as indicated on the Drawings.

D. The existing well pump shall be tested under each operating mode described under Section 40_61_16.08 - Specific Control Strategies - Well 8 except for Well 8 - Off (All Stop) Mode.

E. The existing well pump shall be tested following completed of the Work in accordance with the Level 3 Performance Test described in this Section at the design flows indicated on the Drawings.

F. Submit existing well pump test plan to Engineer for review a minimum of 20 working days prior to schedule testing.

3.03 VARIABLE SPEED EQUIPMENT TESTS

A. Use the existing variable frequency drive to complete well pump tests as specified.

B. Establish performance over the entire speed range and at the average operating condition.

C. Establish performance curves for the following speeds:
   1. Speed corresponding to the rated maximum capacity.
   2. Speed corresponding to the minimum capacity.
   3. Speed corresponding to the average operating conditions.

3.04 PUMP TESTS - ALL LEVELS OF TESTING

A. Test in accordance with the following:
   1. Applicable HI standards.
   2. This Section.
   3. Equipment sections.

B. Test tolerances: In accordance with appropriate HI standards, except the following modified tolerances apply:
   1. From 0 to plus 5 percent of head at the rated design point flow.
   2. From 0 to plus 5 percent of flow at the rated design point head.
   3. No tolerance for head and flow when ranges are specified.
   4. No negative tolerance for the efficiency at the rated design point, and other specified conditions.
   5. Use of specified test tolerances shall not result in motor overload while operating at any point on the supplied pump operating head-flow curve, including runout.
   6. No positive tolerance for vibration limits. Vibration limits and test methods in HI standards do not apply. Use limits and methods specified in this or other sections of the Specifications.

3.05 DRIVERS TESTS

A. Test motors as specified in Section 26_05_09 - Low Voltage Motors up to 500 Horsepower.

B. Test other drivers as specified in the equipment section.

3.06 NOISE REQUIREMENTS AND CONTROL

A. Perform noise tests in conjunction with vibration test analysis.

B. Make measurements in relation to reference pressure of 0.0002 microbar.

C. Make measurements of emitted noise levels on sound level meter meeting or exceeding ANSI S1.4, Type II.

D. Set sound level meter to slow response.

E. Unless otherwise specified, maximum free field noise level not to exceed 85 dBA measured as sound pressure level at 3 feet from the equipment.

3.07 PRESSURE TESTING

A. Hydrostatically pressure test pressure containing parts at the appropriate standard or code required level above the equipment component specified design pressure or operating pressure, whichever is higher.

3.08 INSPECTION AND BALANCING

A. Statically and dynamically balance each of the individual rotating parts as required to achieve the required field vibration limits.

B. Statically and dynamically balance the completed equipment rotating assembly and drive shaft components.

C. Furnish copies of material and component inspection reports, including balancing reports for equipment system components and for the completed rotating assembly.

D. Critical speed of rotating equipment:
   1. Satisfy the following:
      a. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered rigid such as horizontal pumps, non-clog pumps, blowers, air compressors, and engines shall be at least 25 percent above the equipment's maximum operating speed.
      b. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered flexible or flexibly mounted such as vertical pumps (vertical in-line and vertical non-clog pumps excluded) and fans shall at least 25 percent below the equipment's lowest operating speed.
      c. The second lateral and torsional critical speed of all constant, variable, and 2-speed equipment that is considered flexible or flexibly mounted shall be at least 25 percent above the maximum operating speed.

E. Vibration tests:
   1. Definitions:
      a. Root mean square: For pumps operating at speeds greater than 600 revolutions per minute (rpm), the vibration measurement shall be measured as the overall velocity in inches per second root mean square (RMS).
      b. Peak-to-peak displacement: The root means squared average of the peak-to-peak displacement multiplied by the square root of 2.
      c. Peak velocity: The root mean squared average of the peak velocity multiplied by the square root of 2.
      d. Peak acceleration: The root mean squared average of the peak acceleration multiplied by the square root of 2.
      e. High-frequency enveloping: A process to extract very low amplitude time domain signals associated with impact or impulse events such as bearing

or gear tooth defects and display them in a frequency spectrum of acceleration versus frequency.
1) Manufacturers: One of the following or equal:
a) CSI, PeakVue.
b) Rockwell Automation, Entek Group, Spike Energy analysis.

f. Rotor bar pass frequency (RBF): For detecting loose rotor bars.
g. Low speed equipment: Equipment or components of equipment rotating at less than 600 rpm.
h. High speed equipment: Equipment and equipment components operating at or above 600 rpm.
i. Preferred operating range: Manufacturer's defined preferred operating range (POR) for the equipment.
j. Allowable operating range: Manufacturer's defined allowable operating range (AOR) for the equipment.

2. Vibration instrumentation requirements:
a. Analyzers: Use digital type analyzers or data collectors with anti-aliasing filter, 12-bit A/D converter, fast Fourier transform circuitry, phase measurement capability, time wave form data storage, high-frequency enveloping capabilities, 35 frequency ranges from 21 to 1,500,000 cycles per minute, adjustable fast Fourier transform resolution from 400 to 6,400 lines, storage for up to one hundred 3,200 line frequency spectra, data output port, circuitry for integration of acceleration data to velocity or double integration to displacement.
1) Manufacturers: One of the following or equal:
a) Computational Systems Inc., (CSI) Division of Emerson Process Management, Model 2120A, Data Collector/analyzer with applicable analysis software.
b) Pruftechnik, VIBXPERT II.

b. Analyzer settings:
1) Units: English, inches/second, mils, and gravitational forces.
2) Fast Fourier transform lines: Most equipment 1,600 minimum; for motors, enough lines as required to distinguish motor current frequencies from rotational frequencies, use 3,200 lines for motors with a nominal speed of 3,600 rpm; 3,200 lines minimum for high-frequency enveloping; 1,600 lines minimum for low speed equipment.
3) Sample averages: 4 minimum.
4) Maximum frequency (Fmax): 40 times rotational frequency for rolling element bearings, 10 times rotational frequency for sleeve bearings.
5) Amplitude range: Auto select but full scale not more than twice the acceptance criteria or the highest peak, whichever is lower.
6) Fast Fourier transform windowing: Hanning window.
7) High pass filter: Minus 3 dB at 120 cycles per minute for high speed equipment. Minus 3 dB at 21 cycles per minute for low speed equipment.

c. Accelerometers:
1) For low speed equipment: Low frequency, shear mode accelerometer, 500 millivolts per gravitational force sensitivity, 10 gravitational force

range, plus/minus 5 percent frequency response from 0.5 hertz to 850 hertz, magnetic mount.
a) Manufacturers: One of the following or equal:
(1) PCB, Model 393C.
(2) Wilcoxon Research, Model 797L.
2) For high speed equipment: General purpose accelerometer, 100 millivolts per gravitational force sensitivity, 50 gravitational force range, plus/minus 3 dB frequency response range from 2 hertz to 12,000 hertz when stud mounted, with magnetic mount holder.
a) Manufacturers: One of the following or equal:
(1) Entek-IRD, Model 943.
(2) Wilcoxon Research, Model 793.

3. Accelerometer mounting:
   a. Use magnetic mounting or stud mounting.
   b. Mount on bearing housing in location with best available direct path to bearing and shaft vibration.
   c. Remove paint and mount transducer on flat metal surface or epoxy mount for high-frequency enveloping measurements.
4. Vibration acceptance criteria:
   a. Testing of rotating mechanical equipment: Tests are to be performed by an experienced, factory trained, and independent authorized vibration analysis expert.
   b. Vibration displacement limits: Unless otherwise specified, equipment operating at speeds 600 rpm or less is not to exhibit unfiltered readings in excess of the following:

Operating Conditions and Application Data	Overall Peak-to-Peak Displacement	
	Field (mils)	Factory (mils)
Operation within the POR	3.0	4.0
Operation within the AOR	4.0	5.0
Additive value when measurement location is greater than 5 feet above foundation.	2.0	2.0

   c. Equipment operation: Measurements are to be obtained with equipment installed and operating within capacity ranges specified and without duplicate equipment running.
   d. Additional criteria:
      1) No narrow band spectral vibration amplitude components, whether sub-rotational, higher harmonic, or synchronous multiple of running speed, are to exceed 40 percent of synchronous vibration amplitude component without the manufacturer's detailed verification of origin and ultimate effect of such excitation.
      2) The presence of discernable vibration amplitude peaks in test Level 2 or 3 vibration spectra at bearing inner or outer race frequencies shall be cause for rejection of the equipment.
      3) For motors, the following shall be cause for rejection:
         a) Stator eccentricity evidenced by a spectral peak at 2 times electrical line frequency that is more than 40 percent of the peak at rotational frequency.

b) Rotor eccentricity evidenced by a spectral peak at 2 times electrical line frequency with spectra side bands at the pole pass frequency around the 2 times line frequency peak.
c) Other rotor problems evidenced by pole pass frequency side bands around operating speed harmonic peaks or 2 times line frequency side bands around rotor bar pass frequency or around 2 times the rotor bar pass frequency.
d) Phasing problems evidenced by 1/3 line frequency side band spectral peaks around the 2 times electrical line frequency peak.

4) The presence of peaks in a high-frequency enveloping spectra plot corresponding to bearing, gear or motor rotor bar frequencies or harmonics of these frequencies shall be cause for rejection of the equipment; since inadequate lubrication of some equipment may be a cause of these peaks, lubrication shall be checked, corrected as necessary and the high-frequency envelope analysis repeated.

5. Vibration testing results presentation:
   a. Provide equipment drawing with location and orientation of measurement points indicated.
   b. For each vibration measurement take and include appropriate data on equipment operating conditions at the time vibration data is taken; for pumps, compressors, and blowers record suction pressure, discharge pressure, and flow.
   c. When vibration spectra data required:
      1) Plot peak vibration velocity versus frequency in cycles per minute.
      2) Label plots showing actual shaft or part rotation frequency, bearing inner and outer race ball pass frequencies, gear mesh frequencies and relevant equipment excitation frequencies on the plot; label probable cause of vibration peaks whether in excess of specification limits or not.
      3) Label plots with equipment identification and operating conditions such as tag number, capacity, pressure, driver horsepower, and point of vibration measurement.
      4) Plot motor spectra on a log amplitude scale versus frequency.
   d. For low speed equipment, plot peak vibration displacement versus frequency as well as velocity versus frequency.
   e. Provide name of the manufacturer and model number of the vibration instrumentation used, including analyzer and accelerometer used together with mounting type.

3.09 TESTING LEVELS

A. Level 1 tests:
   1. Level 1 Performance Test:
      a. General:
         1) For equipment, operate, rotate, or otherwise functionally test for 15 minutes minimum after components reach normal operating temperatures.
         2) Operate at rated design load conditions.
         3) Confirm that equipment is properly assembled.
         4) Confirm the equipment moves or rotates in the proper direction.

5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.

b. Pumps:
1) In accordance with general performance test requirements as specified in this Section.
2) Measure flow and head while operating at or near the rated condition; for factory testing, testing may be at reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
a) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 26_05_09 - Low Voltage Motors up to 500 Horsepower, or the applicable equipment section.
b) Use actual driver for field tests.
3) Record measured flow, suction pressure, discharge pressure, and make observations on bearing temperatures and noise levels.

2. Level 1 Vibration Test:
a. Test requirement:
1) Measure filtered vibration spectra versus frequency in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component.
2) Vibration spectra versus frequency shall be in accordance with vibration acceptance criteria.
b. Equipment operating condition: Test at specified maximum speed.

3. Level 1 Noise Test:
a. Measure unfiltered overall A-weighted sound pressure level in dBA at 3 feet horizontally from the surface of the equipment and at a mid-point of the equipment height.

B. Level 2 tests:
1. Level 2 Performance Test:
a. General:
1) For equipment, operate, rotate, or otherwise functionally test for at least 2 hours after components reach normal operating temperatures.
2) Operate at rated design load conditions.
3) Confirm that equipment is properly assembled.
4) Confirm the equipment moves or rotates in the proper direction.
5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.

b. Pumps:
1) In accordance with general performance test requirements as specified in this Section.
2) Test 2 hours minimum for flow and head at the rated condition; for factory testing, testing may be at a reduced speeds with flow and

head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
a) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 26_05_09 - Low Voltage Motors up to 500 Horsepower.
b) Use actual driver for field tests.
3) Test for flow and head at 2 additional conditions; one at 25 percent below the rated flow and one at 10 percent above the rated flow.
4) Record measured flow, suction pressure, discharge pressure, and observations on bearing temperatures and noise levels at each condition.

2. Level 2 Vibration Test:
a. Test requirement:
1) Measure filtered vibration spectra versus frequency and measure vibration phase in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component; measure actual rotational speeds for each vibration spectra measured using photometric or other tachometer input connected directly to the vibration data collector.
2) Vibration spectra versus frequency shall be in accordance with vibration acceptance criteria.
b. Equipment operating condition: Repeat test requirements at design specified maximum speed and at minimum speed for variable speed equipment.
c. Natural frequency test of field installed equipment:
1) Excite the installed equipment and support system in 3 perpendicular planes, use same planes as operating vibration measurement planes, and determine the as-installed natural resonant frequency of the driven equipment, the driver, gears, and supports.
2) Perform test at each bearing housing, at each support pedestal, and for pumps on the suction and discharge piping.
3) Perform with equipment and attached piping full of intended service or process fluid.

3. Level 2 Noise Test:
a. Measure filtered A-weighted overall sound pressure level in dBA for each of 8 octave band mid-points beginning at 63 hertz, measured at 3 feet horizontally from the surface of the equipment at mid-point height of the noise source.

C. Level 3 tests:
1. Level 3 Performance Tests:
a. General:
1) For equipment, operate, rotate, or otherwise functionally test for at least 4 hours after components reach normal operating temperatures.
2) Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
3) Confirm that equipment is properly assembled.
4) Confirm the equipment moves or rotates in the proper direction.

5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
7) Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure, and temperature readings using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
8) Bearing temperatures: During maximum speed or capacity performance testing, measure and record the exterior surface temperature of each bearing versus time.

b. Pumps:
1) In accordance with general performance test requirements as specified in this Section.
2) Test 4 hours minimum for flow and head; begin tests at or near the rated condition; for factory and field-testing, test at full speed.
3) Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 15 minutes or longer as necessary to measure required performance, vibration, and noise data at each test condition.
4) Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices are not required by the equipment section) and record observations on noise levels.

END OF SECTION

Plot Date: 10-SEP-2025 9:15:40 AM
User: svcPW
DesignScript: Carollo_Std_Pen_v0905.pen
PlotScale: 1:1
ColorTable: gshade.ctb
Model: Layout1

CITY OF SANTA CRUZ

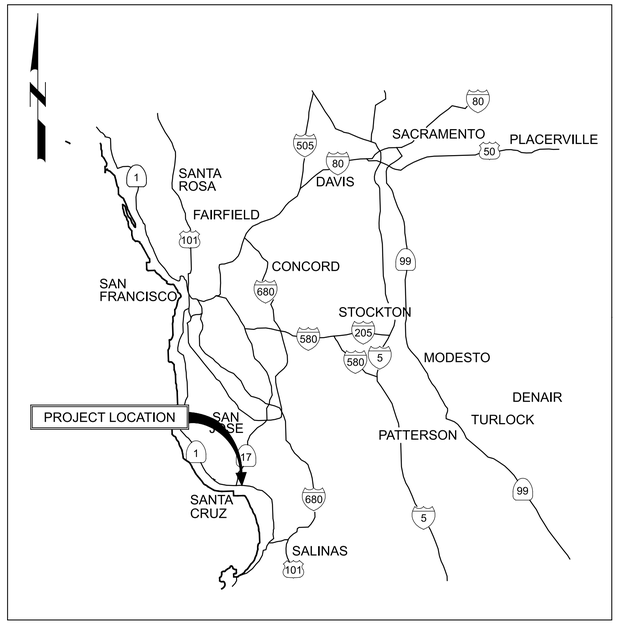
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

SEPTEMBER 2025

VOLUME 3 OF 3

CWO# 2024-005

BID SET



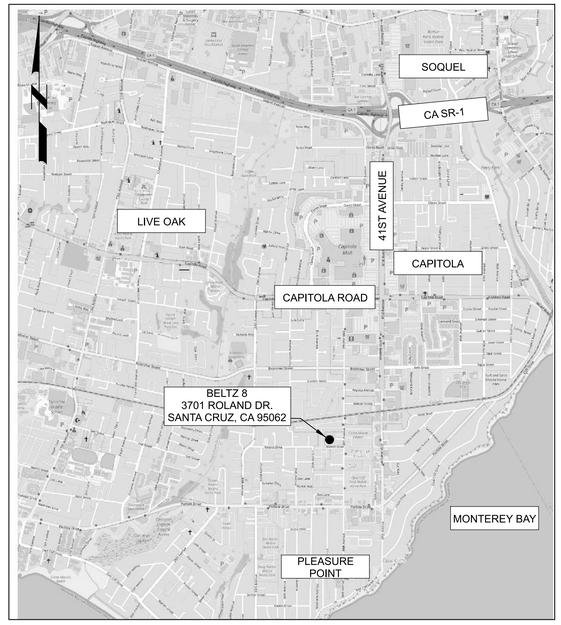
VICINITY MAP

REGISTERED PROFESSIONAL ENGINEER
JUSTIN C. PETERSON
No. 78444
CIVIL
STATE OF CALIFORNIA

Digitally signed by Justin C. Peterson
Contact Info: Carollo Engineers, Inc.
Date: 2025-09-10 09:24:13 07'00"

REGISTERED PROFESSIONAL ENGINEER
MICHAEL E. DUCKER
No. 63626
CIVIL
STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:20:58-07'00'



LOCATION MAP

carollo®

JOB NO. 202431
DRAWING NO. 00G01
SHEET NO. 1 OF 71

SHT NO.	DWG NO.	DESCRIPTION
		(G) - GENERAL
1	00G01	COVER SHEET
2	00G02	DRAWING INDEX
3	00G03	GENERAL NOTES, LEGEND, AND SYMBOLS
4	00G04	ABBREVIATIONS
5	00G05	DESIGN CRITERIA
		(D) - DEMOLITION
6	08D01	WELL 8 DEMOLITION SITE PLAN
7	08D02	WELL 8 DEMOLITION PHOTOS
		(C) - CIVIL
8	00GC01	CIVIL ABBREVIATIONS, LEGEND, AND SYMBOLS
9	00GS01	STRUCTURAL NOTES FOR CIVIL IMPROVEMENTS
10	08C01	WELL 8 SITE PLAN AND SURVEY CONTROL
11	08C02	WELL 8 YARD PIPING PLAN
12	08C03	MISCELLANEOUS CIVIL DETAILS
13	08C04	WELL 8 YARD PIPING PROFILES
		(M) - MECHANICAL
14	00GM01	GENERAL MECHANICAL LEGEND AND SYMBOLS
15	08M01	WELL 8 PERSPECTIVE
16	08M02	WELL 8 PLAN
17	08M03	WELL 8 SECTIONS
18	08M04	WELL 8 DETAILS 1
19	08M05	AIR GAP PIPE SUPPORT PLAN, SECTION, AND DETAIL
		(E) - ELECTRICAL
20	00GE01	LEGEND
21	00GE02	ABBREVIATIONS
22	08E01	WELL 8 POWER & CONTROL PLAN
23	08E02	WELL 8 POWER & CONTROL DETAILS
24	08E03	WELL 8 DUCT BANK SECTIONS
25	08E04	WELL 8 MCC-8 ELEVATION
26	08E05	WELL 8 MCC-8 ONE-LINE DIAGRAM
27	08E06	WELL 8 DEMOLITION MCC-A ELEVATION
28	08E07	WELL 8 MCC-8A ELEVATION
29	08E08	WELL 8 MCC-8A ONE-LINE DIAGRAM
30	08E09	WELL 8 SCHEDULES
31	08E10	WELL 8 CONDUIT SCHEDULES 1
32	08E11	WELL 8 CONDUIT SCHEDULES 2
33	08E12	WELL 8 CONDUIT SCHEDULES 3
		(N) - INSTRUMENTATION
34	00GN01	SYMBOLS AND ABBREVIATIONS 1
35	00GN02	SYMBOLS AND ABBREVIATIONS 2
36	00GN03	SYMBOLS AND ABBREVIATIONS 3
37	00GN04	SYMBOLS AND ABBREVIATIONS 4
38	00GN05	SCHEMATIC SYMBOLS
39	00GN06	SAMPLE LOOP DRAWING
40	03N01	WELL 8 COMMUNICATIONS DIAGRAM
41	05N01	WELL 8 CONTROL PANEL ELEVATION AND BACK PANEL LAYOUT
42	06N01	WELL 8 CONTROL PANEL SCHEMATICS
43	06N03	WELL 8 PUMP CONTROL SCHEMATICS
44	08N03	WELL 8 WELL PUMP P&ID 1
45	08N04	WELL 8 WELL PUMP P&ID 2
46	08N05	WELL 8 WELL PUMP P&ID 3
47	08N06	WELL 8 WELL PUMP P&ID 4
48	08N07	BELTZ WTP BACKWASH TANK P&ID

SHT NO.	DWG NO.	DESCRIPTION
		(T) - TYPICAL DETAILS
49	00TC01	CITY WATER DEPARTMENT STANDARD DETAILS 1
50	00TC02	CITY WATER DEPARTMENT STANDARD DETAILS 2
51	00TC03	CITY OF SANTA CRUZ, CITY OF CAPITOLA, AND COUNTY OF SANTA CRUZ STANDARD DETAILS 1
52	00TC04	CIVIL 1
53	00TE01	ELECTRICAL 1
54	00TE02	ELECTRICAL 2
55	00TE03	ELECTRICAL 3
56	00TE04	ELECTRICAL 4
57	00TE05	ELECTRICAL 5
58	00TE06	ELECTRICAL 6
59	00TE07	ELECTRICAL 7
60	00TN01	INSTRUMENTATION 1
61	00TN02	INSTRUMENTATION 2
62	00TN03	INSTRUMENTATION 3
63	00TN04	INSTRUMENTATION 4
64	00TN05	INSTRUMENTATION 5
65	00TN06	INSTRUMENTATION 6
66	00TN07	INSTRUMENTATION 7
67	00TM01	MECHANICAL 1
68	00TM02	MECHANICAL 2
69	00TM03	MECHANICAL 3
70	00TS01	STRUCTURAL 1
71	00TS02	STRUCTURAL 2

EXCLUDED FROM THE PACKAGE

DWG NO.	DESCRIPTION
	(C) - CIVIL
08C05	WELL 8 DETAILS FOR FUTURE CONSTRUCTION (NOT USED)
	(M) - MECHANICAL
08M10	WELL 8 ORTHOPHOSPHATE CHEMICAL FEED SYSTEM DETAILS (NOT USED)
08M11	WELL 8 ORTHOPHOSPHATE CHEMICAL FEED PHOTOS (NOT USED)
08M12	WASTE DRAIN PUP STATION PLAN AND SECTION (NOT USED)
	(N) - INSTRUMENTATION
08N08	WASTE DRAIN PUMP STATION P&ID (NOT USED)
08M09	BELTZ WTP ORTHOPHOSPHATE P&ID (NOT USED)

REV	DATE	BY	DESCRIPTION

DESIGNED NKM
DRAWN OB
CHECKED JP
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER MICHAEL E. DUCKER No. 63626 CIVIL STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:21:56-07'00'

carollo®

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

GENERAL

DRAWING INDEX

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00G02
SHEET NO. 2 OF 71

PROJECT NO. 202431-100000 FILE NAME: 20243100G02.dgn

Plot Date: 10-SEP-2025 8:49:51 AM
User: svcPW
PlotScale: 1:1
DesignScript: Carollo_Std_Pen_v0905.pen
ColorTable: gshade.ctb
Model: Layout1
LAST SAVED BY: obonafaux

Plot Date: 10-SEP-2025 9:15:49 AM
User: svcPW
PlotScale: 1:1
DesignScript: Carollo_Std_Pen_v0905.pen
ColorTable: gshade.ctb
Model: Layout1
LAST SAVED BY: OBarranco

GENERAL NOTES

1. FOLLOWING NOTES ARE GENERAL AND APPLY TO ALL SHEETS OF THESE CONTRACT DOCUMENTS AS IF THEY WERE WRITTEN IN THEIR ENTIRETY ON EACH SHEET.
2. CONTRACTOR SHALL VERIFY ALL DIMENSIONS BEFORE STARTING WORK AND SHALL IMMEDIATELY NOTIFY THE ENGINEER OF ANY DISCREPANCIES. CONTRACTOR SHALL BE RESPONSIBLE FOR FIELD VERIFYING ALL EXISTING CONDITIONS INCLUDING LOCATION AND DIMENSIONS OF ALL EXISTING CONSTRUCTION AND UTILITIES. CONTRACTOR SHALL NOTIFY ENGINEER IF THERE IS A CONFLICT BETWEEN THE CONTRACT DOCUMENTS AND EXISTING CONSTRUCTION BEFORE PROCEEDING WITH WORK.
3. UNLESS DETAILED, SPECIFIED, OR OTHERWISE INDICATED ON THE DRAWINGS, CONSTRUCTION SHALL BE AS INDICATED IN THE APPLICABLE TYPICAL DETAILS AND GENERAL NOTES. TYPICAL DETAILS SHALL APPLY EVEN THOUGH NOT REFERENCED AT SPECIFIC LOCATIONS ON DRAWINGS.
4. REFER TO SECTION 01 14 00 FOR RESTRICTIONS AND REQUIREMENTS ON WORK OUTSIDE THE CITY OF SANTA CRUZ RIGHT-OF-WAY.
5. WHERE NO CONSTRUCTION DETAILS ARE SHOWN OR NOTED FOR ANY PART OF WORK. DETAILS SHALL BE IN THE SAME AS FOR OTHER SIMILAR WORK.
6. CONTRACTOR SHALL COMPLY WITH LOCAL AND STATE CONSTRUCTION STORM WATER DISCHARGE REGULATIONS AND REQUIREMENTS PER WATER POLLUTION CONTROL AND EROSION AND SEDIMENT CONTROL REQUIREMENTS SECTION 01 57 13.
7. PRIOR TO EXCAVATION FOR NEW STRUCTURES, ELECTRICAL CONDUIT, FABRICATION OF NEW PIPING AND/OR OTHER PROPOSED UTILITIES, CONTRACTOR SHALL BE RESPONSIBLE FOR VERIFYING THE LOCATION OF ALL EXISTING PIPING AND UTILITIES IN THE CONSTRUCTION AREA. THE CONTRACTOR SHALL NOTIFY THE ENGINEER OF EXISTING UTILITY CONFLICTS PRIOR TO CONSTRUCTION.
8. ALL PIPELINES 12" AND LARGER SHALL HAVE A MINIMUM COVER OF 36" UNLESS THE COVER DEPTH IS SPECIFICALLY INDICATED ON THE DRAWINGS. PIPE SMALLER THAN 12" SHALL HAVE A MINIMUM COVER OF 30" UNLESS NOTED OTHERWISE. PROVIDE 12" CONCRETE CAP ON PIPELINES WITH COVER LESS THAN 36" PER CITY WATER DEPARTMENT STANDARD DETAIL 16. PIPES SHALL BE ROUTED AS SHOWN UNLESS MINOR REVISIONS ARE NECESSARY TO AVOID EXISTING PIPES, STRUCTURES, ETC. CONTRACTOR SHALL BE RESPONSIBLE FOR FURNISHING ALL FITTINGS AND ADAPTERS REQUIRED TO MAKE THE ROUTING CHANGES AT NO ADDITIONAL COST TO THE OWNER. CONTRACTOR SHALL INCLUDE COST FOR THIS IN THE BID.
9. EXISTING FACILITY AND UTILITY INFORMATION SHOWN ON THE DRAWINGS WAS OBTAINED FROM AVAILABLE RECORDS OR ELECTRONIC FILES. NEITHER THE OWNER NOR ENGINEER ASSUMES ANY RESPONSIBILITY FOR FACILITIES AND UTILITIES NOT SHOWN OR NOT IN THE LOCATION SHOWN. THE CONTRACTOR SHALL FIELD VERIFY ALL LOCATIONS, SIZES, MATERIAL TYPES, AND ELEVATIONS SHOWN AROUND OR NEAR AREAS OF NEW CONSTRUCTION PRIOR TO START OF CONSTRUCTION.
10. THE CONTRACTOR SHALL TAKE ALL PRECAUTIONARY MEASURES NECESSARY TO PROTECT FROM DAMAGE EXISTING FACILITIES AND UTILITIES SHOWN OR NOT SHOWN THAT ARE TO REMAIN IN PLACE. ALL FACILITIES DAMAGED BY THE CONTRACTOR'S OPERATIONS SHALL BE EXPEDITIOUSLY REPAIRED OR RECONSTRUCTED TO THE ORIGINAL OR BETTER CONDITION AT THE CONTRACTOR'S EXPENSE WITHOUT ADDITIONAL COMPENSATION.
11. CONTRACTOR SHALL MAKE CONNECTIONS TO EXISTING PIPE, EQUIPMENT, ETC. AS REQUIRED AND SHALL PROVIDE ALL FITTINGS, ADAPTERS, AND APPURTENANCES REQUIRED TO MAKE THE CONNECTIONS. PROVIDE ALL SUPPORTS REQUIRED FOR A RIGIDLY SUPPORTED COMPLETE AND WORKING SYSTEM.
12. ADJUST ALL VALVE BOXES, VAULTS, PULL BOXES, AND MANHOLES TO FINISHED GRADE UNLESS OTHERWISE SHOWN OR DIRECTED. MANHOLES IN OPEN FIELDS SHALL BE SET TWELVE INCHES ABOVE FINISHED GRADE AND VAULTS SHALL BE SIX INCHES ABOVE FINISHED GRADE. REFER TO 2009 CITY STANDARD SPECIFICATIONS AND CITY WATER DEPARTMENT STANDARD DETAIL 11.
13. THE CONTRACTOR SHALL CONTACT THE PROPER UTILITY REPRESENTATIVE AS FOLLOWS FOR QUESTIONS OR COORDINATION OF CONSTRUCTION RELATED TO EXISTING UTILITIES.

    CITY OF SANTA CRUZ WATER DEPARTMENT: (831) 420-5200
    COUNTY OF SANTA CRUZ PUBLIC WORKS: (831) 454-2160
    CITY OF CAPITOLA: (831) 475-7300
    UNDERGROUND ALERT: 811
14. CONTRACTOR SHALL VERIFY THAT PIPING SHOWN TO BE ABANDONED OR AS ABANDONED PREVIOUSLY IS NO LONGER IN SERVICE. LINES IN SERVICE SHALL BE MAINTAINED UNTIL NO LONGER REQUIRED BY THE CITY.
15. ALL EXISTING PIPES THAT ARE TO BE ABANDONED IN PLACE OR REMOVED MAY NOT BE SHOWN. WHERE PIPING IS TO BE ABANDONED AND MUST REMAIN IN SERVICE UNTIL COMPLETION OF OTHER PHASES OF WORK, AND IT CONFLICTS WITH NEW PIPING, TEMPORARILY RELOCATE PIPING AS REQUIRED TO MAINTAIN SERVICE BY THE PLANT.
16. CONTRACTOR SHALL REROUTE THE EXISTING PIPING IF REQUIRED TO AVOID PROPOSED STRUCTURES. EXISTING PIPE SHALL REMAIN IN SERVICE UNTIL NEW PIPING IS READY TO BE PLACED INTO SERVICE. THE MAXIMUM DURATION OF A SYSTEM SHUTDOWN SHALL BE 8 HOURS FROM MAY THROUGH OCTOBER. THE MAXIMUM DURATION OF A SYSTEM SHUTDOWN SHALL BE 240 CONSECUTIVE HOURS FROM NOVEMBER THROUGH APRIL. A MAXIMUM OF 2 WATER SYSTEM SHUTDOWN WILL BE ALLOWED PER FACILITY PER MONTH. SEE SECTION 01 14 00 WORK RESTRICTIONS.
17. THE CONTRACTOR SHALL TAKE SPECIAL PRECAUTIONS IN THE VICINITY OF ANY OVERHEAD ELECTRIC LINES. CONTRACTOR SHALL ABIDE BY THE NATIONAL ELECTRIC CODE AND ANY REQUIREMENT BY THE OWNER OF THE ELECTRIC LINES.
18. PROVIDE ALL SHEETING/SHORING REQUIRED TO PROTECT EXISTING STRUCTURES, PIPES AND FACILITIES.
19. CONTRACTOR SHALL VERIFY LOCATION OF ALL ARCHITECTURAL, MECHANICAL, AND ELECTRICAL ITEMS BEFORE PLACING ANY STRUCTURAL STEEL OR CONCRETE. ALSO, STRUCTURAL DIMENSIONS AND OPENINGS CONTROLLED BY ARCHITECTURAL, MECHANICAL, OR ELECTRICAL EQUIPMENT SHALL BE VERIFIED BY THE CONTRACTOR PRIOR TO CONSTRUCTION.
20. MECHANICAL AND ELECTRICAL EQUIPMENT SUPPORTS, ANCHORAGES, OPENINGS, RECESSES, AND REVEALS NOT SHOWN ON THE CIVIL DRAWINGS AND STRUCTURAL DETAILS, THAT ARE REQUIRED BY OTHER CONTRACT DRAWINGS, SHALL BE PROVIDED PRIOR TO CASTING CONCRETE.
21. DIMENSIONS TO STRUCTURES, REFERENCED PIPING, PAVING, AND OTHER IMPROVEMENTS IS APPROXIMATE. THE CONTRACTOR SHALL FIELD VERIFY ALL DIMENSIONS AND CONDITIONS 14 DAYS IN ADVANCE OF THE CONSTRUCTION PROGRESS. THE CONTRACTOR SHALL REPORT ANY DISCREPANCIES TO THE ENGINEER.
22. ALL NEW WATER MAINS SHALL BE INSTALLED ABOVE EXISTING STORM DRAIN AND SANITARY SEWER PIPING WITH MINIMUM 1 FOOT VERTICAL CLEARANCE AND 10 FEET HORIZONTAL CLEARANCE, UNLESS NOTED OTHERWISE.
23. PERCHED GROUNDWATER MAY BE PRESENT AT THE PROJECT SITE. CONTRACTOR SHALL NOT BE PERMITTED TO DISCHARGE GROUNDWATER FROM TRENCHING ACTIVITIES TO THE STORM DRAIN WITHOUT PRIOR APPROVAL FROM THE CITY AND SANTA CRUZ COUNTY. IF SUCH DISCHARGES TO THE STORM DRAIN ARE ALLOWED, CONTRACTOR SHALL PREPARE AND SUBMIT TO THE CITY A DEWATERING WORK PLAN DETAILING THE MEANS AND METHODS OF DEWATERING, WATER TREATMENT, AND WATER QUALITY MONITORING PURSUANT TO GENERAL NPDES PERMIT FOR ORDER NO. R3-2022-0035 LIMITED-THREAT DISCHARGES NPDES NO. CA993004. GROUNDWATER DISCHARGES TO THE COUNTY SANITARY SEWER SYSTEM WILL REQUIRE A SPECIAL DISCHARGE PERMIT (SEE CONTRACT DOCUMENTS EXHIBIT L). REFER TO SECTION 01 14 00 (WORK RESTRICTIONS), 01 35 43 (ENVIRONMENTAL PROCEDURES), SECTION 31 23 22 (DEWATERING), AND SUPPLEMENTAL INFORMATION SI-4 (GEOTECHNICAL REPORT) FOR ADDITIONAL REQUIREMENTS AND INFORMATION.
24. THE CONTRACTOR SHALL MAINTAIN ACCESS TO ALL PROPERTIES ADJACENT TO THE WORK, THROUGHOUT THE CONSTRUCTION PERIOD.
25. ALL OPEN TRENCHES, WORK AREAS AND SHAFTS SHALL HAVE A SHORING SYSTEM IN ACCORDANCE WITH OSHA, STATE AND LOCAL REQUIREMENTS.
26. THE CONTRACTOR SHALL COMPLY WITH ALL FEDERAL, STATE, COUNTY, AND LOCAL LAWS AND ORDINANCES RELATING TO THE SAFETY AND CHARACTER OF WORK EQUIPMENT AND PERSONNEL. THIS INCLUDES BUT IS NOT LIMITED TO SHEETING, SHORING, BRACING, VENTILATION, CONFORMANCE WITH TRAFFIC CONTROL AND MAINTENANCE OF BARRICADES AND WARNING DEVICES.
27. LAYOUT DRAWINGS ARE REQUIRED FOR PIPING INSTALLED.
28. ALL MATERIAL IN CONTACT WITH POTABLE DRINKING WATER SHALL BE ANSI/NSF 61 CERTIFIED EXCEPT WHERE EXPLICITLY NOTED OTHERWISE.
29. CONTRACTOR SHALL COMPLY WITH SECTION 01 35 43 TO PROTECT WATER QUALITY, SPECIAL STATUS SPECIES, AND HABITAT IN STREAM 472 AND MORAN LAKE. DRINKING WATER DISCHARGES SHALL COMPLY WITH STATE NPDES PERMIT ORDER WQ 2014-0194-DWQ, GENERAL ORDER NO. CAG140001.
30. PIPELINES DESIGNATED "GPR" WERE IDENTIFIED BY GROUND PENETRATING RADAR. HOWEVER, THE PROCESS, SERVICE MATERIAL, AND DIAMETER ARE UNVERIFIED. REFER TO SI-5 BELTZ 8 POTHOLE AND GPR REPORT FOR AVAILABLE INFORMATION.

SYMBOLS

BRACKET

BREAK LINE

PIPE BREAK PLAN VIEW

PIPE BREAK CROSS SECTION

PIPE CONTINUATION (SINGLE LINE)

KEY TAG — X

KEY NOTE — 34

REVISION DELTA — 2

EXISTING ELEVATION — T.O.W. XXXX.X± (EXIST)

ELEVATION — TOC XXXX.XX

SCALE — 0 50' 100' 200'

NORTH ARROW/PLANT NORTH — 30° NORTH NORTH TRUE PLANT

EQUIPMENT/DEVICE TAG AND NUMBER — XXX-XX-XXXX
EQUIPMENT
EX-EQUIP = EXISTING EQUIPMENT
EF-EQUIP = FUTURE EQUIPMENT

PIPE TAG — PIPE SIZE — X" XXX — FLOW STREAM
SIZE FLOW STREAM
EX-SIZE FLOW STREAM = EXISTING
EF-SIZE FLOW STREAM = FUTURE

UNDERGROUND/ OVERHEAD WARNING

811 Know what's below. Call before you dig.

Avoid overhead power line contact. It's costly.
Call before you OVERHEAD

DETAIL REFERENCES

PLAN/VIEW TITLE — A PLAN — VIEW, DESCRIPTION, VIEW DESCRIPTION, AS NECESSARY
FILE: FILE
PLAN NOT REFERENCED

SECTION CUT — C – — VIEW; - = SHOWN ON SAME DRAWING; ##X## = SEE INDICATED DRAWING

SECTION OR DETAIL VIEW TITLE W/ REFERENCE — C/1 SECTION/DETAIL — ALPHA = SECTION, NUMERIC = DETAIL; VIEW DESCRIPTION, AS NECESSARY; DESCRIPTION; ##X## SCALE: SCALE; FILE: FILE; DRAWING CUT ORIGINATION

DETAIL OR ENLARGED PLAN CALL OUT — 1 ##X## — ALPHA = ENLARGED PLAN, NUMERIC = DETAIL; SEE INDICATED DRAWING

DRAWING REFERENCE — ##X## — AREA DESIGNATOR (WHEN APPLICABLE); DISCIPLINE DESIGNATOR; SHEET NUMBER

TYPICAL DETAIL REFERENCE — ? TYP (TYP) — TYPICAL DETAIL #; (TYP) - INDICATES THE TYPICAL DETAIL IS USED IN MULTIPLE LOCATIONS WITHIN THE DRAWING

EXTERIOR ELEVATION VIEWS — A ##X## — SEE INDICATED DRAWING

PHOTO LOCATION — # ##X## — ARROW INDICATES POINT OF VIEW; SEE INDICATED DRAWING

GRID BUBBLE — A 1

TYPICAL DETAIL NUMBER — ? TYP — LINE 3 TYPICAL DETAIL TITLE; LINE 1; LINE 2
MOD — MODIFICATION NOTE: S = STANDARD, J = JOB SPECIFIC, R = REVISED, N = NOTE TO TYPICAL DETAIL USER
SHT # OF # — SHEETS IN DETAIL
VER DATE — DATE CREATED (REVISED)
INDICATES LOCATED ON TYPICAL DETAIL SHEETS

HATCH PATTERNS

AGGREGATE BASE COURSE (ABC)
ALUMINUM
ASPHALT PAVING
BEDROCK
BRICK OR BLOCK
BRONZE, BRASS, OR COPPER
CAST IRON OR FIBERGLASS
CLSM
CONCRETE (ALL CLASSES)
DRAIN ROCK
GRAVEL
GRATING — SPAN
LANDSCAPING
RUBBER
SAND OR GROUT
EXISTING/ UNDISTURBED SOIL
STRUCTURAL FILL OR BACKFILL
STEEL
TREAD PLATE
WOOD

LINE WORK

	NEW	EXISTING
CONSTRUCTION AND PIPING	———	———
FENCE	———	———
FUTURE CONSTRUCTION	— · — · —	— · — · —
CENTER LINE	——— — ———	——— — ———
HIDDEN LINE	— — — —	— — — —
REMOVE AND/OR ABANDON	////	
GATE		
MATCH LINE	MATCH LINE SEE DWG ##X##	

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED JP
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER — MICHAEL E. DUCKER — No. 63626 — CIVIL — STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:21:39-07'00'

carollo®

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
GENERAL
GENERAL NOTES, LEGEND, AND SYMBOLS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00G03
SHEET NO. 3 OF 71

@	AT (MEASUREMENT)	
△	DEFLECTION ANGLE, CENTRAL ANGLE	
#	NUMBER (REBAR Ø)	

A

ABC	AGGREGATE BASE COURSE
AC	ASBESTOS CEMENT
ACI	AMERICAN CONCRETE INSTITUTE
ACP	ASBESTOS CEMENT PIPE
ACU	AIR CONDITIONING UNIT
ADDL	ADDITIONAL
AHU	AIR HANDLING UNIT
ALT	ALTERNATE
AL	ALUMINUM
ANCH	ANCHOR
ANTN	ANTENNA
APPROX	APPROXIMATE, APPROXIMATELY
ARCH	ARCHITECTURAL
ARV	AIR RELEASE VALVE
ASSY	ASSEMBLY
ASTM	AMERICAN SOCIETY FOR TESTING AND MATERIALS
AVG	AVERAGE
AVV	AIR AND VACUUM VALVE

B

BC	BRASS CAP, BACK OF CURB, BOLT CIRCLE
BF	BLIND FLANGE, BACKFLUSH
BFG	BELOW FINISHED GRADE
BFV	BUTTERFLY VALVE
BLDG	BUILDING
BLKHD	BULKHEAD
BLRD	BOLLARD
BM	BENCH MARK
BPV	BACK PRESSURE VALVE
BV	BALL VALVE
BW	BACKWASH
BWCCP	BAR-WRAPPED CONCRETE CYLINDER PIPE

C

C	CLOSE, CONDUIT CHANNEL (STRUCTURAL)
CB	CATCH BASIN
CD	CONDENSATE DRAIN
CDL	CHEMICAL DRAIN LINE
CDT	CONDUIT
CF	CUBIC FEET
CFS	CUBIC FEET PER SECOND
CHEMD	CHEMICAL DRAIN
CHF	CHEMICAL FEEDER
CI	CAST IRON
CIP	CAST IRON PIPE
CKA	CHECK VALVE, ANGLE
CKB	CHECK VALVE, BALL
CKF	CHECK VALVE, FLAP
CKS	CHECK VALVE, SWING
CL	CENTER LINE, CHLORINE
CLSM	CONTROLLED LOW STRENGTH MATERIAL
CML	CEMENT MORTAR LINED
CMLC	CEMENT MORTAR LINED AND COATED
CMP	CORRUGATED METAL PIPE
CMU	CONCRETE MASONRY UNIT
CO	CLEANOUT
COMP	COMPRESSION FITTING
CONC	CONCRETE
CONN	CONNECT, CONNECTION
CP	CONTROL POINT
CPLG	COUPLING
CPVC	CHLORINATED POLYVINYL CHLORIDE
CSL	CHLORINE SAMPLE LINE
CSP	CHEMICAL SUMP PUMP, CORRUGATED STEEL PIPE
CTR	CENTER, CENTERED
CU	CUBIC
CUP	COPPER PIPE
CV	CHECK VALVE
CY	CUBIC YARD

D

D	DEPTH, DIGITAL OR DISCRETE, DRAIN
D/W	DRIVEWAY
DBL	DOUBLE
DEG or °	DEGREE
DEMO	DEMOLISH, DEMOLITION
DET	DETAIL
DHCV	DOWNHOLE CONTROL VALVE
DI	DUCTILE IRON
DIA or Ø	DIAMETER
DIAG	DIAGONAL
DIM	DIMENSION
DIP	DUCTILE IRON PIPE
DISCH	DISCHARGE
DL	DEAD LOAD, DRAIN LINE
DP	DEEP (OR DEPTH)
DR	DOOR, DRAIN
DRV	DRAIN VALVE
DWG(S)	DRAWING(S)
DWL(S)	DOWEL(S)

E

E	EAST
EA	EACH
EC	END OF CURVE
EF	EXHAUST FAN, EACH FACE
EFF	EFFLUENT
EL	ELEVATION
ELEC	ELECTRICAL
ELL	ELBOW
EMBED	EMBEDMENT
EP	EDGE OF PAVEMENT
EQ	EQUAL
EQUIP	EQUIPMENT
ES	EACH SIDE
ESEW	EMERGENCY SHOWER AND EYE WASH
EW	EACH WAY
EWEF	EACH WAY EACH FACE
EX	EXISTING
EXIST	EXISTING
EXP	EXPANSION
EXT	EXTERIOR

F

FBW	FILTER BACKWASH
FC	FACE OF CURB, FLEXIBLE COUPLING
FCA	FLANGE COUPLING ADAPTER
FCO	FLOOR CLEANOUT
FCV	FLOW CONTROL VALVE
FD	FLOOR DRAIN
FDL	FLOOR DRAIN LINE
FH	FIRE HYDRANT
FILT	FILTRATE
FIN FL	FINISHED FLOOR
FIN GR	FINISHED GRADE
FL	FLOOR, FLOW LINE, FLUSH
FLD	FILTER DRAIN
FLE	FILTER EFFLUENT
FLEX	FLEXIBLE
FLG	FLANGE, OR FLANGED
FLR	FILTER
FM	FORCE MAIN
FT or '	FOOT, FEET
FTG	FOOTING
(F)	FUTURE
FW	FLUSHING WATER, FINISHED WATER

G

G	GAS, GROUND, GUTTER
GA	GAUGE or GAGE
GAL	GALLONS
GALV	GALVANIZE(D)
GEN	GENERAL, GENERATOR
GL	GLASS
GM	GAS METER
GND	GROUND
GPD	GALLONS PER DAY
GPM	GALLONS PER MINUTE
GPR	GROUND PENETRATING RADAR (SEE NOTE 1)
GR	GRADE
GRTG	GRATING
GSP	GALVANIZED STEEL PIPE
GV	GATE VALVE

H

H	HIGH, HORIZONTAL
HB	HOSE BIBB
HDPE	HIGH DENSITY POLYETHYLENE
HGT	HEIGHT
HORIZ	HORIZONTAL
HP	HORSEPOWER, HIGH PRESSURE
HPA	HIGH PRESSURE AIR
HPT	HIGH POINT
HSS	HOLLOW STRUCTURAL SECTION (STEEL)
HWL	HIGH WATER LEVEL
HYD	HYDRANT

I

IA	INSTRUMENT AIR
ID	INSIDE DIAMETER, INSIDE DIMENSION, IDENTIFICATION
IN or "	INCHES
INCL	INCLUDE, INCLUDING
INF	INFLUENT
INJ	INJECTOR
INSTR	INSTRUMENTATION
INSUL	INSULAT(E)(ED)(ING)(ION)
INT	INTERIOR
INV	INVERT
IP	IRON PIPE
IRR	IRRIGATION

J

JT	JOINT

K

KGV	KNIFE GATE VALVE

L

L	LENGTH
LB(S)	POUND(S)
LF	LINEAL FEET
LG	LONG
LP	LOW PRESSURE
LPA	LOW PRESSURE AIR
LPT	LOW POINT
LR	LONG RADIUS
LT	LEFT
LWL	LOW WATER LEVEL

M

M	MOTOR
MAINT	MAINTENANCE
MAN	MANUAL
MASY	MASONRY
MATL	MATERIAL
MAX	MAXIMUM
MDPE	MEDIUM DENSITY POLYETHYLENE
MECH	MECHANICAL
MET	METAL
MFR	MANUFACTURER
MG/L	MILLIGRAMS PER LITER
MGD	MILLION GALLONS PER DAY
MH	MANHOLE
MIN	MINIMUM
MISC	MISCELLANEOUS
MIX	MIXER
MJ	MECHANICAL JOINT
MOD	MODIFIED
MOIST	MOISTURE
MON	MONUMENT
MOV	MOTOR OPERATED VALVE
MPM	METERING PUMP
MPT	MALE PIPE TAPER THREAD
MTD	MOUNTED

N

N	NORTH, NEW, NITROGEN (PIPING SERVICE)
NA	NOT APPLICABLE
NC	NORMALLY CLOSED
NEV	VALVE, NEEDLE
NG	NATURAL GRADE
NIC	NOT IN CONTRACT
NO., #	NUMBER
NOM	NOMINAL
NPT	NATIONAL PIPE THREAD
NPW	NON-POTABLE WATER
NS	NEAR SIDE
NTS	NOT TO SCALE

O

O	OPEN
OC	ON CENTER
OD	OUTSIDE DIAMETER, OUTSIDE DIMENSION
O.F.	OUTSIDE FACE
OFL	OVERFLOW
OP	ORTHOPHOSPHATE
OPNG	OPENING
OPP	OPPOSITE
OSG	ON-SITE GENERATOR
OZ	OUNCE

P

PC	POINT OF CURVATURE
PD	PLANT DRAIN
PE	PLAIN END
PERP	PERPENDICULAR
PFA	PERFLUOROALKOXY
PG	PRESSURE GAUGE
PI	POINT OF INTERSECTION
PIV	POST INDICATOR VALVE
PL	PLATE, PROPERTY LINE
PLAS	PLASTIC
PLCS	PLACES
PMP	PUMP
PNL(S)	PANEL(S)
POL	POLYMER
POLY	POLYETHYLENE
POS	POSITION
POW	POTABLE WATER
PP	POWER POLE
PPD	POUNDS PER DAY
PPMV	PARTS PER MILLION (VOLUME)
PRG	PRESSURE REGULATOR
PRI	PRIMARY
PRR	PRESSURE OR VACUUM RELIEF VALVE
PRV	PRESSURE REDUCING VALVE, PRESSURE REGULATION VALVE, PRESSURE RELIEF VALVE
PS	PUMP STATION, PIPE SUPPORT
PDSTL	PEDESTAL
PSF	POUNDS PER SQUARE FOOT
PSG	PRESSURE GAUGE
PSI	POUNDS PER SQUARE INCH
PSIG	POUNDS PER SQUARE INCH GAUGE
PT	POINT
PV	PLUG VALVE
PVC	POLYVINYL CHLORIDE
PVMT	PAVEMENT
PW	POTABLE WATER

Q

QTY	QUANTITY

R

R/W	RIGHT OF WAY
RAD	RADIUS, RADIAL
RAW	RAW WATER
RCW	RECYCLED WATER (BACKWASH TANK)
RED	REDUCER, ROOF EQUIPMENT DRAIN
REF	REFERENCE
REG	REGULATOR, REGULATING
REINF	REINFORCE(D)(ING)(MENT)
REQD	REQUIRED
RES	RESERVOIR
REV	REVISION, REVERSE
RM	ROOM
RP	RADIUS POINT
RPM	REVOLUTIONS PER MINUTE
RSR	RISER
RW	RECLAIMED WATER, REUSE WATER
RWR	RECLAIMED WATER RETURN
RWW	RAW WASTEWATER

S

S/W	SIDEWALK
S	SOUTH, SWITCH, SLOPE
SAM	SAMPLE
SCFM	STANDARD CUBIC FEET PER MINUTE
SCH	SCHEDULE
SCO	SURFACE CLEANOUT
SD	STORM DRAIN
SDL	SUMP DISCHARGE DRAIN LINE, SLUDGE DRAIN LINE
SEC	SECONDARY, SECOND
SECT	SECTION
SED	SEDIMENTATION
SFM	SEWER FORCE MAIN
SHT	SHEET
SIM	SIMILAR
SL	SLOPE
SMP	SAMPLER, SUMP PUMP
SP	STATIC PRESSURE, SET POINT
SPD	SUMP PUMP DRAIN
SPEC(S)	SPECIFICATION(S)
SPL	SPLITTER BOX
SPR	SPARE
SPW	SAMPLE WATER
SQ	SQUARE
SQ FT	SQUARE FEET
SQ IN(S)	SQUARE INCH(ES)
SR	SHORT RADIUS
SS	SANITARY SEWER, SELECTOR SWITCH
SSPS	SANITARY SEWER PUMP STATION
SST	STAINLESS STEEL
STA	STATION
STB	STABILIZER
STD(S)	STANDARDS(S)
STIFF	STIFFENER
STIR	STIRRUPS
STL	STEEL
STP	STEEL PIPE
STR	STRAINER
STRUCT	STRUCTURAL
SUPT	PIPE SUPPORT, SUPPORT
SV	SERVICE VALVE, SHUTOFF VALVE, SOLENOID VALVE
SW	SANITARY WASTE
SWR	SEAL WATER
SYM	SYMMETRICAL

T

T&B	TOP AND BOTTOM
TAS	THREADED ANCHOR STUD
TBM	TEMPORARY BENCHMARK
TC	TOP OF CURB
TDH	TOTAL DYNAMIC HEAD
TEL	TELEPHONE
THK	THICKNESS, THICK
TNK	TANK
T.O.	TOP OF
TOC	TOP OF CONCRETE
TOG	TOP OF GRATING
TOS	TOP OF STEEL
T.O.W.	TOP OF WALL
TR	TRIAD (THREE CONDUCTOR SHIELDED CABLE), TIMING RELAY
TSPL	TURBIDIMETER SAMPLE
TUR	TURBINE
TYP	TYPICAL

U

UC	UNDERCUT
UG	UNDERGROUND
UNK	UNKNOWN
UNO	UNLESS NOTED OTHERWISE
UTIL	UTILITY

V

VAL	VALVE
VAR	VARIES
VB	VALVE BOX
VERT	VERTICAL
VOL	VOLUME

W

W	WEST, WIDTH, WATER
W/	WITH
W/O	WITHOUT
WD	WASTE DRAIN
WDFM	WASTE DRAIN FORCE MAIN
WDPS	WASTE DRAIN PUMP STATION
WL	WATER LEVEL
WM	WATER METER
WS	WATER SURFACE
WSTP	WATERSTOP
WT	WEIGHT
WTP	WATER TREATMENT PLANT
WTR	WATER
WV	WATER CONTROL VALVE
WW	WASTEWATER
WWF	WELDED WIRE FABRIC
WWTF	WASTEWATER TREATMENT FACILITY
WWTP	WASTEWATER TREATMENT PLANT

Y

Y	WYE
YCO	YARD CLEANOUT
YH	YARD HYDRANT

NOTES:

1. PIPELINES DESIGNATED "GPR" WERE IDENTIFIED BY GROUND PENETRATING RADAR, HOWEVER THE PROCESS, SERVICE, MATERIAL, AND DIAMETER ARE UNVERIFIED.
2. REFER TO SI-5 BELTZ 8 POTHOLE AND GPR REPORT FOR AVAILABLE INFORMATION.

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED JP
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER MICHAEL E. DUCKER No. 63626 CIVIL STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:22:12-07'00'

carollo®

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

GENERAL

ABBREVIATIONS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00G04
SHEET NO. 4 OF 71

PROJECT NO. 202431-100000 FILE NAME: 20243100G04.dgn

Plot Date: 10-SEP-2025 9:16:05 AM
User: svcPW
DesignScript: Carollo_Std_Pen_v0905.pen
ColorTable: gshade.ctb
Model: Layout1
PlotScale: 1:1
LAST SAVED BY: OBarranco

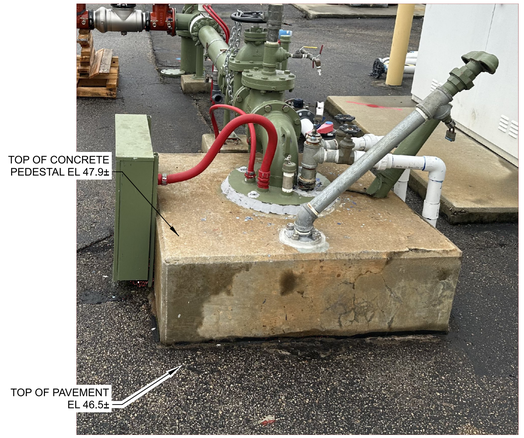
DESIGN PARAMETERS			
PARAMETER	**UNITS**	**BELTZ 8**	**NOTES**
WELLHEAD REFERENCE ELEVATIONS			
TOP OF ROUND STEEL PLATE (SOLE PLATE)	FT	47.9 (-1.4 FT BGS)	(1)
TOP OF PAVEMENT AT FINISHED GRADE	FT	46.5 (0.0 FT BGS)	(1)
WATER LEVELS AND FLOWS			
DEPTH TO STATIC WATER SURFACE LEVEL	FT BGS	32.1	(2) (3)
MAXIMUM WATER SURFACE ELEVATION	FT BGS	0 (0 PSI)	(2) (3) (4)
MAXIMUM ALLOWABLE DRAWDOWN	FT	67.9	(3)
WELL 24-HOUR SPECIFIC CAPACITY	GPM/FT	22.1	(10)
DEPTH AT PUMP SHUTOFF DUE TO LOW WATER	FT BGS	100	(2)
MINIMUM INJECTION RATE	GPM	100	-
TARGET INJECTION RATE	GPM	375	(5)
MAXIMUM INJECTION RATE	GPM	425	-
BACKFLUSH EXTRACTION RATE	GPM	750	(5) (11)
MINIMUM EXTRACTION RATE	GPM	200	-
TARGET EXTRACTION RATE	GPM	250 - 450	(5)
MAXIMUM TARGET EXTRACTION RATE (SHORT TERM)	GPM	730	(8) (12)
MAXIMUM TARGET EXTRACTION RATE (LONG TERM)	GPM	565	(13)
REPLACEMENT WELL PUMP			
MOTOR HORSEPOWER (MAXIMUM)	HP	50	(15)
PUMP TYPE	-	SUBMERSIBLE	-
MOTOR SPEED	-	VARIABLE	-
DEPTH TO PUMP INTAKE	FT BGS	191.0	(2) (7)
COLUMN PIPE			
COLUMN PIPE OUTSIDE DIAMETER AND WALL THICKNESS	INCHES	6.625 OD X 0.312 WALL	-
COLUMN PIPE MATERIAL	-	304L STAINLESS STEEL	(9)
FOOT VALVE			
DEPTH TO BOTTOM OF VALVE SETTING	FT BGS	182.0	(2)
DOWNHOLE CONTROL VALVE (DHCV)			
DESIGN INJECTION RATE	GPM	470	-
DEPTH TO BOTTOM OF VALVE SETTING	FT BGS	90.0	(2)
POWER UNIT	-	COMPRESSED NITROGEN GAS CYLINDER	-
LEVEL SENSOR			
DEPTH TO LEVEL SENSOR SETTING	FT BGS	110.0	(2)
STILLING TUBE MATERIAL	-	HDPE	-
STILLING TUBE DIAMETER	INCHES	1.5	-
TRICKLE FLOW TUBE			
DEPTH TO TRICKLE FLOW OUTLET SETTING	FT BGS	80.0	(2)
TRICKLE FLOW RANGE	GPM	2 - 10	-
TRICKLE FLOW TUBE MATERIAL	-	304 SST	
SOURCE WATER			
RECHARGE WATER SOURCE	-	DISTRIBUTION TO PUMP COLUMN PIPE	-
DISTRIBUTION SYSTEM PRESSURE	PSI	78 - 100	-
GEOCHEMICAL INTERACTION	-	NOT ANTICIPATED	(5)
EXISTING WELL CONSTRUCTION			
CONDUCTOR CASING NOMINAL DIAMETER	INCHES	30	(6)
CONDUCTOR CASING MATERIAL	-	CARBON STEEL, ASTM A-139 OR A-53 GRADE B	(6)
CONDUCTOR CASING DEPTH	FT BGS	20.0	(2) (6)
SEAL DEPTH	FT BGS	20.0	(2) (6)
GRAVEL FILL TUBE DIAMETER	INCHES	3	(6)
GRAVEL FILL TUBE MATERIAL	-	LOW CARBON STEEL	(6)
GRAVEL FILL TUBE DEPTH	FT BGS	90.0	(2)
CASING DIAMETER	INCHES	14	(6)
CASING MATERIAL	-	LOW CARBON STEEL (0-70 FT) 304 SST (70-100 FT)	(6)
SCREEN MATERIAL	-	304 SST WIRE WRAPPED	(6)
WELL SCREEN INTERVAL	FT BGS	100.0 - 180.0	(2) (6)
BOTTOM OF HOLE	FT BGS	220.0	(2) (6)
EXISTING RECLAIM PUMP			
MOTOR HORSEPOWER	HP	3	(6)
PUMP TYPE	-	CENTRIFUGAL	(6)
OPERATING RANGE	GPM	120 - 150	(6) (14)
ORTHOPHOSPHATE METERING PUMPS			
TYPE	-	DOUBLE DIAPHRAGM	-
NUMBER	-	1	-
CAPACITY (EACH)	GPH	0.03 - 0.25	-
DOSE RATE	mg/l	0.5 TO 1.5	-
MAXIMUM INJECTION PRESSURE	PSI	110	-

DESIGN PARAMETERS NOTES:

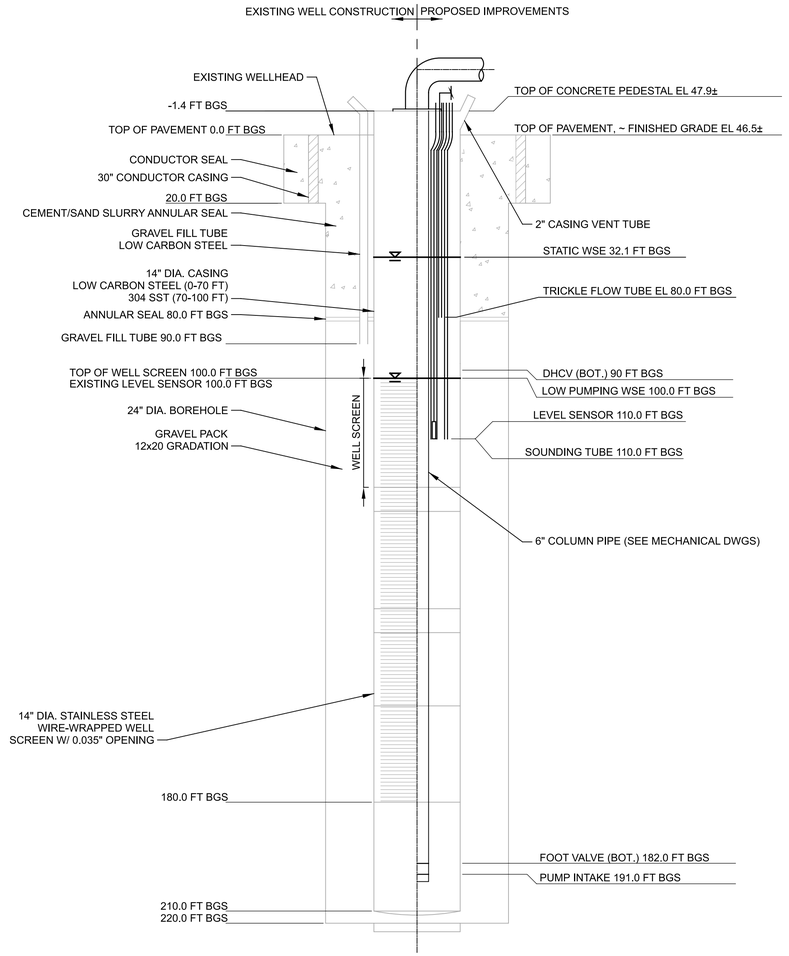
1. WELLHEAD VERTICAL DATUM IS BASED ON NGVD 29. WATER LEVELS AND INTERNAL WELL COMPONENTS ARE MEASURED RELATIVE TO TOP OF CONCRETE PUMP PEDESTAL. REFER TO 08C01 FOR ADDITIONAL TOPOGRAPHIC AND SURVEY INFORMATION.
2. "FT BGS" RELATIVE TO THE GROUND SURFACE ELEVATION (46.5±) AT THE WELLHEAD. POSITIVE VALUES ARE BELOW THE GROUND SURFACE. NEGATIVE VALUES ARE ABOVE THE GROUND SURFACE.
3. VALUES ARE BASED ON HISTORICAL CONDITIONS (PILOT TESTING) AND MAY VARY SEASONALLY.
4. WELLHEAD IS NOT DESIGNED FOR PRESSURIZED INJECTION.
5. INJECTION/EXTRACTION RATES AND GEOCHEMICAL INTERACTION PER BELTZ 8 ASR PILOT TEST PROJECT, MARCH 2023.
6. INSTALLED CONDITION OF EXISTING FACILITIES.
7. SET PUMP INTAKE MIN. 3 FT BELOW THE SCREEN OF THE LOWERMOST SCREENED INTERVAL AND 19 FT ABOVE THE BOTTOM OF THE WELL CASING.
8. MAXIMUM TARGET EXTRACTION RATE AS IDENTIFIED BY CITY STAFF, FEBRUARY 2025.
9. PUMP COLUMN PIPE SHALL BE 304L STAINLESS STEEL MANUFACTURED IN ACCORDANCE WITH ASTM A778, TAPER THREADED, THREADED AND COUPLED CONNECTIONS. MAXIMUM 20-FT PIPE SEGMENT LENGTHS. REFER TO SECTIONS 40_05_52 AND 43_25_20.02 FOR ADDITIONAL INFORMATION.
10. WELL 24-HOUR SPECIFIC CAPACITY PROVIDED IN "BELTZ 8 ASR PILOT TEST PROJECT SUMMARY OF OPERATIONS REPORT" PREPARED BY PUEBLO WATER RESOURCES AND DATED MARCH 2023.
11. 30 MINUTES (WEEKLY) DURING INJECTION SEASON.
12. SHORT DURATION (2-4 WEEKS).
13. LONG DURATION (UP TO 6 MONTHS).
14. MINIMUM 2 PSI (APPROX. 5 FEET) SUCTION HEAD REQUIRED FOR OPERATION.
15. REFER TO SECTION 43_25_20.02 FOR ADDITIONAL INFORMATION.

WELL 8 PROFILE NOTES:

1. EXISTING WELL PROFILE IS SHOWN SCHEMATICALLY FOR REFERENCE. REFER TO DWG 08M04 AND RECORD DRAWINGS FOR ADDITIONAL INFORMATION AND DETAILS.
2. WELL PROFILE INFORMATION BASED ON BELTZ WELL 8 AS-BUILT PROVIDED BY PUEBLO WATER RESOURCES, APRIL 2024.
3. CONTRACTOR SHALL INSTALL NEW WELL COLUMN PIPING, WELL PUMP, MOTOR SHROUD, DHCV, FOOT VALVE, TRICKLE FLOW TUBE, AND LEVEL SENSOR. SEE DESIGN PARAMETER TABLE, TECHNICAL SPECIFICATIONS, AND DWG 08M04 FOR ADDITIONAL INFORMATION.



EXISTING WELL 8 PHOTO
NO SCALE



WELL 8 PROFILE
NO SCALE

REV	DATE	BY	DESCRIPTION

DESIGNED NKM
DRAWN OB
CHECKED JP
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER MICHAEL E. DUCKER No. 63626 CIVIL STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:21:15-07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

GENERAL

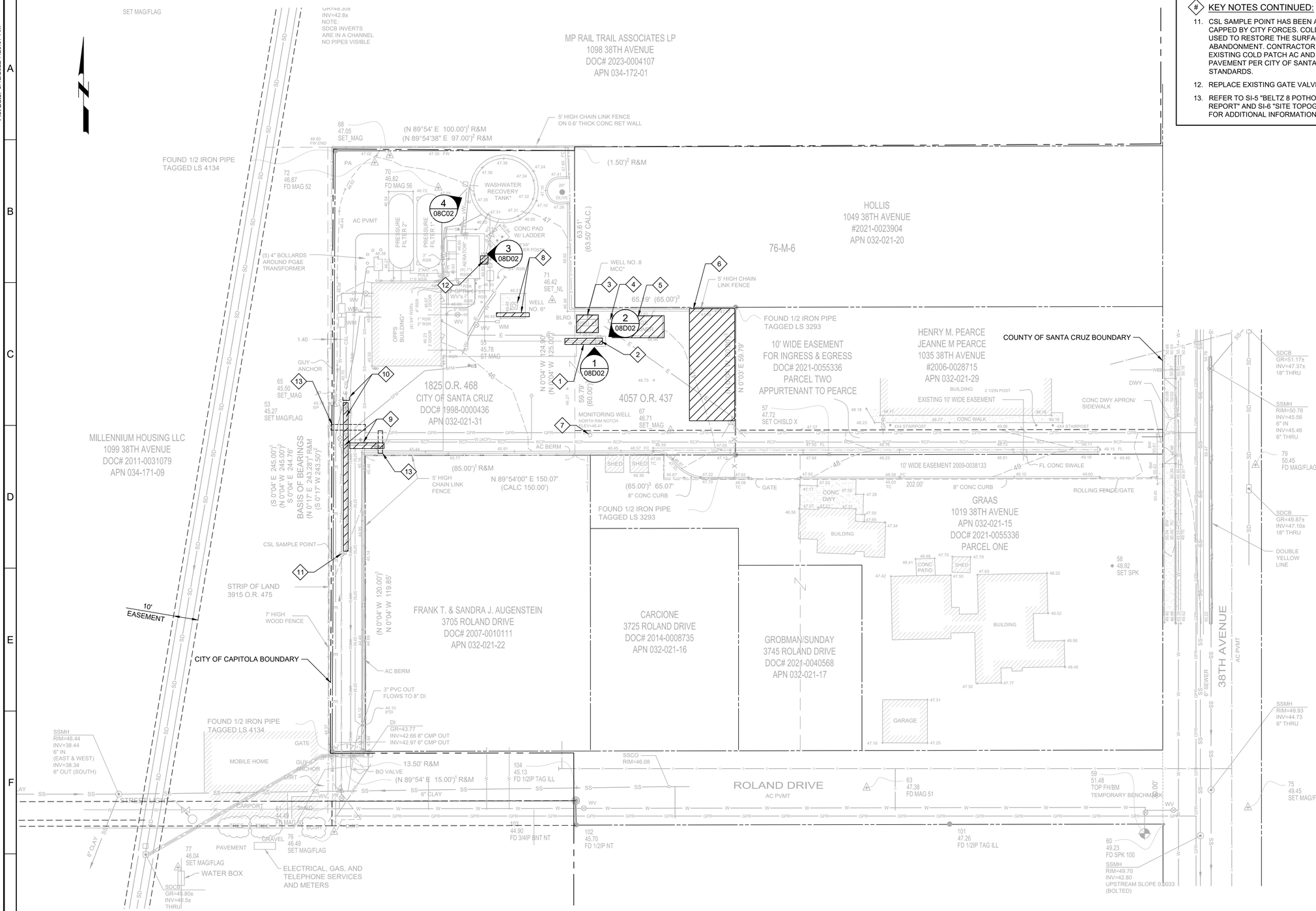
DESIGN CRITERIA

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00G05
SHEET NO. 5 OF 71

PROJECT NO. 202431-100000 FILE NAME: 20243100G05.dgn

Model: Layout1 ColorTable: gshade.ctb DesignScript: Carollo_Std_Pen_v0905.pen PlotScale: 1:1 Plot Date: 10-SEP-2025 9:16:13 AM User: svcPW LAST SAVED BY: OBarranco



KEY NOTES CONTINUED:

11. CSL SAMPLE POINT HAS BEEN ABANDONED AND CAPPED BY CITY FORCES. COLD PATCH AC WAS USED TO RESTORE THE SURFACE FOLLOWING ABANDONMENT. CONTRACTOR SHALL REMOVE EXISTING COLD PATCH AC AND RESTORE PAVEMENT PER CITY OF SANTA CRUZ STANDARDS.
12. REPLACE EXISTING GATE VALVE. SEE DWG 08D02.
13. REFER TO SI-5 "BELTZ 8 POTHOLE AND GPR REPORT" AND SI-6 "SITE TOPOGRAPHIC SURVEY" FOR ADDITIONAL INFORMATION.

GENERAL NOTES:

1. THE BELTZ 8 WATER TREATMENT PLANT IS SUPPLIED WITH RAW WATER FROM EXISTING WELLS 8, 9 AND 10. THE TEMPORARY DECOMMISSIONING OF WELL 8 DURING CONSTRUCTION WILL REDUCE THE CITY'S WATER SUPPLY CAPACITY. THE CONTRACTOR SHALL SUBMIT A DECOMMISSIONING AND REPLACEMENT PLAN WITH A PROJECT SCHEDULE FOR REVIEW AND APPROVAL PRIOR TO TAKING WELL 8 OFFLINE FOR DECOMMISSIONING. THE BELTZ WTP, BACKWASH/RECLAIM TANK, WELL 9, WELL 10, AND ASSOCIATED FACILITIES SHALL REMAIN IN SERVICE WHILE BELTZ 8 IS OFFLINE. REFER TO SECTION 01 14 00 FOR WORK RESTRICTIONS.
2. THE CONTRACTOR SHALL HAVE ALL NEW EQUIPMENT FACTORY TESTED, ONSITE, AND PREASSEMBLED PRIOR TO TAKING WELL 8 OFFLINE FOR DECOMMISSIONING.
3. THE CONTRACTOR SHALL COORDINATE WITH CITY OPERATIONS PRIOR TO DECOMMISSIONING, SHUTDOWN, AND DEMOLITION. REFER TO SPECIFICATIONS FOR ADDITIONAL REQUIREMENTS.

KEY NOTES:

1. DEMOLISH EXISTING ABOVE GROUND WELL PIPING. REMOVE BURIED PIPING UP TO THE PROPOSED POINT OF CONNECTION. BACKFILL AND COMPACT TRENCH, AND REPAIR AC PAVEMENT PER SECTION 32_01_15.
2. EXISTING DOWNHOLE WELL, INCLUDING CASING AND SCREENS, TO REMAIN. PROTECT AND DO NOT DROP DEBRIS DOWN WELL. FASTEN TEMPORARY BLIND FLANGE OR PLATE OVER OPEN WELL HOLE. SEE DWG 00G05 FOR DOWNHOLE IMPROVEMENTS.
3. DEMOLISH EXISTING WELL 8 MCC-A AND CONCRETE HOUSEKEEPING PAD. SEAL OFF EXISTING CONDUITS PER SPECIFICATIONS. REPLACE A.C. PAVEMENT PER CITY STANDARDS. MCC-A SHALL REMAIN IN SERVICE UNTIL NEW MCC-8A HAS BEEN INSTALLED. REPAIR AC PAVEMENT PER SECTION 32_01_15.
4. EXISTING POLE MOUNTED LIGHT, CONDUITS, AND CONDUCTORS TO REMAIN.
5. EXISTING CONTAINER WILL BE RELOCATED BY CITY FORCES PRIOR TO MOBILIZATION.
6. EXISTING FREE STANDING EQUIPMENT, CONTAINERS, AND FACILITIES WILL BE RELOCATED BY CITY FORCES.
7. EXISTING BELTZ 8 MONITORING WELL TO REMAIN.
8. EXISTING BELTZ 8 MONITORING WELL TO REMAIN. SELECTIVELY DEMOLISH CONCRETE AS REQUIRED TO INSTALL DUCT BANK. CONTRACTOR SHALL FIELD VERIFY LOCATION OF EXISTING SUBSURFACE WELL FACILITIES AND ADJUST ROUTING OF DUCT BANKS AS REQUIRED TO AVOID CONFLICTS. SEE ELECTRICAL DWGS.
9. REMOVE EXISTING FIRE HYDRANT AND 6" HYDRANT LATERAL. INSTALL BLIND FLANGE ON EXISTING 6" GATE VALVE.
10. REMOVE EXISTING CSL LINE AS REQUIRED FOR INSTALLATION OF 12" FL AS SHOWN ON CIVIL DWGS. CAP REMAINING PORTIONS OF CSL PIPE LEFT IN PLACE.

LEGEND:

DEMOLISH

811 Know what's below. Call before you dig. usanorth811.org

REV	DATE	BY	DESCRIPTION

DESIGNED MED
DRAWN ART
CHECKED JP
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER MICHAEL E. DUCKER No. 63626 CIVIL STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:17:54-07'00'

carollo

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

DEMOLITION

WELL 8 DEMOLITION SITE PLAN

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08D01
SHEET NO. 6 OF 71

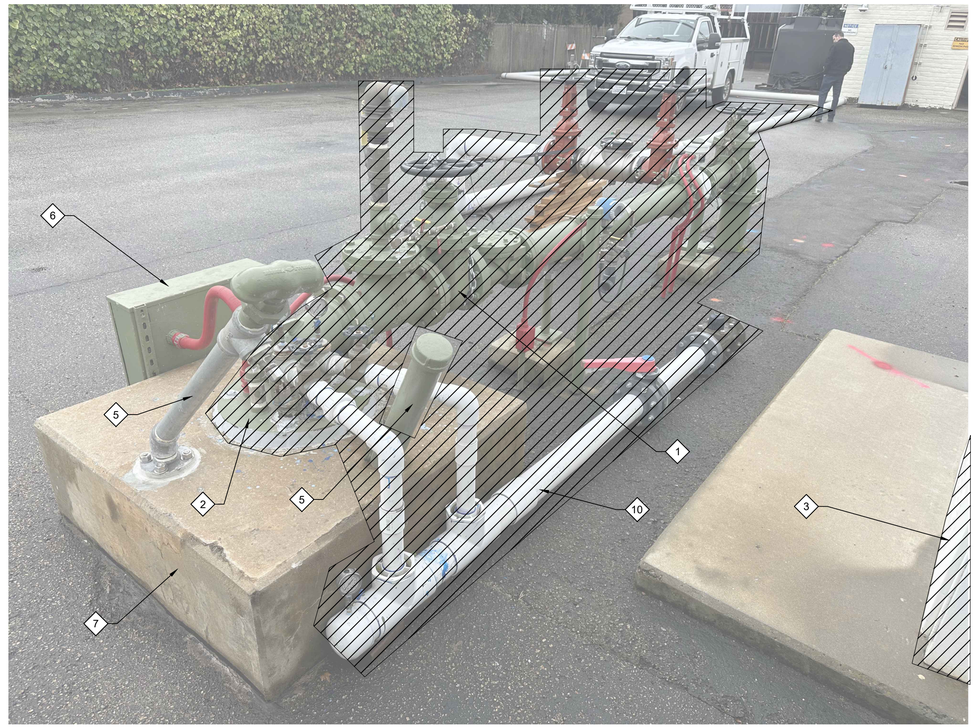
Plot Date: 9/12/2022 7:29:07 AM
LAST SAVED BY: atucker
PROJECT NO. 202431-100000 FILE NAME: 20243108D01.dwg



EXISTING WELL 8

1 PHOTO

08D01 FILE: 20243108D02
SCALE: NO SCALE



EXISTING WELL HEAD

2 PHOTO

08D01 FILE: 20243108D02
SCALE: NO SCALE



GATE VALVE REPLACEMENT

3 PHOTO

08D02 FILE: 20243108D02
SCALE: NO SCALE



RECLAIM TANK MODIFICATIONS

4 PHOTO

08D02 FILE: 20243108D02
SCALE: NO SCALE

LEGEND:

DEMOLISH

GENERAL NOTES:

1. THE BELTZ 8 WATER TREATMENT PLANT IS SUPPLIED WITH RAW WATER FROM EXISTING WELLS 8, 9, AND 10. THE TEMPORARY DECOMMISSIONING OF WELL 8 DURING CONSTRUCTION WILL REDUCE THE CITY'S WATER SUPPLY CAPACITY. THE CONTRACTOR SHALL SUBMIT A DECOMMISSIONING AND REPLACEMENT PLAN WITH A PROJECT SCHEDULE FOR REVIEW AND APPROVAL PRIOR TO TAKING WELL 8 OFFLINE FOR DECOMMISSIONING. THE BELTZ WTP, BACKWASH/RECLAIM TANK, WELL 9, WELL 10, AND ASSOCIATED FACILITIES SHALL REMAIN IN SERVICE WHILE BELTZ 8 IS OFFLINE. REFER TO SECTION 01 14 00 FOR WORK RESTRICTIONS.
2. THE CONTRACTOR SHALL HAVE ALL NEW EQUIPMENT FACTORY TESTED, ONSITE, AND PREASSEMBLED PRIOR TO TAKING WELL 8 OFFLINE FOR DECOMMISSIONING.
3. THE CONTRACTOR SHALL COORDINATE WITH CITY OPERATIONS PRIOR TO DECOMMISSIONING, SHUTDOWN, AND DEMOLITION. REFER TO SPECIFICATIONS FOR ADDITIONAL REQUIREMENTS.

KEY NOTES:

1. DEMOLISH EXISTING ABOVE GROUND WELL PIPING. REMOVE BURIED PIPING UP TO THE PROPOSED POINT OF CONNECTION. BACKFILL AND COMPACT TRENCH, AND REPAIR AC PAVEMENT PER SECTION 32_01_15. SEE DRAWING 08D01 FOR LIMITS OF DEMOLITION.
2. EXISTING DOWNHOLE WELL, INCLUDING CASING AND SCREENS, TO REMAIN. PROTECT AND DO NOT DROP DEBRIS DOWN WELL. FASTEN TEMPORARY BLIND FLANGE OR PLATE OVER OPEN WELL HOLE. SEE DWG 00G05 FOR DOWNHOLE IMPROVEMENTS.
3. DEMOLISH EXISTING WELL 8 MCC AND CONCRETE HOUSEKEEPING PAD. SEE ELECTRICAL DRAWINGS FOR IMPROVEMENTS AT EXISTING MCC LOCATION. REPAIR AC PAVEMENT PER SECTION 32_01_15.
4. EXISTING POLE MOUNTED LIGHT, CONDUITS, AND CONDUCTORS TO REMAIN.
5. EXISTING 2" GRAVEL FEED TUBE (NORTH) AND 2" CASING VENT (EAST) TO REMAIN.
6. EXISTING ELECTRICAL JUNCTION BOX TO REMAIN.
7. EXISTING CONCRETE WELLHEAD TO REMAIN.
8. REMOVE AND REPLACE EXISTING 8" FL X FL GATE VALVE PER SECTION 40_05_65.01. CONTRACTOR SHALL COMPLETE THE VALVE REPLACEMENT AS THE FIRST ITEM OF WORK. REFER TO SECTION 01 14 00 FOR WORK RESTRICTIONS.
9. REMOVE EXISTING 2" 90° ELL, GV, AND UNION. SEE DWG 08C03 FOR IMPROVEMENTS.
10. EXISTING TEMPORARY ABOVE GROUND PVC LINES USED FOR PILOT TESTING HAVE BE REMOVED BY CITY FORCES.

REV	DATE	BY	DESCRIPTION

DESIGNED MED
DRAWN ART
CHECKED JP
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER — MICHAEL E. DUCKER — No. 63626 — CIVIL — STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:18:10-07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

DEMOLITION

WELL 8 DEMOLITION PHOTOS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08D02
SHEET NO. 7 OF 71

LAST SAVED BY: atucker

PROJECT NO. 202431-100000 FILE NAME: 20243108D02.dwg

ABBREVIATIONS

	△	DELTA, DEFLECTION ANGLE, OR CENTRAL ANGLE
	#	NUMBER (REBAR Ø)
	@	AT (MEASUREMENT)
	±	PLUS/MINUS
A	ABC	AGGREGATE BASE COURSE
	ABND	ABANDONED
	AC	ASPHALTIC CONCRETE
	ACI	AMERICAN CONCRETE INSTITUTE
	ACP	ASBESTOS CEMENT PIPE
	ADDL	ADDITIONAL
	ADJ	ADJACENT, ADJUST(ABLE)
	AL	ALUMINUM
	APPROX	APPROXIMATE(LY)
	ARV	AIR RELEASE VALVE
	ASSY	ASSEMBLY
	ASTM	AMERICAN SOCIETY FOR TESTING AND MATERIALS
	AVG	AVERAGE
	AVV	AIR AND VACUUM VALVE
B	BC	BEGIN CURB
	BF	BACKFLUSH
	BFP	BACK FLOW PREVENTER
	BFV	BUTTERFLY VALVE
	BH	BOREHOLE
	BLDG	BUILDING
	BM	BENCH MARK
	BO	BLOW OFF
	BOC	BACK OF CURB
	BOP	BOTTOM OF PIPE
	BOT	BOTTOM
	BV	BALL VALVE
	BVC	BEGINNING OF VERTICAL CURVE
	BYP	BYPASS
C	CATV	CABLE TV
	CAV	COMBINATION AIR VALVE
	CB	CATCH BASIN
	CC	CENTER OF CURVATURE, CENTER TO CENTER, CONCRETE CURB
	CDT	CONDUIT
	CF	CUBIC FEET
	CFM	CUBIC FOOT PER MINUTE
	CFS	CUBIC FEET PER SECOND
	CI	CAST IRON
	CIP	CAST IRON PIPE
	CIPP	CURED IN PLACE PIPE
	CJ	CONSTRUCTION JOINT
	CL	CENTER LINE
	CLK	CHAIN LINK
	CLR	CLEAR / CLEARANCE
	CLSM	CONTROL LOW STRENGTH MATERIAL
	CMLC	CEMENT MORTAR LINED AND COATED
	CMP	CORRUGATED METAL PIPE
	CMU	CONCRETE MASONRY UNIT
	CO	CLEANOUT
	CONC	CONCRETE
	CONN	CONNECT, CONNECTION
	CONST	CONSTRUCTION
	CONT	CONTINUOUS OR CONTINUATION OR (D)
	COORD	COORDINATE
	CP	CONTROL POINT
	CPLG	COUPLING
	CSP	CORRUGATED STEEL PIPE
	CTJ	CONTROL JOINT
	CTL	CONTROL
	CTR	CENTER, CENTERED
	CU	CUBIC
	CULV	CULVERT
	CY	CUBIC YARD
D	D	DRAIN, DEPTH
	D/W	DRIVEWAY APRON
	DEG or °	DEGREE
	DEMO	DEMOLISH, DEMOLITION
	DET	DETAIL
	DI	DROP INLET
	DIA or Ø	DIAMETER
	DIFF	DIFFERENCE
	DIM	DIMENSION
	DIP	DUCTILE IRON PIPE
	DIST	DISTANCE
	DR	DRIVE, DRAIN
	DWG(S)	DRAWING(S)
E	E	ELECTRICAL, EAST, EASTING
	EA	EACH
	EC	END OF CURB
	ECC	ECCENTRIC REDUCER
	EG	EXISTING GROUND
	EL	ELEVATION
	ELL	ELBOW
	ELEC	ELECTRICAL
	EMH	ELECTRICAL MANHOLE
	EOP	END OF PIPE
	EP	EDGE OF PAVEMENT
	EQ	EQUAL
	EQUIP	EQUIPMENT
	ES	EACH SIDE
	ESMT	EASEMENT
	EVC	END OF VERTICAL CURVE
	EW	EACH WAY
	EX/EXIST	EXISTING
	EXP	EXPANSION
	EXT	EXTERIOR
F	FC	FLEXIBLE COUPLING
	FCA	FLANGE COUPLING ADAPTER
	FF	FINISHED FLOOR
	FG	FINISHED GRADE
	FH	FIRE HYDRANT
	FIN	FINISH
	FL	FLOOR, FLOW LINE
	FLEX	FLEXIBLE
	FLG	FLANGE(D)
	FM	FORCE MAIN
	FND	FOUNDATION
	FO	FIBER OPTIC
	FOB	FLAT ON BOTTOM
	FOC	FACE OF CURB
	FOT	FLAT ON TOP
	FPM	FEET PER MINUTE
	FS	FIRE SERVICES
	FSP	FABRICATED STEEL PIPE
	FT or '	FOOT, FEET
	FTG	FOOTING
G	G	GAS, GUTTER
	GA	GAUGE
	GAL	GALLONS
	GALV	GALVANIZE(D)
	GB	GRADE BREAK
	GC	GROOVED COUPLING
	GEN	GENERAL, GENERATOR
	GM	GAS METER
	GND	GROUND
	GPD	GALLONS PER DAY
	GPM	GALLONS PER MINUTE
	GR	GRADE
	GRTG	GRATING
	GSP	GALVANIZED STEEL PIPE
	GV	GATE VALVE
H	HDPE	HIGH DENSITY POLYETHYLENE
	HORIZ	HORIZONTAL
	HP	HIGH POINT
	HPGM	HIGH PRESSURE GAS MAIN
	HW	HEADWALL, HOT WATER
	HWL	HIGH WATER LEVEL
	HWY	HIGHWAY
	HYD	HYDRANT
I	ID	INSIDE DIAMETER
	IE	INVERT ELEVATION
	IN or "	INCHES
	INCL	INCLUDE, INCLUDING
	INSTR	INSTRUMENTATION
	INV	INVERT
	IP	IRON PIPE
	IRR	IRRIGATION
J	JT	JOINT
L	L	LENGTH
	LAT	LATERAL, LATITUDE
	LB(S)	POUND(S)
	LF	LINEAL FEET
	LH	LEFT HAND
	LONG	LONGITUDINAL
	LP	LOW POINT
	LT	LEFT
	LWL	LOW WATER LEVEL
M	MATL	MATERIAL
	MAX	MAXIMUM
	MECH	MECHANICAL
	MFR	MANUFACTURER
	MGD	MILLION GALLONS PER DAY
	MH	MANHOLE
	MIN	MINIMUM
	MISC	MISCELLANEOUS
	MJ	MECHANICAL JOINT
	MON	MONUMENT
	MOV	MOTOR OPERATED VALVE
N	N	NORTH, NORTHING
	NA	NOT APPLICABLE
	NE	NORTHEAST
	NG	NATURAL GAS
	NIC	NOT IN CONTRACT
	NO OR #	NUMBER
	NOM	NOMINAL
	NW	NORTHWEST
O	O.F.	OUTSIDE FACE
	OC	ON CENTER
	OD	OUTSIDE DIAMETER, OUTSIDE DIMENSION
	OHE	OVERHEAD ELECTRIC
P	PB	PULLBOX
	PC	POINT OF CURVATURE
	PCC	POINT OF COMPOUND CURVE
	PERP	PERPENDICULAR
	PH	POTHOLE
	PI	POINT OF INTERSECTION
	PL	PLATE, PROPERTY LINE
	POB	POINT OF BEGINNING
	PP	POWER POLE
	PRC	POINT OF REVERSE CURVATURE
	PROP	PROPERTY
	PL	PROPERTY LINE
	PSI	POUNDS PER SQUARE INCH
	PT	POINT, POINT OF TANGENCY
	PV	PLUG VALVE
	PVC	POINT OF VERTICAL CURVATURE
	PVC	POLYVINYL CHLORIDE
	PVI	POINT OF VERTICAL INTERSECTION
	PVMT	PAVEMENT
	PVT	POINT OF VERTICAL TANGENCY
Q	QTY	QUANTITY
R	R	RADIUS
	RAD	RADIAL
	RCB	REINFORCED CONCRETE BOX CULVERT
	RCP	REINFORCED CONCRETE PIPE
	RED	REDUCER
	REF	REFERENCE
	REINF	REINFORCE(D)(ING)(MENT)
	REQ'D	REQUIRED
	REV	REVISION
	RFCA	RESTRAINED FLEX COUPLING ADAPTER
	RH	RIGHT HAND
	R/W or ROW	RIGHT OF WAY
	RR	RAILROAD
	RT	RIGHT
S	S	SLOPE, SOUTH
	SCH	SCHEDULE
	SD	STORM DRAIN
	SDDI	STORM DRAIN DROP INLET
	SDMH	STORM DRAIN MANHOLE
	SE	SOUTHEAST
	SECT	SECTION
	SHLD	SHOULDER
	SHT	SHEET
	SIM	SIMILAR
	SL	SLOPE
	SPEC(S)	SPECIFICATION(S)
	SQ	SQUARE
	SS	SANITARY SEWER
	SSCO	SANITARY SEWER CLEANOUT
	SSMH	SANITARY SEWER MANHOLE
	SST	STAINLESS STEEL
	ST	STREET
	STA	STATION
	STD(S)	STANDARD(S)
	STL	STEEL
	STRUCT	STRUCTURAL
	SW	SOUTHWEST
	SWK	SIDEWALK
	SYM	SYMMETRICAL
T	TB	THRUST BLOCK
	TC	TOP OF CURB
	TEL	TELEPHONE
	TOG	TOP OF GRATING
	TMH	TELEPHONE MANHOLE
	TOC	TOP OF CONCRETE
	TOP	TOP OF PIPE
	TOW or TW	TOP OF WALL
	TRD	TREAD
	TYP	TYPICAL
U	UC	UNDERCUT
	UG	UNDERGROUND
	UGE	UNDERGROUND ELECTRIC
	UNKN	UNKNOWN
	UNO	UNLESS NOTED OTHERWISE
	USA	UNDERGROUND SERVICE ALERT
	UTIL	UTILITY
V	V	VERTICAL, VALVE
	VAR	VARIES
	VB	VALVE BOX
	VC	VERTICAL CURVE, VICTAULIC COUPLER
	VCP	VITRIFIED CLAY PIPE
	VERT	VERTICAL
	VLT	VAULT
	VPI	VERTICAL POINT OF INTERSECTION
W	W	WATER, WIDTH OR WEST
	W/	WITH
	W/O	WITHOUT
	WL	WATER LEVEL
	WM	WATER METER
	WS	WATER SURFACE
	WSP	WELDED STEEL PIPE
	WSTP	WATERSTOP
	WV	WATER CONTROL VALVE
	WW	WASTEWATER
X	XFMR	TRANSFORMER
Y	YD	YARD

LINE WORK

- NEW STRUCTURES OR EDGE OF PAVEMENT
- EXISTING STRUCTURES (SCREENED)
- NEW PIPING (TRIPLE LINES)
- NEW PIPING (SINGLE LINE)
- EXISTING PIPING (TRIPLE LINES) (SCREENED)
- EXISTING PIPING (SINGLE LINE)(SCREENED)
- HIDDEN LINE OR TRAIL EDGE
- CENTER, MONUMENT, OR SURVEY LINE
- GUARDRAIL
- EXISTING CONTOURS (SCREENED) — 310
- NEW CONTOURS — 310
- NEW FENCE — X — X —
- EXISTING FENCE (SCREENED) — X — X —
- REMOVE OR ABANDONED (CROSS HATCHING: FENCE SHOWN AS EXAMPLE)
- POWER POLE & LINE — OHE — PP OHE —
- CABLE TV (UNDERGROUND) — CTV — CTV —
- FIBER OPTIC — FO — FO —
- FUEL — F — F —
- NATURAL GAS — NG — NG —
- UNDERGROUND ELECTRIC — UGE — UGE —
- SANITARY SEWER — SS — SS —
- FORCEMAIN SANITARY SEWER — FM — FM —
- STORM DRAIN — SD — SD —
- TELEPHONE — TEL — TEL —
- WATER — W — W —
- PROPERTY LINE OR RIGHT OF WAY
- SLOPE
- NEW ROAD
- EXISTING ROAD (SCREENED)
- FUTURE ROAD, WATER EDGE OR RIDGE
- CURB & GUTTER
- CURB
- SWALE
- FLOWLINE
- SHORING
- RAILROAD TRACKS
- LIMITS OF CONSTRUCTION — LOC — LOC —
- SILT FENCE — SF — SF — SF —
- EASEMENT
- EXISTING EASEMENT
- CITY LIMITS
- EXISTING GRADE (PROFILE)
- PROPOSED GRADE (PROFILE)
- MATCH LINE — MATCH LINE STA XXX SEE DWG XXX

COORDINATES / ELEVATION

COORDINATES — XX — N 1600000 E 1000000 — N XXXXXXX.XX E XXXXXXX.XX

CONTROL POINT — XX

SPOT ELEVATION — FG XX.XX

ANY SPECIFIC DESIGNATIONS NOTED WILL NEED TO REFER TO ABBREVIATIONS

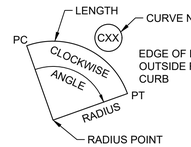
EXISTING SPOT ELEVATION — X 1325.00

SLOPE CALLOUT — 2:1 — 2 / 1 — 2.0% — S=0.0020

ROADWAY / PIPE CURVES

ROADWAY / PIPE CURVE

(SEE TABLE ON EACH PAVING AND GRADING OR CIVIL PIPING DWG WITH ROADWAY / PIPE CURVES.)



EDGE OF PVMT OR OUTSIDE FACE OF CURB

HATCH PATTERNS

- AGGREGATE BASE COURSE (ABC)
- ASPHALT PAVING
- OR
- (WITH AERIAL)
- BEDROCK
- CLSM
- CONCRETE (ALL CLASSES)
- DRAIN ROCK
- GRAVEL
- GRATING — SPAN
- LANDSCAPING
- RIPRAP
- EXISTING/ UNDISTURBED SOIL
- STRUCTURAL FILL OR BACKFILL
- STEEL
- STAGING AREA
- TREAD PLATE

SYMBOLS

SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
△	EXISTING CONTROL POINT		LIGHT
	EXISTING MONUMENT		UTILITY POLE
XX	CONTROL POINT		UTILITY POLE GUY WIRE
B-XX	SOIL BORING LOCATIONS	PP	POWER POLE
PH	POTHOLE		FIRE HYDRANT
PHXX	POTHOLE NUMBER	CO	CLEANOUT
	FLOW/SLOPE DIRECTION		AIR RELEASE VALVE
	MANHOLE		BLOW OFF VALVE
	MANHOLE (PROFILE)		HOSE BIBB / YARD HYDRANT
			SERVICE CONNECTION
	CATCH BASIN		BURIED VALVE
E	ELECTRICAL MANHOLE AND PULL BOX		FLANGE
M	METER BOX		BALL VALVE
P	PULL BOX		BUTTERFLY VALVE
T	TELEPHONE PEDESTAL		CHECK VALVE
CTV	CABLE TV		GATE VALVE
	POWER TOWER		PLUG VALVE
	GATE		PIPE CAP OR CONNECTION
	GUARD POST		REDUCER
	HEADWALL		
	ROCK WALL		
	SHRUB/HEDGE		
	TREE		
	SIGN/SIGN POST		

NOTE: ALL SYMBOLS SHOWN AS NEW. EXISTING SYMBOLS ARE SCREENED.

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED CE
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER MICHAEL E. DUCKER No. 63626 CIVIL STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:17:00-07'00'

carollo®

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

CIVIL

CIVIL ABBREVIATIONS, LEGEND, AND SYMBOLS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00GC01
SHEET NO. 8 OF 71

LAST SAVED BY: atucker

PROJECT NO. 202431-100000 FILE NAME: 20243100GC01.dwg

GENERAL NOTES:

1. USE CIVIL DRAWINGS AND STRUCTURAL DETAILS IN CONJUNCTION WITH PROJECT DRAWINGS BY OTHER DISCIPLINES AND WITH THE SPECIFICATIONS.

2. UNLESS DETAILED, SPECIFIED, OR INDICATED OTHERWISE, CONSTRUCTION SHALL BE AS INDICATED IN THE GENERAL NOTES AND TYPICAL DETAILS.

3. PRESENTATION CONVENTIONS FOR CIVIL DRAWINGS AND STRUCTURAL DETAILS:

   A. SCREENED LINE WORK INDICATES EXISTING CONDITIONS.
   B. WRITTEN DIMENSIONS TAKE PRECEDENCE OVER SCALED SIZES.
   C. PLANS ARE TREATED AS HORIZONTAL SECTIONS. (I.E.: "PLAN AT ELEVATION 110" SHOWS CONSTRUCTION AT AND BELOW ELEVATION 110.)

4. VERIFY DIMENSIONS AND CONDITIONS BEFORE BEGINNING WORK. ADVISE ENGINEER IMMEDIATELY OF DISCREPANCIES BETWEEN EXISTING CONDITIONS AND DIMENSIONS, AND INFORMATION SHOWN ON THESE DRAWINGS. CONFIRM THE FOLLOWING BEFORE PREPARATION AND SUBMITTAL OF SHOP DRAWINGS:

   A. DIMENSIONS AND WEIGHTS FOR EQUIPMENT SELECTED.
   B. SIZES AND LOCATIONS OF EQUIPMENT PADS FOR EQUIPMENT SELECTED.

5. TYPICAL DETAILS ARE INCLUDED ON THE "TS" DRAWINGS.

   A. TYPICAL DETAILS ARE INTENDED TO APPLY AT LOCATIONS DESCRIBED BY THEIR TITLES, EVEN WHEN NOT SPECIFICALLY REFERENCED ON THE DRAWINGS.
   B. IN STRUCTURAL TYPICAL DETAILS, ORIENTATION OF BARS IN EACH MAT OF REINFORCEMENT (WHETHER "LINES" OR "DOTS"ARE CLOSER TO THE FACE OF THE CONCRETE) IS GENERALLY ARBITRARY. SEE DRAWINGS OF EACH STRUCTURE FOR ORIENTATION REQUIRED AT THAT STRUCTURE.

6. SEE CIVIL DRAWINGS FOR STRUCTURE COORDINATES. POINTS ON THE STRUCTURES TO WHICH SITE COORDINATES REFER ARE SHOWN ON THE STRUCTURAL PLANS.

7. DRAWINGS PREPARED BY OTHER DISCIPLINES INCLUDE OPENINGS, ANCHORS, PIPES, CONDUITS, AND OTHER ITEMS THAT ARE EMBEDDED INTO OR PASS THROUGH STRUCTURES.

   A. CONFIRM SIZE AND LOCATIONS OF OPENINGS, PENETRATIONS AND EMBEDMENT FOR ITEMS AND EQUIPMENT FURNISHED.
   B. IN GENERAL, OPENINGS, EMBEDMENTS, AND PENETRATIONS LESS THAN 12 INCHES IN DIAMETER ARE NOT SHOWN ON THE CIVIL DRAWINGS AND STRUCTURAL DETAILS .
   C. SEE MECHANICAL DRAWINGS FOR DETAILS OF PIPE PENETRATIONS, PIPE SUPPORTS, AND ASSOCIATED STRUCTURAL REQUIREMENTS.
   D. SEE MECHANICAL DRAWINGS FOR EQUIPMENT PADS AND PIPE SUPPORTS.

STRUCTURAL DESIGN CRITERIA - GENERAL:

SEE DRAWINGS OF INDIVIDUAL STRUCTURES FOR SPECIFIC DESIGN CRITERIA BASED ON THESE OVERALL CRITERIA FOR THE SITE.

1. BUILDING CODE:

   A. 2022 CALIFORNIA BUILDING CODE ("CBC 2022") WITH ASCE 7-16.
   B. LOCAL AMENDMENTS: CITY OF SANTA CRUZ.

2. STRUCTURE RISK CATEGORY: III.

3. DEAD LOADS: CALCULATED FOR STRUCTURE SELF-WEIGHT.

4. LIVE LOADS: (REDUCTIONS NOT USED)

   A. FLOOR LIVE LOAD: SEE PLANS.
   B. GRATING AND CHECKERED PLATE: 100 PSF (UNO).
   C. ROOF LIVE LOAD: SEE PLANS, IF ANY. (20 PSF MINIMUM).
   D. EQUIPMENT LOADS: SEE PLANS.
   E. CONCENTRATED AND IMPACT LOADS: SEE PLANS, IF ANY.

5. FLUID PRESSURE LOADS: 63 PSF/FT (UNO).

6. WIND DESIGN DATA:

   A. SPECIAL WIND REGION: NO
   B. WIND-BORNE DEBRIS REGION: YES
   C. BASIC WIND SPEED (3 SEC GUST, 33 FEET ABOVE GROUND): 98 MPH.

8. EARTHQUAKE DESIGN DATA:

		0.2 SECOND		*1.0 SECOND	
A.	SITE CLASS: D.				
B.	MAPPED SPECTRAL RESPONSE ACCELERATIONS:	Ss = 1.50	g	S1 = 0.6	g
C.	MAXIMUM CONSIDERED ACCELERATIONS:*	Sms = 1.62	g	Sm1 = 1.65	g
D.	DESIGN SPECTRAL RESPONSE ACCELERATIONS:*	Sds = 1.08	g	Sd1 = 1.1	g

(* 5% DAMPED)

9. RAIN LOADS:

   A. DESIGN RAINFALL INTENSITY: i = 1.56 INCHES / HOUR. (100 YEAR/1 HOUR EVENT)

GEOTECHNICAL REPORT / FOUNDATION DESIGN CRITERIA:

1. GEOTECHNICAL INVESTIGATION REPORT (FOR REFERENCE ONLY):

   TITLE: GEOTECHNICAL INVESTIGATION FOR PROPOSED WATER TANK,
   38TH AVENUE - ROLAND DRIVE FACILITY
   PREPARED BY: BAULDRY ENGINEERING INC.
   REPORT NO: 1101-SZ993-B14 DATED: FEBRUARY 1, 2011

2. FOUNDATION DESIGNS ARE BASED ON RECOMMENDATIONS IN THE GEOTECHNICAL INVESTIGATION REPORT.

   A. NET ALLOWABLE: 1900 PSF

   B. MAXIMUM EXPECTED GROUNDWATER: 2-FT BELOW GRADE.

TYPICAL STRUCTURAL MATERIALS:

1. MATERIALS SHALL CONFORM TO THE FOLLOWING REQUIREMENTS UNLESS OTHERWISE INDICATED ON THE DRAWINGS.

2. SEE PROJECT SPECIFICATIONS AND NOTES ON DRAWINGS OF SPECIFIC STRUCTURES FOR DETAILED AND LOCATION-SPECIFIC REQUIREMENTS.

REINFORCING STEEL (FOR CONCRETE AND MASONRY):

1. DEFORMED BARS:
   A. TYPICAL: ASTM A 615, GRADE 60.
   B. WHERE INDICATED ON THE DRAWINGS: ASTM A 706.

2. WELDED WIRE FABRIC: ASTM A 1064.

CONCRETE:

1. NORMAL DENSITY.

2. MINIMUM SPECIFIED CONCRETE COMPRESSIVE STRENGTH, f'c (AT 28 DAYS UNO).

   A. STRUCTURES: "CLASS A"OR "CLASS B" f'c = 4500 PSI.
   B. FILL AND THRUST BLOCKS: "CLASS C" f'c = 2500 PSI.
   C. PIPE ENCASEMENT: "CLASS _" f'c = 4,00 PSI.
   D. ELECTRICAL DUCT ENCASEMENT: "CLASS CE" f'c = 2500 PSI.
   E. PRECAST AND PRECAST-PRESTRESSED MEMBERS: "CLASS D" f'c = 5000 PSI.

STRUCTURAL STEEL:

1. SECTIONS

   A. SHAPES W, WT: ASTM A 992 (Fy = 50 KSI)
   B. SHAPES S, ST, M, MT, HP, C, MC, L: ASTM A 36 (Fy = 36 KSI)
   C. PLATES AND BARS: ASTM A 36 (Fy = 36 KSI)
   D. PIPES: ASTM A 53, GRADE B (Fy = 35 KSI)
   E. HOLLOW STRUCTURAL SECTIONS:
      ROUND: ASTM A 500, GRADE B (Fy = 42 KSI)
      SQUARE AND RECTANGULAR: ASTM A 500, GRADE B (Fy = 46 KSI)

2. CONNECTIONS:

   A. BOLTS - STEEL TO-STEEL:
      ASTM F 3125 GRADE A325 HIGH-STRENGTH BOLTS, WITH LOAD INDICATOR WASHERS.
   B. BOLTS - STEEL TO CONCRETE OR MASONRY:
      ANCHOR BOLTS WITH HEX FORGED HEAD.
      ASTM F 593, STAINLESS TYPE 316 (304)
      ASTM F 1554, GRADE 36 GALVANIZED.
   C. WELDS - SHIELDED METAL ARC PROCESS USING E70-XX ELECTRODES.

STAINLESS STEEL:

1. ANSI TYPE 316/316L EXCEPT WHERE TYPE 304/304L IS INDICATED ON THE DRAWINGS.

2. SECTIONS: SHAPES AND BARS: ASTM A 276.

3. BOLTED CONNECTIONS - BOLTS AND ANCHOR BOLTS:

   A. MATCH ALLOY OF THE STRUCTURAL MEMBERS CONNECTED.
   B. TYPE 316/316L: ASTM F 593, GRADE B8M, CLASS 1, HEAVY HEX.
   C. TYPE 304/304L: ASTM F 593, GRADE B8, CLASS 1, HEAVY HEX.

4. WELDED CONNECTIONS:

   A. TYPE 316L: E316L-15 ELECTRODES.
   B. TYPE 304L: E304L-15 ELECTRODES.

STRUCTURAL ALUMINUM:

1. SECTIONS

   A. SHAPES: ASTM B 308, ALLOY 6061-T6.
   B. SHEET AND PLATE: ASTM B 209, ALLOY 6061-T6.

2. BOLTED CONNECTIONS - BOLTS AND ANCHOR BOLTS:

   A. STAINLESS STEEL - TYPE 316, ASTM F 593, GRADE B8M, CLASS 1, HEAVY HEX.

3. WELDED CONNECTIONS:

   A. GAS METAL ARC (MIG) OR GAS TUNGSTEN ARC (TIG) PROCESS USING FILLER ALLOY 4043 ELECTRODES.

CONSTRUCTION:

CONFORM TO THE FOLLOWING REQUIREMENTS UNLESS OTHERWISE INDICATED ON THE DRAWINGS.

EXCAVATION AND BACKFILLING:

1. EXPOSE AND PREPARE SUBGRADE AS SHOWN ON THE DRAWINGS AND SPECIFIED. OBTAIN ENGINEER'S OBSERVATION OF SUBGRADE SURFACES, AS EXPOSED AND AS PREPARED, BEFORE PROCEEDING WITH FOUNDATION CONSTRUCTION.

2. DO NOT PLACE BACKFILL AGAINST WALLS UNTIL STRUCTURES SUPPORTING THE TOP OF THE WALL ARE IN PLACE, ARE COMPLETE, AND (IN THE CASE OF CONCRETE) HAVE CURED TO THEIR MINIMUM SPECIFIED 28-DAY COMPRESSIVE STRENGTH.

3. WHERE BACKFILL MUST BE PLACED AGAINST WALLS BEFORE STRUCTURES ABOVE ARE COMPLETE, PROVIDE BRACING FOR WALLS. KEEP BRACING IN PLACE UNTIL THE STRUCTURE ABOVE IS COMPLETE AND (IN THE CASE OF CONCRETE) HAS CURED TO ITS MINIMUM SPECIFIED 28-DAY COMPRESSIVE STRENGTH.

CONCRETE:

1. SEE SC001/TYP FOR CONCRETE NOTES, INCLUDING CLEAR COVER AND LAP SPLICE LENGTH REQUIREMENTS FOR REINFORCING.

2. SUBMIT LOCATIONS OF CONSTRUCTION JOINTS NOT SHOWN ON THE DRAWINGS FOR ACCEPTANCE BY THE ENGINEER BEFORE FORM LAYOUT.

3. PROVIDE CHAMFER AT EXPOSED EDGES OF CAST-IN-PLACE CONCRETE. SEE SPECIFICATION 03_30_01 FOR CHAMFERS.

4. PROVIDE REINFORCING:

   A. AT CORNERS AND JUNCTIONS - AS INDICATED IN SC310/TYP, SUPPLEMENT WITH ADDED BARS WHERE INDICATED ON THE DRAWINGS.
   B. AT OPENINGS - AS INDICATED IN SC012/TYP.

5. WELDING OF REINFORCING IS NOT PERMITTED UNLESS DETAILED ON THE DRAWINGS OR ACCEPTED IN ADVANCE BY THE ENGINEER.

6. MAINTAIN MINIMUM 3 INCHES CLEAR CONCRETE COVER BETWEEN REINFORCING AND EMBEDMENTS.

7. FINISH CONCRETE AS SPECIFIED IN SECTION 03_30_01.

STEEL, STAINLESS STEEL, AND ALUMINUM - CONNECTIONS:

1. BOLTED:

   A. MADE USING 3/4-INCH DIAMETER BOLTS.
   B. HAVING A MINIMUM OF 2 BOLTS, SPACED NOT CLOSER THAN 3 INCHES ON CENTER.
   C. WITH A DISTANCE OF AT LEAST 1 1/2 INCHES FROM CENTER OF BOLT TO ANY EDGE OF A PLATE OR STRUCTURAL ELEMENT.

2. WELDED:

   A. FILLET WELDS: PER AWS CODE BASED ON THE THICKNESS OF THE MATERIALS BEING JOINED, AND FULL LENGTH OF THE JOINT.

3. INTERFACE BETWEEN MATERIALS:

   A. AT BOLTED CONNECTIONS THAT INCLUDE DIFFERENT METALS (E.G.: STEEL AND STAINLESS STEEL, OR ALUMINUM AND STEEL) PROVIDE ISOLATING SLEEVES AND WASHERS AS SPECIFIED IN SECTION 05_05_24.
   B. WHERE ALUMINUM IS IN CONTACT WITH MASONRY OR CONCRETE, COAT ALUMINUM SURFACES AS SPECIFIED IN SECTION 09_96_01.

4. POST-INSTALLED ANCHORS IN CONCRETE AND MASONRY:

   A. INSTALL IN FULL COMPLIANCE WITH ACCEPTED BUILDING CODE EVALUATION REPORT AND MANUFACTURER'S INSTRUCTIONS.
   B. DO NOT CUT, DAMAGE, OR INTERRUPT EXISTING REINFORCEMENT TO INSTALL ANCHORS. USE NON-DESTRUCTIVE TESTING EQUIPMENT TO IDENTIFY LOCATIONS OF REINFORCEMENT IN MEMBERS BEFORE DRILLING HOLES FOR ANCHORS.

METAL FABRICATIONS:

1. HANDRAILS AND GUARDRAILS:

   A. ALUMINUM, EXCEPT WHERE OTHER MATERIALS ARE NOTED.

2. GRATING:

   A. ALUMINUM WITH TYPE 316 STAINLESS STEEL FASTENERS, UNLESS OTHERWISE NOTED.
   B. GRATING AND ITS SEATS OR SUPPORTS SHALL BE OF THE SAME MATERIAL.
   C. UNLESS INDICATED ON THE DRAWINGS AS "REMOVABLE GRATING", SECURELY FASTEN GRATING TO SUPPORTS.

3. COVER PLATES:

   A. ALUMINUM WITH TYPE 316 STAINLESS STEEL FASTENERS, UNLESS OTHERWISE NOTED.
   B. COVER PLATE AND ITS SEATS OR SUPPORTS SHALL BE OF THE SAME MATERIAL.

SPECIAL INSPECTION:

1. SPECIAL INSPECTION IS REQUIRED FOR THE FOLLOWING STRUCTURAL MATERIALS AND CONSTRUCTION. SEE SPECIFICATION SECTION 01_45_24 FOR DETAILS.

2. DIVISION 03 CONCRETE:

   A. LOCATIONS.
   B. FORMWORK AND MEMBER SIZES.
   C. REINFORCING STEEL.
   D. ANCHORS: CAST-IN AND POST-INSTALLED.
   E. CONCRETE MIX AND PLACEMENT.
   F. PROTECTION AND CURING PROCEDURES.

3. DIVISION 05 METALS

   A. GENERAL ALL METALS:
      1) MEMBER LOCATIONS.
      2) MEMBER SIZES/TYPES.
      3) ANCHORS - CAST-IN AND BUILT-IN ANCHOR BOLTS.
      4) ANCHORS - POST-INSTALLED MECHANICAL AND ADHESIVE.

STRUCTURAL OBSERVATION:

1. STRUCTURAL OBSERVATION IS REQUIRED DURING AND AT SPECIFIC STAGES OF CONSTRUCTION. SEE SPECIFICATION SECTION 01_45_24 FOR DETAILS.

STRUCTURAL SYMBOLS:

1. SEE DRAWING 00G03 FOR KEY TO DRAWING TITLES AND SECTION CUTS, AND FOR DEFINITION OF MATERIALS SHADING PATTERNS.

2. WELDING: SYMBOLS: IN ACCORDANCE WITH AMERICAN WELDING SOCIETY (AWS) A2.4.

STRUCTURAL ABBREVIATIONS:

1. SEE DRAWING 00G04 FOR GENERAL LIST OF ABBREVIATIONS USED ON DRAWINGS.

2. ABBREVIATIONS FOR NAMES OF TECHNICAL GROUPS MAY BE FOUND IN THE PROJECT SPECIFICATIONS.

3. STRUCTURAL MEMBERS:

   A. STEEL: ABBREVIATIONS AND DESIGNATIONS ARE IN ACCORDANCE WITH THE AMERICAN INSTITUTE OF STEEL CONSTRUCTION'S STEEL CONSTRUCTION MANUAL, CURRENT EDITION.

   B. ALUMINUM: ABBREVIATIONS AND DESIGNATIONS ARE IN ACCORDANCE WITH THE ALUMINUM ASSOCIATION'S ALUMINUM DESIGN MANUAL, CURRENT EDITION.

REV	DATE	BY	DESCRIPTION

DESIGNED AE
DRAWN MM
CHECKED JN
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER AZMAN EZADDIN No. 53219 CIVIL STATE OF CALIFORNIA

Digitally signed by Azman Ezaddin
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.11 14:25:25-07'00'

carollo®

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
CIVIL
STRUCTURAL NOTES FOR CIVIL IMPROVEMENTS

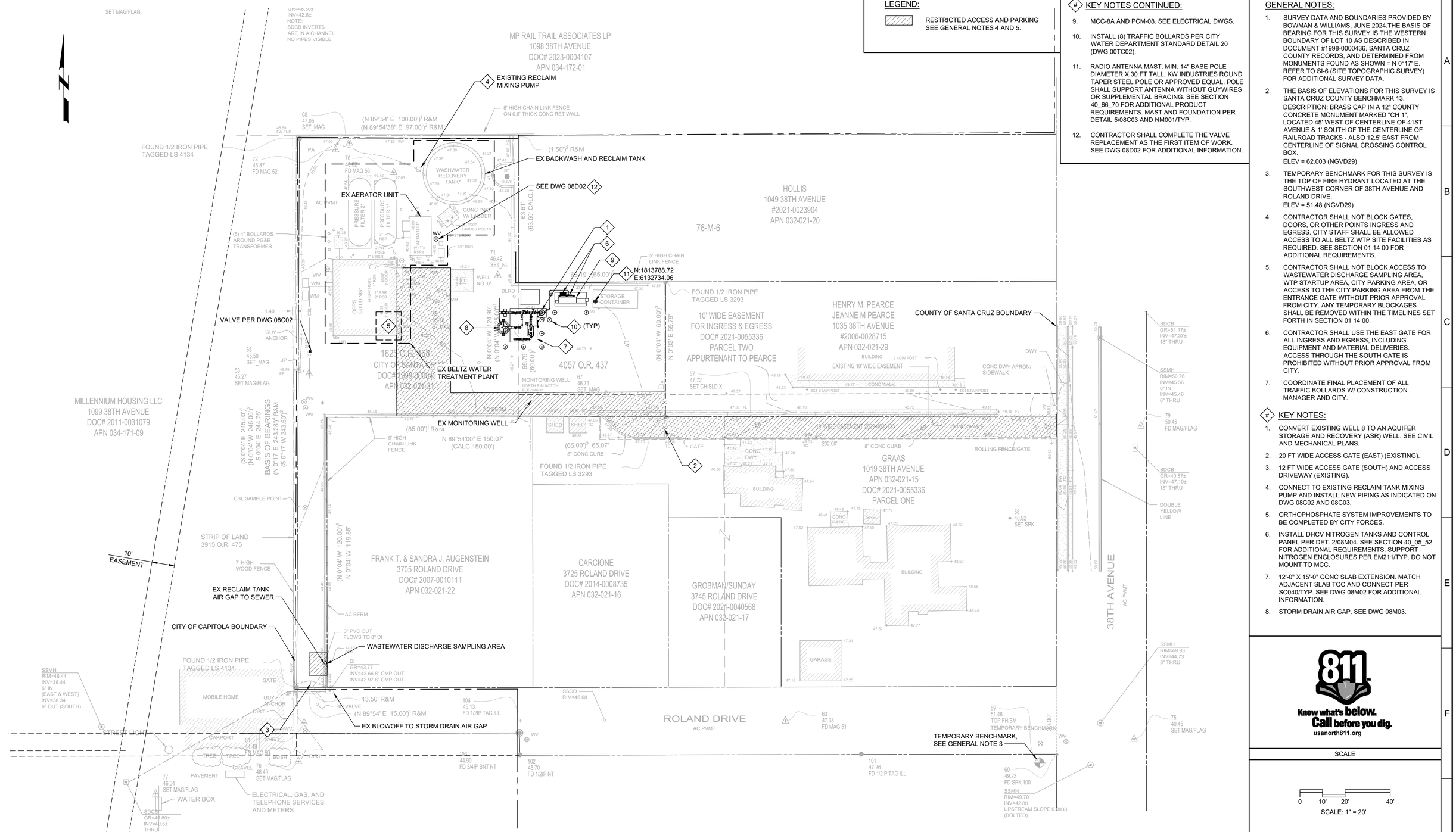
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00GS01
SHEET NO. 9 OF 71

PROJECT NO. 202431-100000 FILE NAME: 20243100GS01.dgn

Plot Date: 11-SEP-2025 11:56:40 AM
User: svcPW
PlotScale: 1:1
DesignScript: Carollo_Std_Pen_v0905.pen
ColorTable: gshade.ctb
Model: Layout1
LAST SAVED BY: OBarranco

Plot Date: 4/2/2024 1:14:16 PM



LEGEND:

▨ RESTRICTED ACCESS AND PARKING SEE GENERAL NOTES 4 AND 5.

KEY NOTES CONTINUED:

9. MCC-8A AND PCM-08. SEE ELECTRICAL DWGS.
10. INSTALL (8) TRAFFIC BOLLARDS PER CITY WATER DEPARTMENT STANDARD DETAIL 20 (DWG 00TC02).
11. RADIO ANTENNA MAST. MIN. 14" BASE POLE DIAMETER X 30 FT TALL, KW INDUSTRIES ROUND TAPER STEEL POLE OR APPROVED EQUAL. POLE SHALL SUPPORT ANTENNA WITHOUT GUYWIRES OR SUPPLEMENTAL BRACING. SEE SECTION 40_66_70 FOR ADDITIONAL PRODUCT REQUIREMENTS. MAST AND FOUNDATION PER DETAIL 5/08C03 AND NM001/TYP.
12. CONTRACTOR SHALL COMPLETE THE VALVE REPLACEMENT AS THE FIRST ITEM OF WORK. SEE DWG 08D02 FOR ADDITIONAL INFORMATION.

GENERAL NOTES:

1. SURVEY DATA AND BOUNDARIES PROVIDED BY BOWMAN & WILLIAMS, JUNE 2024.THE BASIS OF BEARING FOR THIS SURVEY IS THE WESTERN BOUNDARY OF LOT 10 AS DESCRIBED IN DOCUMENT #1998-0000436, SANTA CRUZ COUNTY RECORDS, AND DETERMINED FROM MONUMENTS FOUND AS SHOWN = N 0°17' E. REFER TO SI-6 (SITE TOPOGRAPHIC SURVEY) FOR ADDITIONAL SURVEY DATA.
2. THE BASIS OF ELEVATIONS FOR THIS SURVEY IS SANTA CRUZ COUNTY BENCHMARK 13.
   DESCRIPTION: BRASS CAP IN A 12" COUNTY CONCRETE MONUMENT MARKED "CH 1", LOCATED 45' WEST OF CENTERLINE OF 41ST AVENUE & 1' SOUTH OF THE CENTERLINE OF RAILROAD TRACKS - ALSO 12.5' EAST FROM CENTERLINE OF SIGNAL CROSSING CONTROL BOX.
   ELEV = 62.003 (NGVD29)
3. TEMPORARY BENCHMARK FOR THIS SURVEY IS THE TOP OF FIRE HYDRANT LOCATED AT THE SOUTHWEST CORNER OF 38TH AVENUE AND ROLAND DRIVE.
   ELEV = 51.48 (NGVD29)
4. CONTRACTOR SHALL NOT BLOCK GATES, DOORS, OR OTHER POINTS INGRESS AND EGRESS. CITY STAFF SHALL BE ALLOWED ACCESS TO ALL BELTZ WTP SITE FACILITIES AS REQUIRED. SEE SECTION 01 14 00 FOR ADDITIONAL REQUIREMENTS.
5. CONTRACTOR SHALL NOT BLOCK ACCESS TO WASTEWATER DISCHARGE SAMPLING AREA, WTP STARTUP AREA, CITY PARKING AREA, OR ACCESS TO THE CITY PARKING AREA FROM THE ENTRANCE GATE WITHOUT PRIOR APPROVAL FROM CITY. ANY TEMPORARY BLOCKAGES SHALL BE REMOVED WITHIN THE TIMELINES SET FORTH IN SECTION 01 14 00.
6. CONTRACTOR SHALL USE THE EAST GATE FOR ALL INGRESS AND EGRESS, INCLUDING EQUIPMENT AND MATERIAL DELIVERIES. ACCESS THROUGH THE SOUTH GATE IS PROHIBITED WITHOUT PRIOR APPROVAL FROM CITY.
7. COORDINATE FINAL PLACEMENT OF ALL TRAFFIC BOLLARDS W/ CONSTRUCTION MANAGER AND CITY.

KEY NOTES:

1. CONVERT EXISTING WELL 8 TO AN AQUIFER STORAGE AND RECOVERY (ASR) WELL. SEE CIVIL AND MECHANICAL PLANS.
2. 20 FT WIDE ACCESS GATE (EAST) (EXISTING).
3. 12 FT WIDE ACCESS GATE (SOUTH) AND ACCESS DRIVEWAY (EXISTING).
4. CONNECT TO EXISTING RECLAIM TANK MIXING PUMP AND INSTALL NEW PIPING AS INDICATED ON DWG 08C02 AND 08C03.
5. ORTHOPHOSPHATE SYSTEM IMPROVEMENTS TO BE COMPLETED BY CITY FORCES.
6. INSTALL DHCV NITROGEN TANKS AND CONTROL PANEL PER DET. 2/08M04. SEE SECTION 40_05_52 FOR ADDITIONAL REQUIREMENTS. SUPPORT NITROGEN ENCLOSURES PER EM211/TYP. DO NOT MOUNT TO MCC.
7. 12'-0" X 15'-0" CONC SLAB EXTENSION. MATCH ADJACENT SLAB TOC AND CONNECT PER SC040/TYP. SEE DWG 08M02 FOR ADDITIONAL INFORMATION.
8. STORM DRAIN AIR GAP. SEE DWG 08M03.

Know what's below. Call before you dig. usanorth811.org

SCALE

0 10' 20' 40'

SCALE: 1" = 20'

REV	DATE	BY	DESCRIPTION

DESIGNED MED
DRAWN ART
CHECKED LL
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER MICHAEL E. DUCKER No. 63626 CIVIL STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:16:47 -07'00'

carollo

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

CIVIL

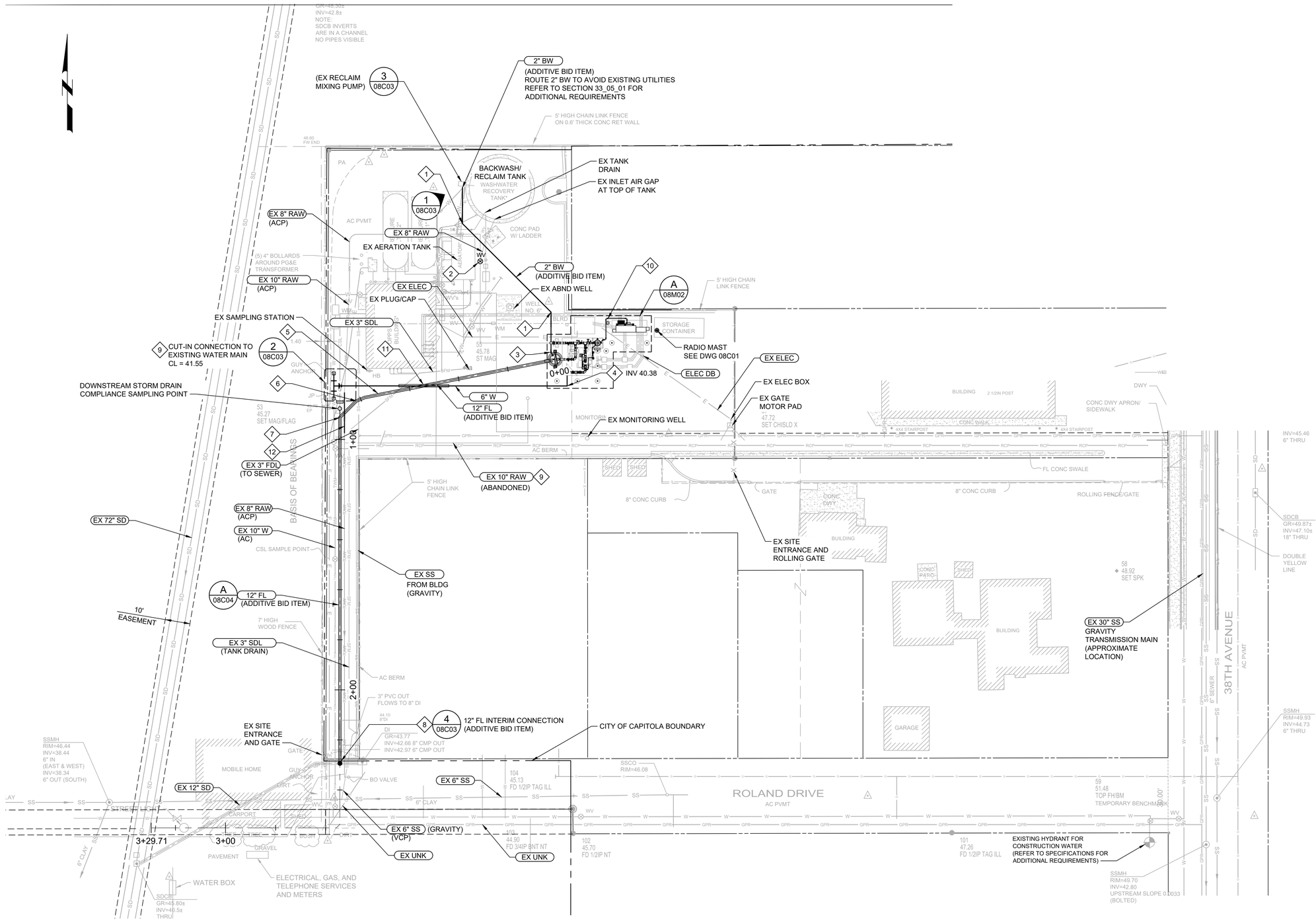
WELL 8 SITE PLAN AND SURVEY CONTROL

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08C01
SHEET NO. 10 OF 71

LAST SAVED BY: alucker

PROJECT NO. 202431-100000 FILE NAME: 20243108C01.dwg



GENERAL NOTES:

1. ALL WORKERS MUST ATTEND ENVIRONMENTAL TRAINING PRIOR TO WORKING ON-SITE.
2. REFER TO SECTION 01 57 13 FOR EROSION AND SEDIMENT CONTROL REQUIREMENTS AND WATER DISCHARGE REQUIREMENTS.
3. REFER TO SECTION 01 35 43 FOR ENVIRONMENTAL REQUIREMENTS REGARDING MITIGATION MEASURES AND STANDARD CONSTRUCTION PRACTICES.
4. STANDARD WORK HOURS ARE 8:00 AM TO 5:00 PM. REFER TO SECTION 01 14 00.
5. ALL PRESSURIZED PIPING SHALL BE RESTRAINED. INSTALL THRUST BLOCKS ON BURIED PIPING AND RESTRAIN JOINTS PER CITY WATER DEPARTMENT STANDARD DETAILS 18 AND 19.
6. REFER TO SPECIFICATIONS FOR TRENCHING, PIPELINE MATERIAL, INSTALLATION, AND TESTING REQUIREMENTS.
7. CONSTRUCT TRENCHES AND INSTALL PIPING PER CITY WATER DEPARTMENT STANDARD DETAIL 15.
8. WHERE MINIMUM 36" COVER COVER CANNOT BE ACHIEVED, INSTALL PIPING PER CITY WATER DEPARTMENT STANDARD DETAIL 16.
9. AFTER INSTALLATION OF UNDERGROUND UTILITIES OR DISTURBING EXISTING GRADE RETURN TO ORIGINAL GRADE AND SURFACE.
10. ALL NEW PIPING IS BURIED EXCEPT WHERE SHOWN AS ABOVE GROUND ON MECHANICAL DWGS OR DWG 08C03.
11. ALL NEW PIPING SHALL BE PRESSURE TESTED AND DISINFECTED PER CITY WATER DEPARTMENT STANDARD SPECIFICATIONS. CITY STAFF WILL ONLY DISINFECT AND TEST PIPES ON MONDAYS, TUESDAYS, AND WEDNESDAYS.
12. REFER TO SPECIFICATIONS FOR DESCRIPTION OF ADDITIVE BID ITEMS.

KEY NOTES:

1. 2" 45° ELL (ADDITIVE BID ITEM).
2. REPLACE EXISTING GATE VALVE. SEE DWG 08D02.
3. 2" BW METER AND VALVE. SEE DWGS 08M02 AND 08M03 (ADDITIVE BID ITEM).
4. 6" 90° ELL.
5. 12" 11.25° ELL (ADDITIVE BID ITEM).
6. 12" 22.5° ELL (ADDITIVE BID ITEM).
7. 12" WYE W/ 4" TYPE I CLEANOUT PER DET. CY411/TYP (ADDITIVE BID ITEM).
8. CONSTRUCT 12" FL TO 12" SD INTERIM CONNECTION (ADDITIVE BID ITEM). CONTRACTOR SHALL POTHOLE TO FIELD VERIFY THE LOCATION, DEPTH, AND DIAMETER OF THE EXISTING SD PIPELINE FOR THE INTERIM CONNECTION. SEE SECTIONS 01 14 00 AND 33_05_01 FOR ADDITIONAL REQUIREMENTS.
9. EXISTING 10" W IS ACP. REFER TO SECTION 01 35 43.13 FOR HAZARDOUS MATERIALS PROCEDURES.
10. ROUTE NITROGEN PIPING TO AVOID EXISTING LIGHT POLE BASE AND OTHER EXISTING UTILITIES.
11. 6" W INV. 40.38 AT INTERSECTION WITH 12" FL. SEE PROFILE A/08C04. ENCASE 6" W IN CONCRETE PER DET. CY119/TYP, EXTENDING 10 FT EACH SIDE OF POINT OF INTERSECTION.
12. RELOCATE A PORTION OF THE EX 8" RAW PIPELINE IF THE 12" FL (ADDITIVE BID ITEM) IS EXECUTED. SEE DET. 6/08C03. FIELD VERIFY DEPTH OF EX 8" RAW AT CROSSING LOCATION PRIOR TO PREPARATION OF SHOP DRAWING SUBMITTALS.

Know what's below. Call before you dig. usanorth811.org

SCALE

0 10' 20' 40'

SCALE: 1" = 20'

REV	DATE	BY	DESCRIPTION

DESIGNED MED
DRAWN ART
CHECKED LL
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER MICHAEL E. DUCKER No. 63626 CIVIL STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:18:34-07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

CIVIL

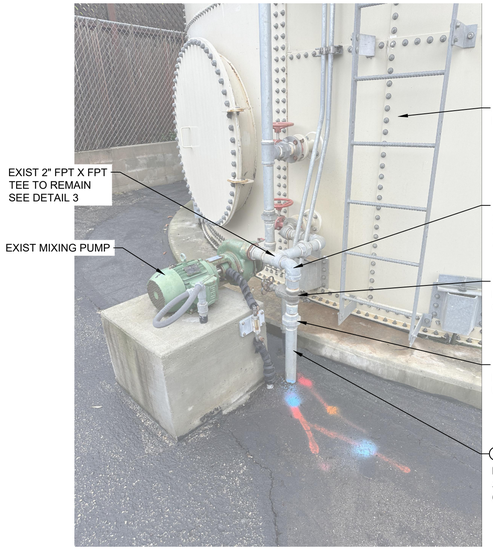
WELL 8 YARD PIPING PLAN

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08C02
SHEET NO. 11 OF 71

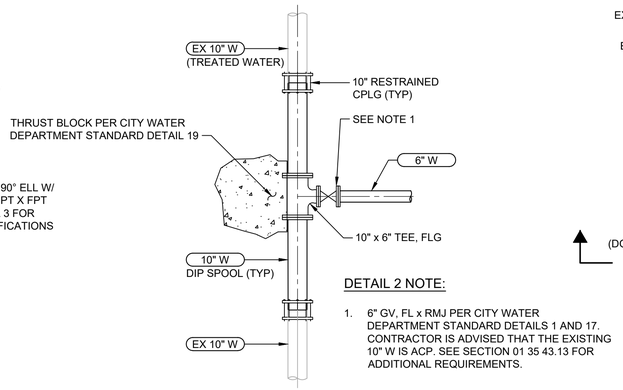
Plot Date: 8/6/2025 3:01:19 PM
LAST SAVED BY: atucker

PROJECT NO. 202431-100000 FILE NAME: 20243108C02.dwg 9/10/2025



BACKWASH/RECLAIM TANK MIXING PUMP MODIFICATIONS
(ADDITIVE BID ITEM)

1 PHOTO
08C02 — FILE: 20243108C03
SCALE: NO SCALE

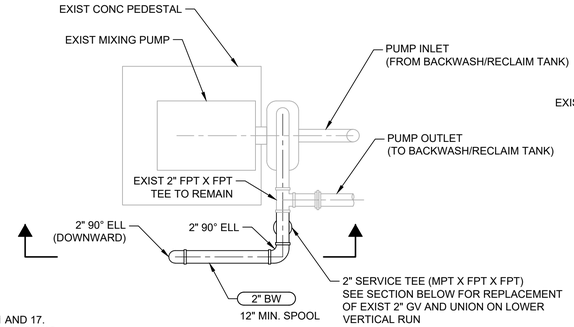


DETAIL 2 NOTE:

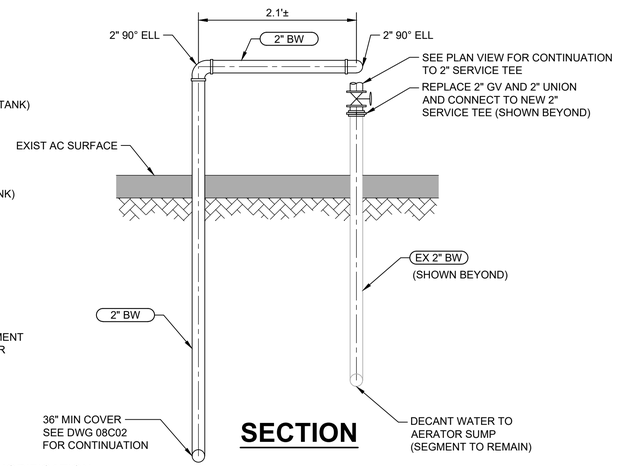
1. 6" GV, FL x RMJ PER CITY WATER DEPARTMENT STANDARD DETAILS 1 AND 17. CONTRACTOR IS ADVISED THAT THE EXISTING 10" W IS ACP. SEE SECTION 01 35 43.13 FOR ADDITIONAL REQUIREMENTS.

WATER MAIN CONNECTION

2 DETAIL
08C02 — SCALE: NO SCALE
FILE: 20243108C02



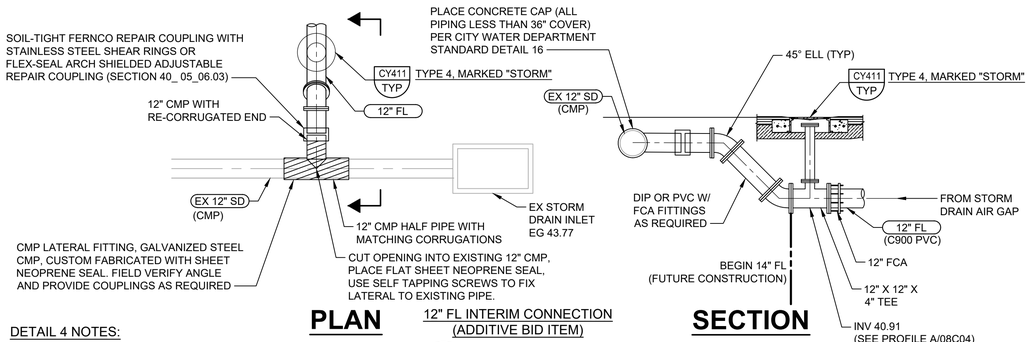
PLAN



SECTION

BACKWASH PIPING MODIFICATION
(ADDITIVE BID ITEM)

3 DETAIL
08C02 — SCALE: 1" =1'
FILE: 20243108C03



PLAN **SECTION**

12" FL INTERIM CONNECTION
(ADDITIVE BID ITEM)

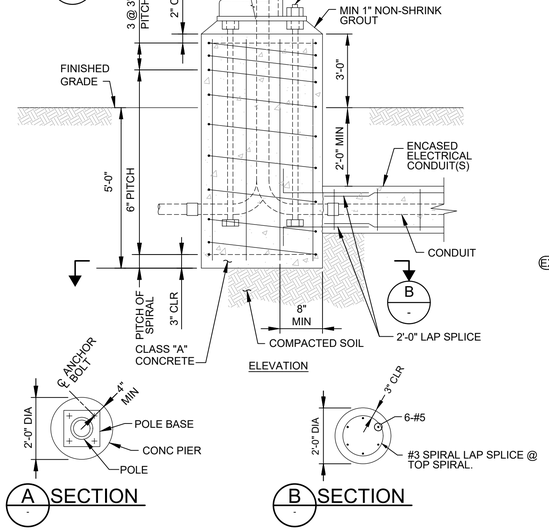
4 DETAIL
08C02 — SCALE: NO SCALE
FILE: -

DETAIL 4 NOTES:

1. EXISTING 12" SD HAS DEFORMED TO APPROXIMATELY 10" X 12" ELLIPTICAL SHAPE. CONTRACTOR SHALL FIELD VERIFY ALIGNMENT, DEPTH, AND ACTUAL DIMENSIONS OF SD PIPELINE PRIOR TO PREPARATION OF SHOP DRAWING SUBMITTALS FOR TEE CONNECTION.

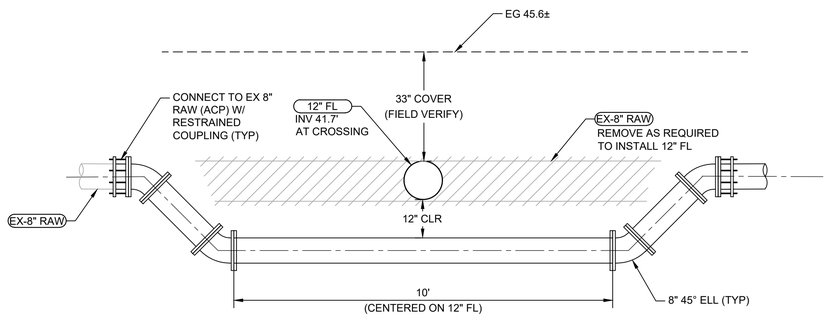
FUTURE CONSTRUCTION NOTES:

1. TO RETROFIT THE INTERIM CONNECTION FOR THE 14" FL EXTENSION, CUT AND CAP THE BRANCH OF THE CMP LATERAL FITTING (TEE). REMOVE REPAIR COUPLING, PIPE, AND FITTINGS BETWEEN THE CMP LATERAL FITTING AND CLEANOUT TEE. EXTEND THE 14" FL FROM THE CLEANOUT TEE PER PROFILE A/08C04.



RADIO MAST FOUNDATION

5 DETAIL
08C01 — SCALE: NO SCALE
FILE: -



RAW WATER RELOCATION
(ADDITIVE BID ITEM)

6 DETAIL
08C02 — SCALE: 1" = 2'
FILE: -

REV	DATE	BY	DESCRIPTION

DESIGNED MED
DRAWN ART
CHECKED LL
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER — MICHAEL E. DUCKER — No. 63626 — CIVIL — STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:18:22-07'00'

carollo

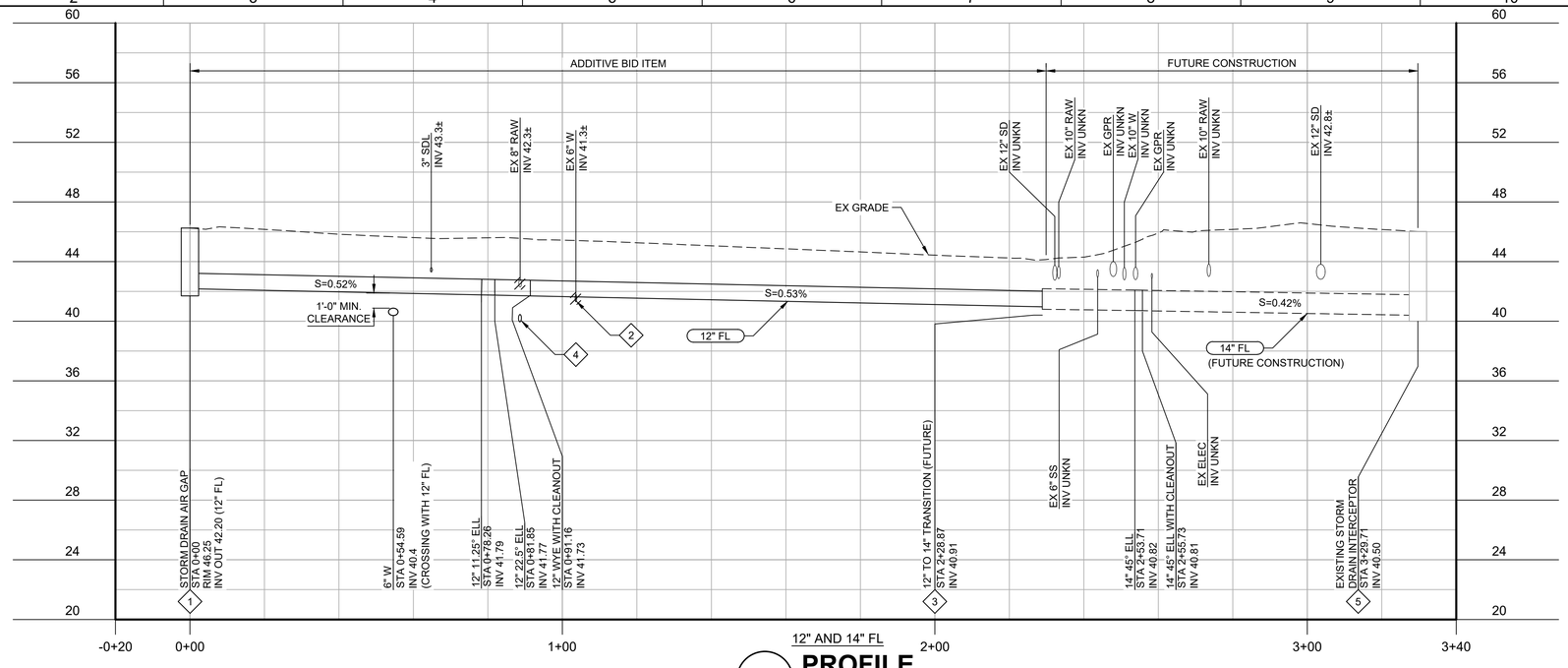
CITY OF SANTA CRUZ

CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
CIVIL
MISCELLANEOUS CIVIL DETAILS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 — 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08C03
SHEET NO. 12 OF 71

Plot Date: 9/12/2022 7:29:07 AM
LAST SAVED BY: atucker
PROJECT NO. 202431-100000 FILE NAME: 20243108C03.dwg



12" AND 14" FL

A PROFILE

FILE: -

GENERAL NOTES:

1. PROFILE A REFLECTS THE ADDITIVE BID ITEM PROFILE (12" FL) AND FUTURE CONSTRUCTION PROFILE (14" FL). SEE KEYNOTE 3 AND DRAWING 08C02 FOR BASE BID REQUIREMENTS.
2. ALL PRESSURIZED PIPING SHALL BE RESTRAINED.
3. REFER TO SPECIFICATIONS FOR TRENCHING, PIPELINE MATERIAL, INSTALLATION, AND TESTING REQUIREMENTS.
4. FIELD VERIFY HORIZONTAL AND VERTICAL LOCATIONS OF ALL EXISTING UTILITIES TO BE CROSSED BY NEW PIPELINES. SEE SUPPLEMENTAL INFORMATION SI-5 FOR AVAILABLE POTHOLE DATA.

◇ KEY NOTES:

1. STORM DRAIN AIR GAP. SEE DWG 08M03 FOR ADDITIONAL INFORMATION.
2. EX. 6" HYDRANT LATERAL TO BE ABANDONED. SEE DWG 08D01.
3. IF ADDITIVE BID ITEM IS EXECUTED, CONSTRUCT 12" INTERIM CONNECTION PER DET. 4/08C03. IF ADDITIVE BID ITEM IS NOT EXECUTED UNDER THIS CONSTRUCTION CONTRACT, THEN FUTURE CONSTRUCTION OF THE 12" FL AND 14" FL SHALL INCLUDE A 12"X14" CONCENTRIC REDUCER AT THIS LOCATION.
4. RELOCATE EX 8" RAW TO CROSS BELOW 12" FL. SEE DET. 6/08C03. FIELD VERIFY HORIZONTAL AND VERTICAL LOCATION OF EX 8" RAW PRIOR TO PREPARATION OF SHOP DRAWING SUBMITTALS.
5. FUTURE CONNECTION TO EXISTING STORM DRAIN INTERCEPTOR.

KEY NOTES FOR FUTURE CONSTRUCTION:

THESE NOTES ARE PROVIDED FOR REFERENCE ONLY. ENGINEER SHALL VERIFY THE ADEQUACY OF THESE NOTES BASED ON THE AS-BUILT CONDITIONS OF THE BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY PRIOR TO FUTURE ISSUANCE FOR BIDDING AND CONSTRUCTION.

6. WASTE DRAIN PUMP STATION WET WELL.
7. WASTE DRAIN PUMP STATION VALVE VAULT.
8. 4" BACKFLOW PREVENTER. SEE CITY WATER DEPARTMENT STANDARD DETAIL 6.
9. 4" CHECK VALVE VAULT.
10. CONSTRUCT NEW MANHOLE AROUND EXISTING 30" SS PER COUNTY OF SANTA CRUZ DETAIL SS-5.

Know what's **below.**
Call before you dig.
usanorth811.org

SCALE

0 10' 20' 40'
SCALE: 1" = 20' (HORIZ)

0 2.5' 5' 10'
SCALE: 1" = 5' (VERT)

REV	DATE	BY	DESCRIPTION

DESIGNED MED
DRAWN ART
CHECKED LL
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER
MICHAEL E. DUCKER
No. 63626
CIVIL
STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:15:51-07'00'

carollo®

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
CIVIL
WELL 8 YARD PIPING PROFILES

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08C04
SHEET NO. 13 OF 71

Plot Date: 9/12/2022 7:29:07 AM
LAST SAVED BY: atucker

PROJECT NO. 202431-100000 FILE NAME: 20243108C04.dwg

PIPING SYMBOLS

DOUBLE LINE	SINGLE LINE	DESCRIPTION
		WELDED JOINT
		GROOVED END JOINT
		FLANGED JOINT
		HUB & SPIGOT JOINT (RUBBER GASKET)
		PUSH-ON JOINT (RESTRAINED)
		ADAPTER SIDE GROOVED END ADAPTER FLANGE
		FLANGED COUPLING ADAPTER
		FLANGED COUPLING ADAPTER WITH THRUST TIES
		FLEXIBLE COUPLING
		FLEXIBLE COUPLING WITH THRUST TIES
		METAL BELLOWS EXP JOINT
		ELASTOMER BELLOWS EXP JOINT
		FLEXIBLE COUPLING ADAPTER
		DISMANTLING JOINT
		EXPANSION COMPENSATOR
		ELBOW UP
		ELBOW DOWN
		TEE UP
		TEE DOWN
		LATERAL UP
		LATERAL DOWN
		CONCENTRIC REDUCER
		ECCENTRIC REDUCER (FOT. FOB)
		UNION
		CAP
		ANCHOR
		ELBOW, 90 DEGREE
		CROSS
		TEE
		ELBOW, 45 DEGREE
		ELBOW, 22.5 DEGREE
		ELBOW, 11.25 DEGREE
		LATERAL

DOUBLE LINE	SINGLE LINE	DESCRIPTION
		GATE VALVE
	K	KNIFE GATE VALVE
		BUTTERFLY VALVE
V	V	CHARACTERIZED BALL CONTROL VALVE
		BALL VALVE
		GLOBE VALVE
		3-WAY GLOBE TYPE MIXING VALVE
		FOUR WAY VALVE
		DIAPHRAGM VALVE
		PLUG VALVE
		LUBRICATED PLUG VALVE
		ECCENTRIC PLUG VALVE
		CONCENTRIC PLUG VALVE
		SWING CHECK VALVE
		WAFER CHECK VALVE
		PINCH VALVE
		BALL CHECK VALVE
		DUAL CHECK VALVE
		SILENT CHECK VALVE
		MUD VALVE (PLAN VIEW)
		NEEDLE VALVE
		CHECK BACKFLOW PREVENTER
		PIPE MATERIAL CHANGE
	M	MOTOR OPERATED VALVE

MECHANICAL SYMBOLS

SINGLE LINE	DESCRIPTION
	AIR OR CHEMICAL DIFFUSER
	QUICK DISCONNECT HIGH PRESSURE AIR OR FLUSHING
	BATCHMETER
	AIR VENT
	BASKET STRAINER
	BLOWER
	CALIBRATION COLUMN
	COMPRESSOR/TURBINE
	COMPRESSOR: RECIPROCATING
	DIAPHRAGM SEAL
	DRAIN
	EJECTOR OR EDUCTOR
M	ELECTRIC MOTOR
	EQUIPMENT DRAIN
	EXPANSION JOINT, FLEXIBLE VIBRATION JOINT
	FAN: EXHAUST/SUPPLY
	FILTER
	FIRE HYDRANT
	FLAME ARRESTER
	FLAME ARRESTER WITH THERMALLY OPERATED VALVE
	FLOOR DRAIN
	FLOW SWITCH
	GAUGE: PRESSURE
	GAUGE: DIFFERENTIAL PRESSURE
	WEIR
	MIXER
	OIL OR MOISTURE TRAP
	PRIMARY LEVEL ELEMENT: BUBBLER
	PRIMARY LEVEL ELEMENT: ELECTRODE
	PRIMARY LEVEL ELEMENT: FLOAT SWITCH
	PRIMARY LEVEL ELEMENT: FLUID
	PRIMARY LEVEL ELEMENT: INVERTED COLUMN

SINGLE LINE	DESCRIPTION
	PRIMARY LEVEL ELEMENT: RADAR
	PRIMARY LEVEL ELEMENT: ULTRASONIC
	PRIMARY FLOW ELEMENT: FLUME
X	PRIMARY FLOW ELEMENT: X = C - CORIOLIS X = M - MAGNETIC X = P - PROPELLER X = PT - PITOT TUBE X = R - ROTAMETER X = T - TURBINE X = TH - THERMAL X = U - ULTRASONIC X = D - DENSITY
	PRIMARY FLOW ELEMENT: ORIFICE PLATE
	PRIMARY FLOW ELEMENT: VENTURI TUBE
	PRIMARY FLOW ELEMENT: WEIR
	PULSATION DAMPENER
	PUMP: CENTRIFUGAL
	PUMP: DIAPHRAGM
	PUMP: METERING
	PUMP: PLUNGER
	PUMP: PERISTALTIC TUBE METERING
	PUMP: PROGRESSIVE CAVITY
	PUMP: RECIPROCATING
	PUMP: ROTARY
	PUMP: SCREW
	PUMP: SUBMERSIBLE
	PUMP: VERTICAL LIFT
	PIPE REDUCER: CONCENTRIC
	PIPE REDUCER: ECCENTRIC (FOT, FOB)
	ROTARY CHEMICAL FEEDER
	RUPTURE DISK
	SAMPLE PORT
	SIGHT GLASS
	SLIDE GATE
	SLUICE GATE
	STRAINER: WYE TYPE

SINGLE LINE	DESCRIPTION
	STRAINER: WYE TYPE WITH BLOWOFF
	THERMOMETER
	VALVE: ANGLE
	VALVE: AIR RELIEF
	VALVE: CONE
	VALVE: FLAPPER CHECK
	VALVE: FOUR WAY
	VALVE: HOSE
	VALVE: PLUG CONCENTRIC
	VALVE: PRESSURE RELIEF PRESSURE-REDUCING REGULATOR
	VALVE: TELESCOPING
	VALVE: THREE WAY AIR OPERATED
M	VALVE: THREE WAY MOTOR OPERATED
S	VALVE: THREE WAY SOLENOID OPERATED
	VALVE: VACUUM
	BACKPRESSURE REGULATOR SELF-CONTAINED
	BACKPRESSURE REGULATOR W/ EXTERNAL PRESSURE TAP
	PRESSURE-REDUCING REGULATOR: SELF-CONTAINED
	PRESSURE-REDUCING REGULATOR W/EXTERNAL PRESSURE TAP

IDENTIFICATION SYMBOLS

CHEMICAL INJECTION POINT	CHEMICAL DWG NO.
PIPE DESIGNATOR	PIPE SIZE — FLOW STREAM X" XXX
CONTINUATION TAG	UNIQUE IDENTIFIER CONTINUATION FROM DWG NO. CONTINUATION TO DWG NO. A B C
EQUIPMENT / VALVE TAG	XXX-XX-XXXX
KEY TAG	X

LINE SYMBOLS

PIPE ABOVE OR BELOW GROUND	
PIPE UNDERNEATH SLAB OR STRUCTURE	
FUTURE	
EXISTING	
DEMO	

PROCESS LINE SYMBOLS

PRIMARY PROCESS FLOW IN PIPE	
SECONDARY PROCESS FLOW IN PIPE	
PRIMARY PROCESS FLOW IN CHANNEL	
SECONDARY PROCESS FLOW IN CHANNEL	

PROCESS FLOW IDENTIFIER

TF	TRICKLE FOW
RAW	RAW WATER
W	WATER (POTABLE)
N	NITROGEN
FL	FLUSH

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED LL
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER MICHAEL E. DUCKER No. 63626 CIVIL STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:33:02-07'00'

carollo®

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

MECHANICAL

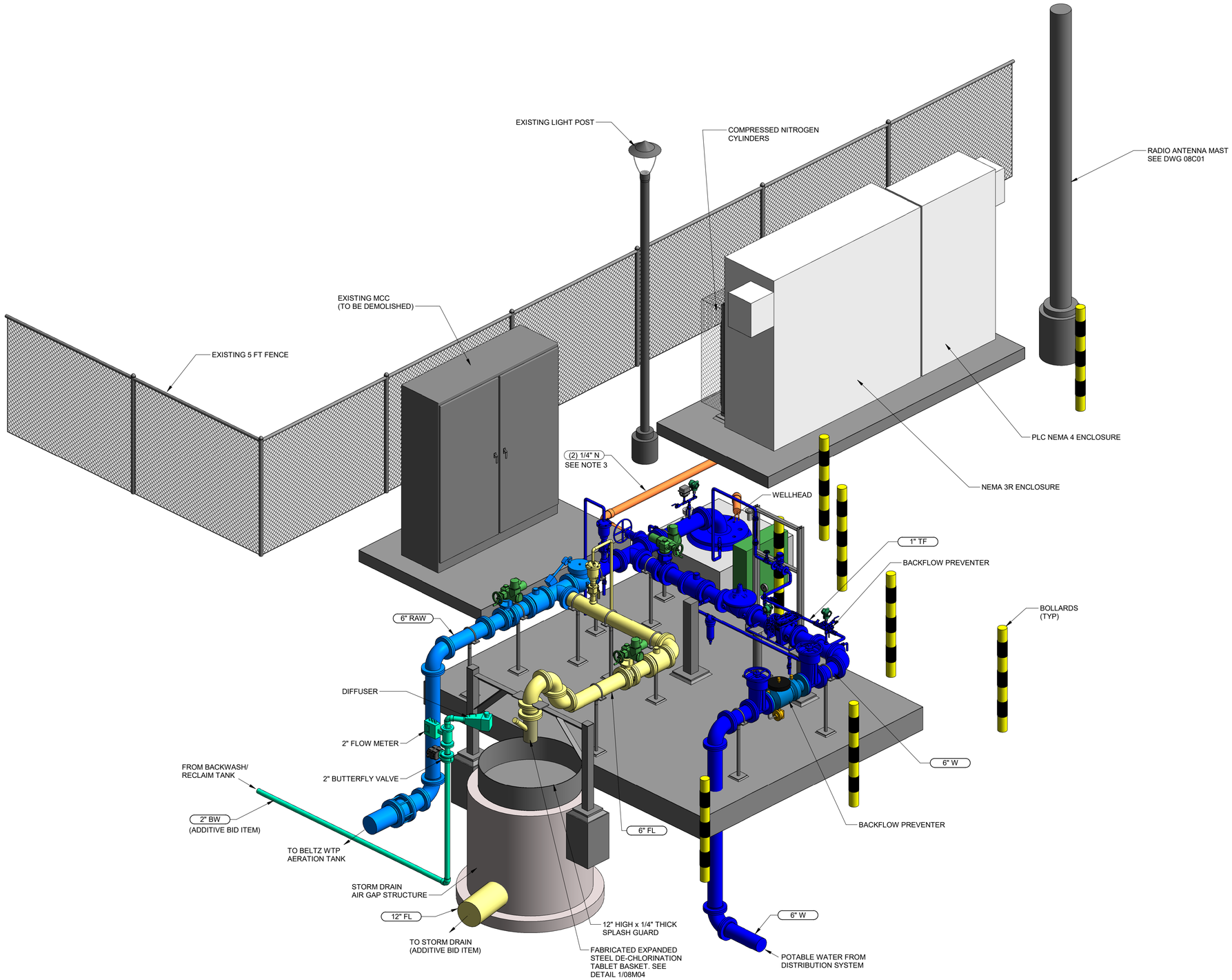
GENERAL MECHANICAL LEGEND AND SYMBOLS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 — 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00GM01
SHEET NO. 14 OF 71

PROJECT NO. 202431-100000 FILE NAME: 20243100GM01.dgn

LAST SAVED BY: OBarranco PlotScale: 1:1 DesignScript: Carollo_Std_Pen_v0905.pen ColorTable: gshade.ctb Model: Layout1 User: svcPW Plot Date: 10-SEP-2025 8:43:14 AM



GENERAL NOTES:

1. THE PERSPECTIVE VIEW PROVIDES A VISUAL REPRESENTATION OF THE PROCESS ELEMENT. IT IS NOT TO SCALE. REFER TO SUBSEQUENT DRAWINGS FOR DETAILED REQUIREMENTS FOR THE PROCESS ELEMENT.
2. REFER TO VALVE SCHEDULE ON DWG 00TM03.
3. (2) 1/4" N PIPING IN 3" SCH 40 PVC SLEEVE. ROUTE PIPING AND SLEEVE TO AVOID LIGHT POLE BASE AND CONDUCTORS.

LEGEND:

- POTABLE WATER PIPING
- RAW WATER PIPING
- BW PIPING FROM RECLAIM TANK
- FLUSH TO STORM DRAIN PIPING
- NITROGEN PIPING
- VALVE ACTUATOR OR INSTRUMENTATION

REV	DATE	BY	DESCRIPTION

DESIGNED MED
DRAWN OB1
CHECKED LL
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER MICHAEL E. DUCKER No. 63626 CIVIL STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:52:27-07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

MECHANICAL

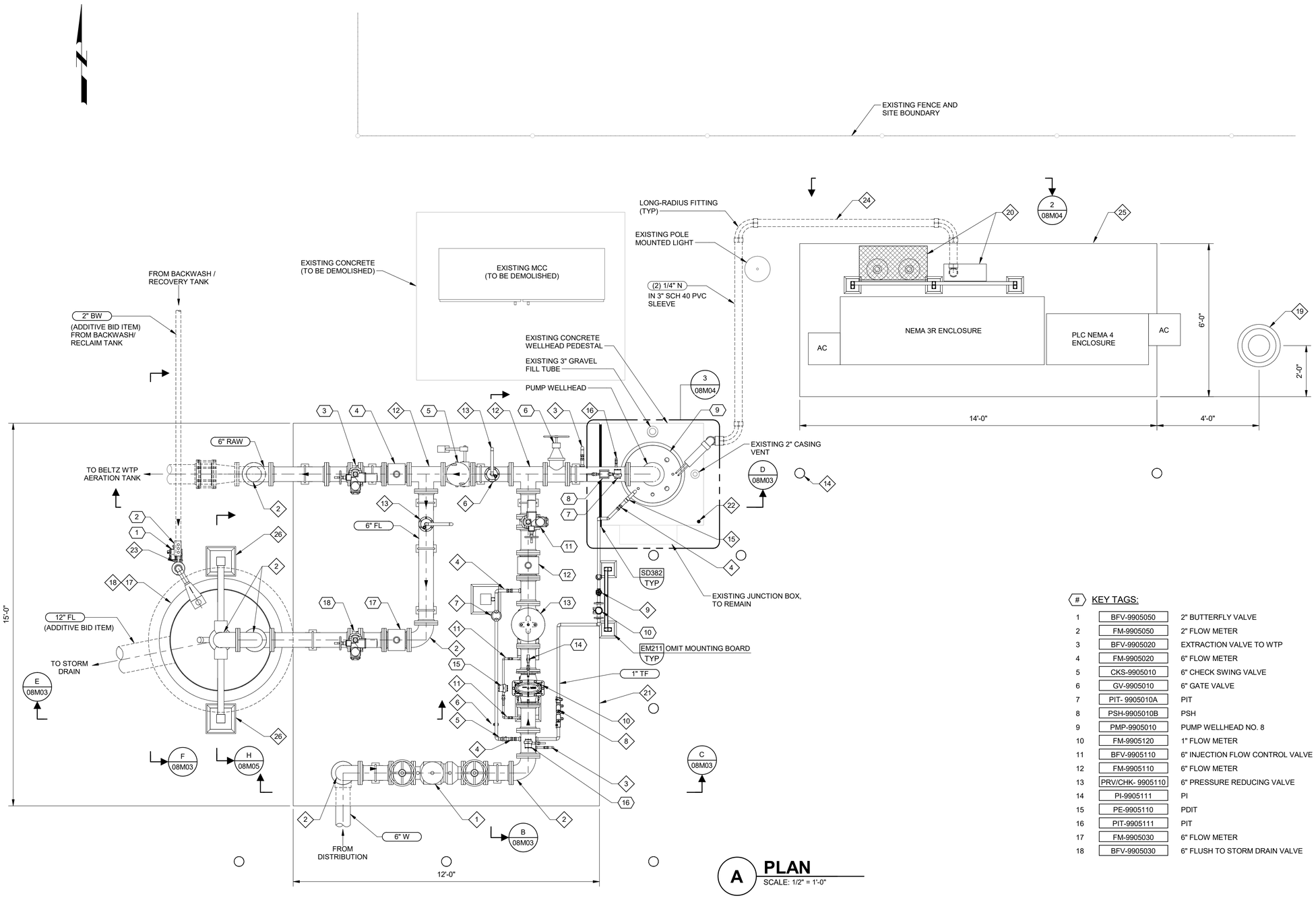
WELL 8
PERSPECTIVE

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08M01
SHEET NO. 15 OF 71

PLOT DATE: 9/10/2025 8:34:46 AM

FILE NAME: R:\d0394906\20243100M0801.rvt



A **PLAN**
SCALE: 1/2" = 1'-0"

GENERAL NOTES:

1. FIELD VERIFY HORIZONTAL LOCATIONS OF ALL EXISTING PIPELINES FOR CONNECTIONS FROM PROPOSED PIPING.
2. ALL PRESSURIZED PIPING SHALL BE FULLY RESTRAINED.
3. REFER TO VALVE SCHEDULE ON DWG 00TM03.
4. ALL SAMPLE TAPS SHALL BE LABELED "SAMPLE" PER SECTION 40_05_00.03.
5. MOUNT FLOW METER TOTALIZERS TO FLOW TUBE. COORDINATE FINAL ORIENTATION IN FIELD WITH CONSTRUCTION MANAGER AND CITY STAFF.
6. ALL NEW PIPING SHALL BE PRESSURE TESTED AND DISINFECTED PER CITY WATER DEPARTMENT STANDARD SPECIFICATIONS. CITY STAFF WILL ONLY DISINFECT AND TEST PIPES ON MONDAYS, TUESDAYS, AND WEDNESDAYS.
7. IF THE ADDITIVE BID ITEM IS NOT EXECUTED UNDER THIS CONTRACT, CONTRACTOR SHALL INSTALL THE AIR GAP STRUCTURE AS SHOWN AND OMIT THE 2" BW AND 12" FL PIPING AND APPURTENANCES. PRECAST AIR GAP STRUCTURE SHALL INCLUDE A KNOCKOUT OPENING FOR THE 12" FL TO BE CONSTRUCTED UNDER A FUTURE CONTRACT.
8. COORDINATE THE ORIENTATION OF ALL PRESSURE GAUGE AND FLOW METER READING HEADS IN THE FIELD WITH CITY STAFF AND CONSTRUCTION MANAGER.

(#) KEY NOTES:

1. 6" BACKFLOW PREVENTER PER CITY WATER DEPARTMENT STANDARD DETAIL 7. OMIT WATER METER.
2. 6" 90° ELBOW.
3. 1/2" SAMPLE TAP W/ 1/2" BALL VALVE AND 1/4" REDUCING BUSHING.
4. 1" BALL VALVE.
5. 1" CHECK VALVE.
6. 1" DRAIN (UNDERSIDE) W/ 1" BALL VALVE.
7. 50 MICRON x 10" (NOMINAL, MIN.) CARTRIDGE FILTER W/ CLEAR CASING FOR VISUAL INSPECTION. WATTS OR APPROVED EQUAL. INSTALL UNION ON EACH SIDE OF FILTER.
8. 1" BACKFLOW PREVENTER PER CITY WATER DEPARTMENT STANDARD DETAIL 8.
9. 1" GLOBE VALVE.
10. 6" H-STRAINER.
11. 1/2" BALL VALVE.
12. 6"x6" TEE.
13. 2" CAV PER MP898/TYP.
14. FIXED TRAFFIC BOLLARDS PER CITY WATER DEPARTMENT STANDARD DETAIL 20 (TYP).
15. 1" UNION.
16. 1" BALL VALVE AND PLUG FOR ROSSUM SAND TESTER.
17. STORM DRAIN AIR GAP. SEE SECTION E/08M03.
18. PRECAST CONCRETE AIR GAP STRUCTURE WITH H-20 GALVANIZED STEEL GRATE. 48" INSIDE DIAMETER PER CITY OF SANTA CRUZ PUBLIC WORKS STANDARD DETAIL 3 OF 20.
19. RADIO ANTENNA MAST. SEE DWG 08C01.
20. DOWNHOLE CONTROL VALVE NITROGEN SYSTEM WITH LOCKING ENCLOSURES. SEE DETAIL 2/08M04.
21. CONCRETE SLAB MIN. 16" THK W/ #5 @ 12" EW T&B. MATCH TOP ELEVATION OF EXISTING ADJACENT PAD. SLOPE TO PREVENT STANDING WATER ON TOP OF PAD. PLACE EXPANSION JOINT PER SD382/TYP AT INTERFACE WITH EXISTING CONCRETE.
22. CONTRACTOR'S SURVEYOR SHALL SET A BRASS SURVEY MARKER ON TOP OF THE WELLHEAD PEDESTAL. REMOVE EXISTING MARKER AND REPAIR CONCRETE BEFORE SURVEYING. MARKER SHALL BE STAMPED WITH THE SURVEYED ELEVATION OF THE TOP OF CONCRETE, GENERALLY IN THE SOUTHEAST CORNER OF THE PEDESTAL. COORDINATE FINAL LOCATION OF MARKER WITH CONSTRUCTION MANAGER. SURVEYOR SHALL ALSO RECORD THE ELEVATION OF THE TOP OF THE SOUNDING TUBE TERMINATION AND EXISTING PAVEMENT IMMEDIATELY ADJACENT TO THE SOUNDING TUBE. SEE SECTION 01 71 23 FOR ADDITIONAL INFORMATION.
23. 2" FITTINGS AS REQUIRED TO TERMINATE 2" BW PIPING AT AIR GAP STRUCTURE PER SECTION E/08M03.
24. ROUTE NITROGEN PIPING TO AVOID EXISTING LIGHT POLE BASE, CONDUCTORS, AND OTHER EXISTING UTILITIES.
25. CONCRETE SLAB MINIMUM 16" THICK WITH #5@12" EACH WAY, TOP & BOTTOM. TOP SURFACE TO BE FLAT AND LEVEL. OVER MINIMUM 6" CLASS 2 AGGREGATE BASE COMPACTED TO 90% RELATIVE COMPACTION. COORDINATE FINAL DIMENSIONS AND LOCATION WITH APPROVED ELECTRICAL SUBMITTALS.
26. CONCRETE BASE FOR PIPE SUPPORT. SEE DWG 08M05.

(#) KEY TAGS:

1	BFV-9905050	2" BUTTERFLY VALVE
2	FM-9905050	2" FLOW METER
3	BFV-9905020	EXTRACTION VALVE TO WTP
4	FM-9905020	6" FLOW METER
5	CKS-9905010	6" CHECK SWING VALVE
6	GV-9905010	6" GATE VALVE
7	PIT- 9905010A	PIT
8	PSH-9905010B	PSH
9	PMP-9905010	PUMP WELLHEAD NO. 8
10	FM-9905120	1" FLOW METER
11	BFV-9905110	6" INJECTION FLOW CONTROL VALVE
12	FM-9905110	6" FLOW METER
13	PRV/CHK- 9905110	6" PRESSURE REDUCING VALVE
14	PI-9905111	PI
15	PE-9905110	PDIT
16	PIT-9905111	PIT
17	FM-9905030	6" FLOW METER
18	BFV-9905030	6" FLUSH TO STORM DRAIN VALVE

REV	DATE	BY	DESCRIPTION

DESIGNED MED
DRAWN OB1
CHECKED LL
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER — MICHAEL E. DUCKER — No. 63626 — CIVIL — STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025-09-12 09:32:49-07'00'

carollo

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

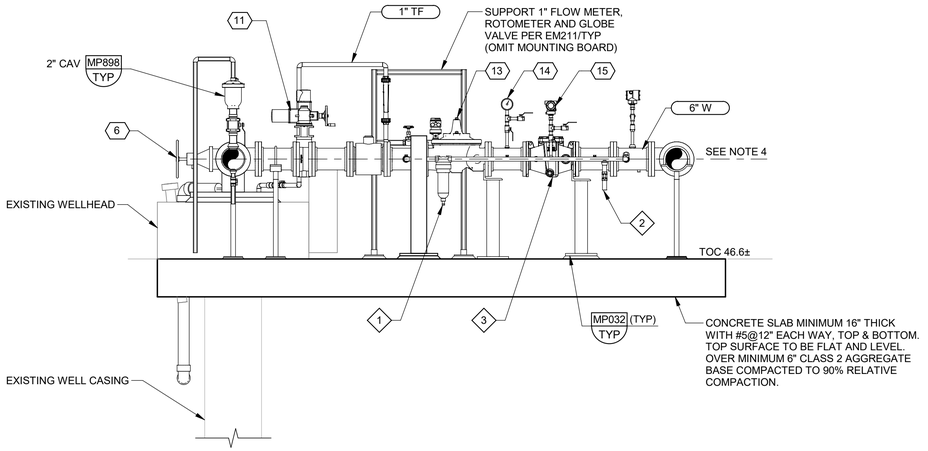
MECHANICAL
WELL 8
PLAN

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 — 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

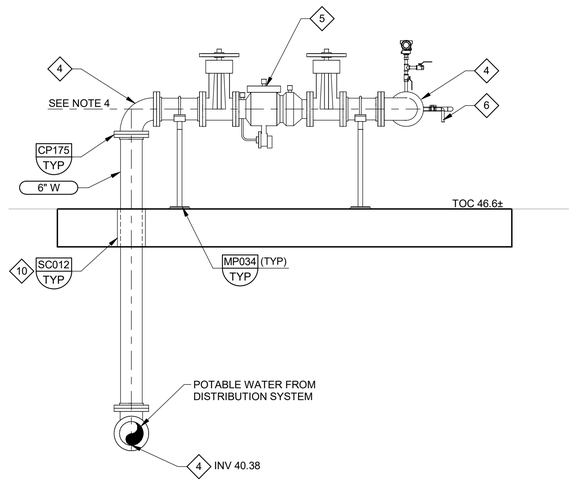
JOB NO. 202431
DRAWING NO. 08M02
SHEET NO. 16 OF 71

PLOT DATE: 9/10/2025 8:34:48 AM

FILE NAME: R:\d0394906\20243100M0801.rvt



B SECTION
08M02 SCALE: 1/2" = 1'-0"



C SECTION
08M02 SCALE: 1/2" = 1'-0"

GENERAL NOTES:

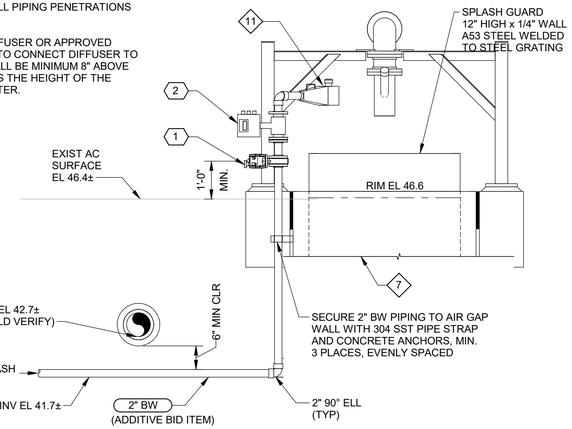
1. FIELD VERIFY HORIZONTAL AND VERTICAL LOCATIONS OF ALL EXISTING PIPELINES FOR CONNECTIONS TO PROPOSED PIPING.
2. ALL PRESSURIZED PIPING SHALL BE FULLY RESTRAINED.
3. REFER TO VALVE SCHEDULE ON DWG 00TM03 AND P&ID DRAWINGS FOR ADDITIONAL INFORMATION.
4. FIELD VERIFY CENTERLINE PER FABRICATED DISCHARGE HEAD, DETAIL 5/08M04. MATCH CENTERLINE FOR ALL 6" PIPING.

KEY NOTES:

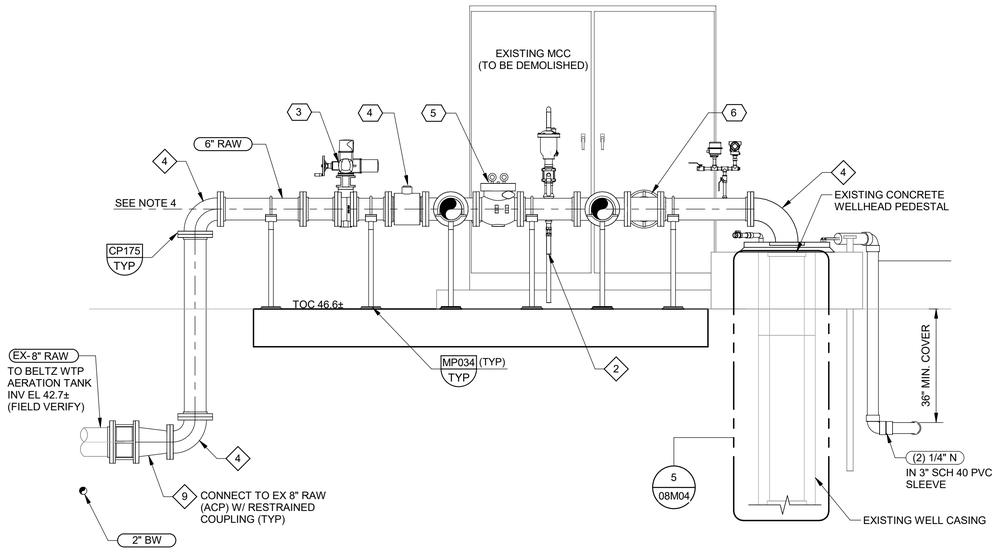
1. 50 MICRON x 10" (NOMINAL, MIN.) CARTRIDGE FILTER W/ CLEAR CASING FOR VISUAL INSPECTION. WATTS OR APPROVED EQUAL. INSTALL UNION ON EACH SIDE OF FILTER.
2. 1" DRAIN (UNDERSIDE) W/ 1" BALL VALVE.
3. 6" H-STRAINER.
4. 6" 90° ELBOW.
5. 6" BACKFLOW PREVENTER PER CITY WATER DEPARTMENT STANDARD DETAIL 7. OMIT WATER METER.
6. 1/2" SAMPLE TAP W/ 1/2" BALL VALVE AND 1/4" REDUCING BUSHING.
7. STORM DRAIN AIR GAP STRUCTURE. 48" INSIDE DIAMETER STANDARD MANHOLE PER CITY OF SANTA CRUZ PUBLIC WORKS STANDARD DETAIL 3 OF 20. OMIT TAPERED SECTION AND COVER. PROVIDE H20 RATED GALVANIZED STEEL GRATING.
8. WIRE CLOTH BUG SCREEN (GARLOCK BLUE-GUARD STYLE 300 STRAINER GASKET OR EQUAL).
9. 6" x 8" REDUCER W/ RESTRAINED COUPLING ADAPTER. FIELD VERIFY ELEVATION OF EXISTING 8" RAW.
10. PLACE EXPANSION JOINT MATERIAL AT ALL PIPING PENETRATIONS PER MP544/TYP.
11. HYDRO-HITCH HFF DECHLORINATING DIFFUSER OR APPROVED EQUAL. FURNISH AND INSTALL FITTINGS TO CONNECT DIFFUSER TO 2" BW PIPING. BOTTOM OF DIFFUSER SHALL BE MINIMUM 8" ABOVE THE SPLASH GUARD RING, OR TWO TIMES THE HEIGHT OF THE DIFFUSER OUTLET, WHICHEVER IS GREATER.

KEY TAGS:

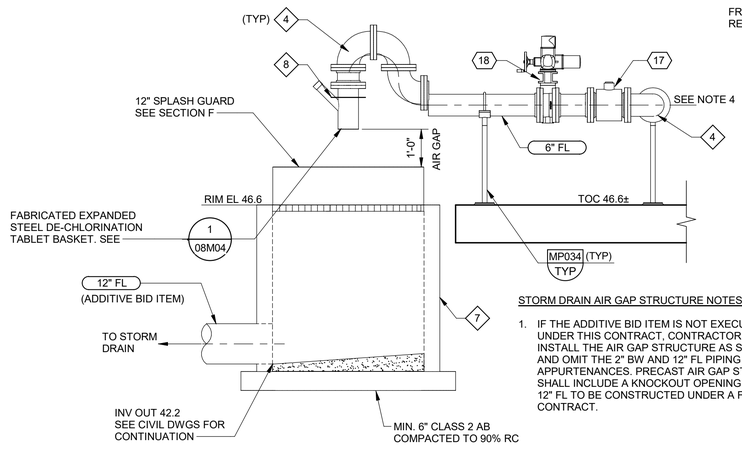
1	BFV-9905050	2" BUTTERFLY VALVE
2	FM-9905050	2" FLOW METER
3	BFV-9905020	EXTRACTION VALVE TO WTP
4	FM-9905020	6" FLOW METER
5	CKS-9905010	6" CHECK SWING VALVE
6	GV-9905010	6" GATE VALVE
7	PIT- 9905010A	PIT
8	PSH-9905010B	PSH
9	PMP-9905010	PUMP WELLHEAD NO. 8
10	FM-9905120	1" FLOW METER
11	BFV-9905110	6" INJECTION FLOW CONTROL VALVE
12	FM-9905110	6" FLOW METER
13	PRV/CHK- 9905110	6" PRESSURE REDUCING VALVE
14	PI-9905111	PI
15	PE-9905110	PDIT
16	PIT-9905111	PIT
17	FM-9905030	6" FLOW METER
18	BFV-9905030	6" FLUSH TO STORM DRAIN VALVE



F SECTION
08M02 SCALE: 1/2" = 1'-0"



D SECTION
08M02 SCALE: 1/2" = 1'-0"



E SECTION
08M02 SCALE: 1/2" = 1'-0"

STORM DRAIN AIR GAP STRUCTURE NOTES

1. IF THE ADDITIVE BID ITEM IS NOT EXECUTED UNDER THIS CONTRACT, CONTRACTOR SHALL INSTALL THE AIR GAP STRUCTURE AS SHOWN AND OMIT THE 2" BW AND 12" FL PIPING AND APPURTENANCES. PRECAST AIR GAP STRUCTURE SHALL INCLUDE A KNOCKOUT OPENING FOR THE 12" FL TO BE CONSTRUCTED UNDER A FUTURE CONTRACT.

REV	DATE	BY	DESCRIPTION

DESIGNED MED
DRAWN OB1
CHECKED LL
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER MICHAEL E. DUCKER No. 63626 CIVIL STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:32:13-07'00'

carollo®

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
MECHANICAL
WELL 8
SECTIONS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08M03
SHEET NO. 17 OF 71

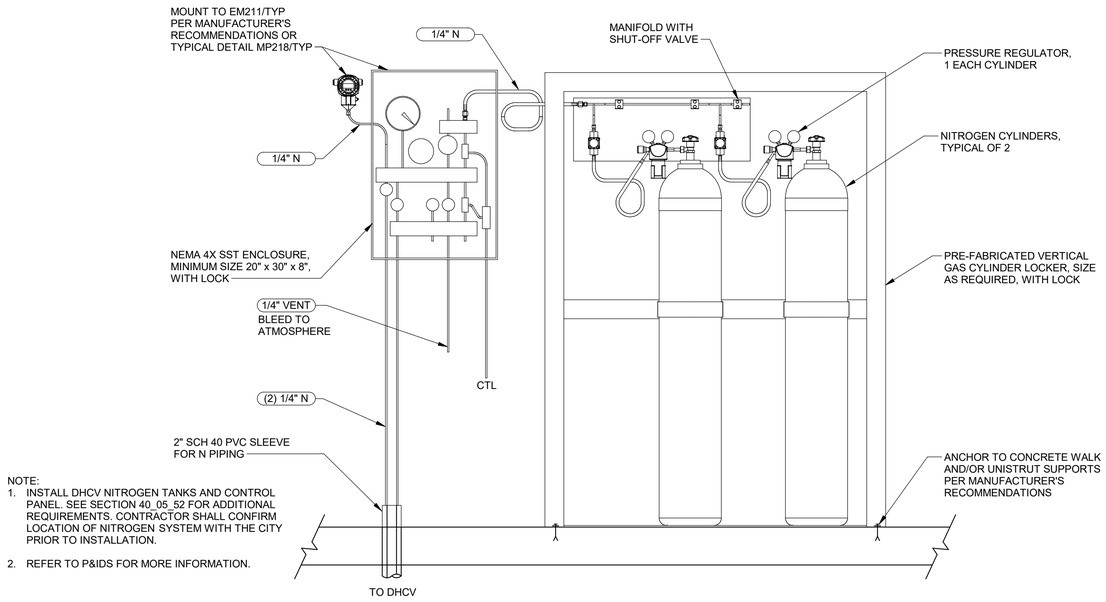
PLOT DATE: 9/10/2025 8:34:49 AM

FILE NAME: R:\d0394906\20243100M0801.rvt



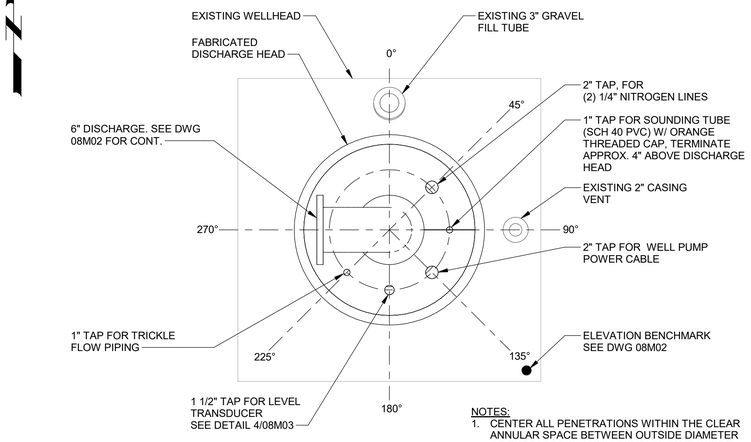
NOTE:
PHOTO PROVIDED FOR REFERENCE. DECHLORINATION TABLET BASKET SHALL BE RIGIDLY CONNECTED TO THE SST BACKING FLANGE.

1 DETAIL
08M03 — SCALE: 1/8" = 1'-0"



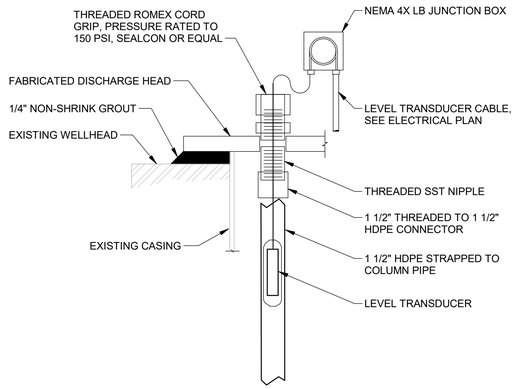
NOTE:
1. INSTALL DHCV NITROGEN TANKS AND CONTROL PANEL. SEE SECTION 40_05_52 FOR ADDITIONAL REQUIREMENTS. CONTRACTOR SHALL CONFIRM LOCATION OF NITROGEN SYSTEM WITH THE CITY PRIOR TO INSTALLATION.
2. REFER TO P&IDS FOR MORE INFORMATION.

2 DETAIL
08M02 — SCALE: 1" = 1'-0"



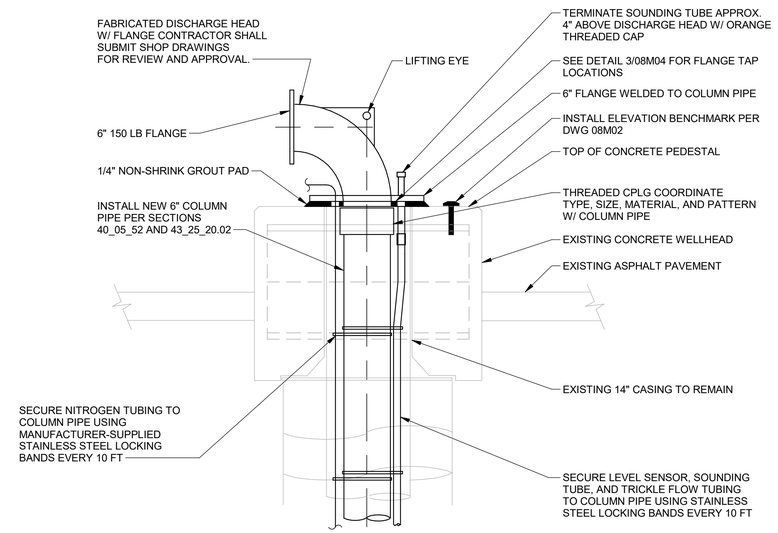
NOTES:
1. CENTER ALL PENETRATIONS WITHIN THE CLEAR ANNULAR SPACE BETWEEN OUTSIDE DIAMETER OF THREADED COLUMN COUPLING AND INSIDE DIAMETER OF THE EXISTING CASING.
2. NOMINAL DIMENSIONS PROVIDED FOR WELL DISCHARGE HEAD PENETRATIONS. COORDINATE FINAL TAP DIMENSIONS WITH APPROVED SHOP DRAWING SUBMITTALS.
3. CENTER TAPS BETWEEN 90° DISCHARGE ELL AND EDGE OF WELLHEAD FLANGE.

3 PLAN
08M02 — SCALE: 1" = 1'-0"



LEVEL TRANSDUCER

4 DETAIL
- — SCALE:NO SCALE



5 DETAIL
08M03 — SCALE:NO SCALE

REV	DATE	BY	DESCRIPTION

DESIGNED MED
DRAWN OB1
CHECKED LL
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER — MICHAEL E. DUCKER — No. 63626 — CIVIL — STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:31:56-07'00'

carollo®

CITY OF SANTA CRUZ

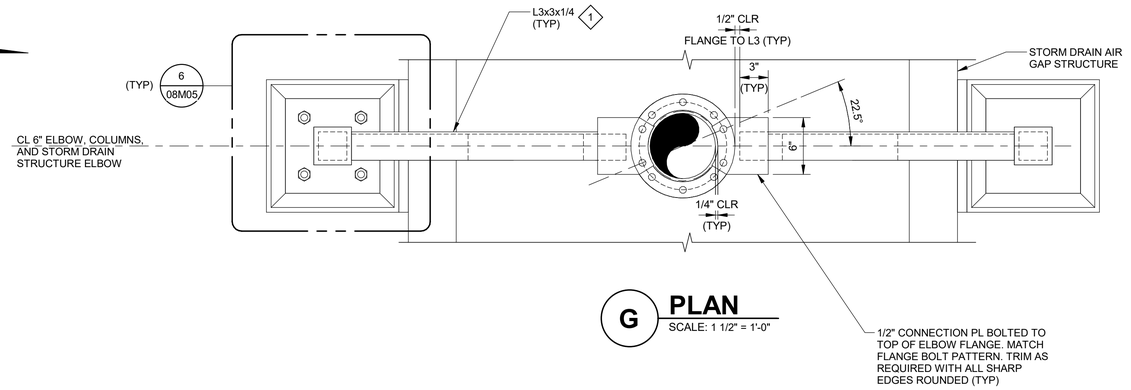
CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
MECHANICAL
WELL 8
DETAILS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 — 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

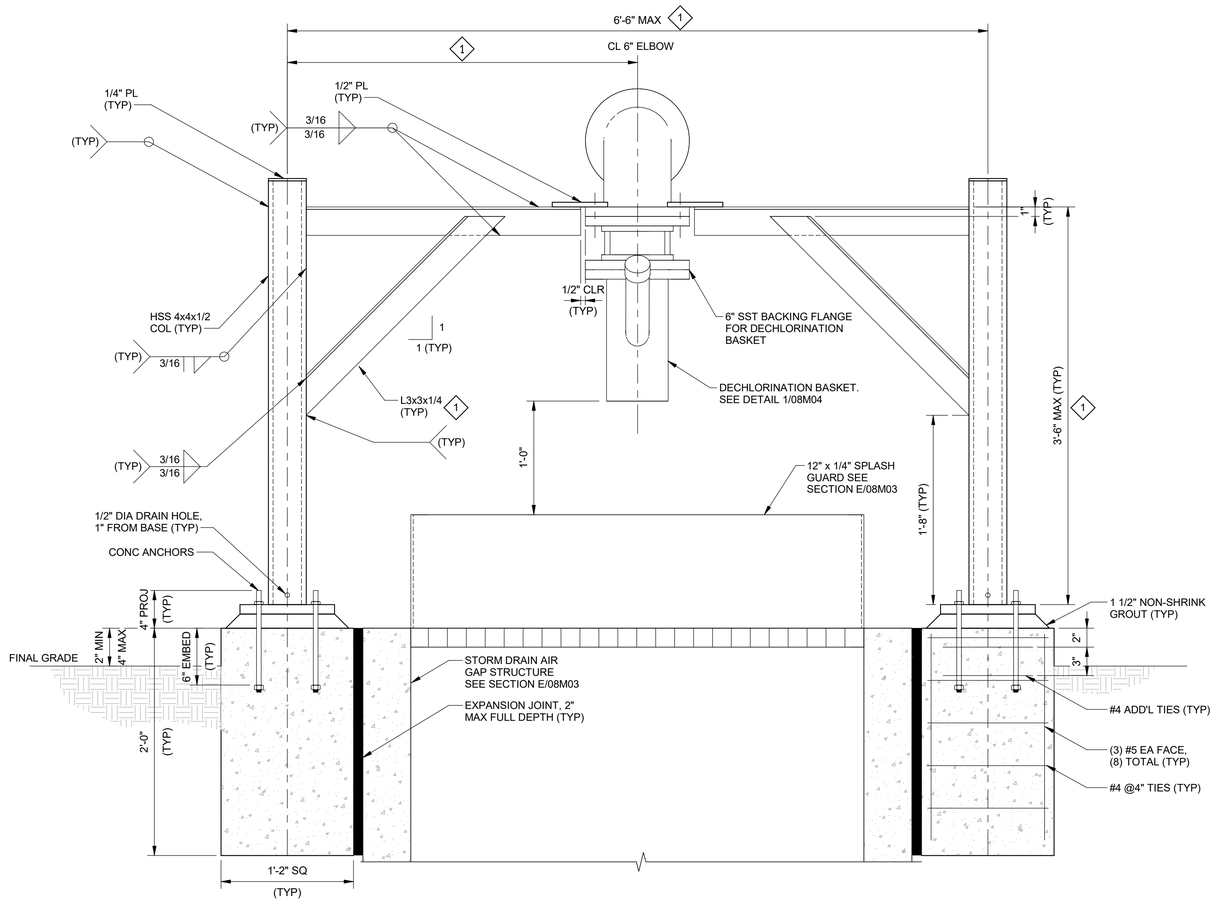
JOB NO. 202431
DRAWING NO. 08M04
SHEET NO. 18 OF 71

PLOT DATE: 9/10/2025 8:34:51 AM

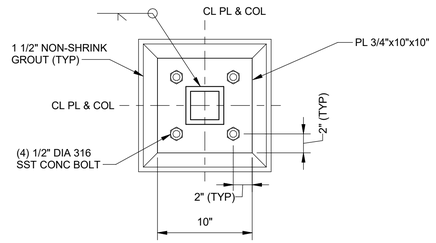
FILE NAME: R:\d0394906\20243100M0801.rvt



G PLAN
SCALE: 1 1/2" = 1'-0"



H SECTION (08M02)
SCALE: 1 1/2" = 1'-0"



6 DETAIL (08M05)
SCALE: 1 1/2" = 1'-0"

GENERAL NOTES:

1. REFER TO 00GS01 FOR GENERAL STRUCTURAL NOTES.

KEY NOTES:

1. FIELD VERIFY AND COORDINATE DIMENSION AND LAYOUT WITH STORM DRAIN, SPLASH GUARD AND 6" ELBOW CONSTRUCTION.

REV	DATE	BY	DESCRIPTION

DESIGNED MED
DRAWN OB1
CHECKED LL
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER MICHAEL E. DUCKER No. 63626 CIVIL STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:30:53-07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
MECHANICAL
AIR GAP PIPE SUPPORT
PLAN, SECTION, AND DETAIL

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08M05
SHEET NO. 19 OF 71

PLOT DATE: 9/10/2025 8:34:51 AM
FILE NAME: R:\d0394906\20243100M0801.rvt

ELECTRICAL PLAN SYMBOLS

IDENTIFICATION SYMBOLS

EQUIP # — EQUIPMENT AND INSTRUMENT IDENTIFICATION

EQUIPMENT/INSTRUMENT LOCATOR

LUMINAIRE IDENTIFICATION
a = CIRCUIT DESIGNATION
b = DEVICE SWITCHED FROM
c = MOUNTING HEIGHT IN FEET TO BOTTOM OF FIXTURE
X = LUMINAIRE TYPE, REFER TO THE LUMINAIRE SCHEDULE

XXXX — CONDUIT IDENTIFICATION
XXXX = CONDUIT NUMBER, REFER TO CONDUIT SCHEDULE
UNLESS OTHERWISE NOTED, GROUPED CONDUITS ARE LABELED LEFT TO RIGHT OR TOP TO BOTTOM.

X — INDICATES KEYNOTE X (PERTAINS ONLY TO SHEET WHERE NOTE IS FOUND)

A — DISCONNECT SWITCH
A = TYPE, REFER TO DISCONNECT SCHEDULE

CAMERA

LUMINAIRES

LINEAR FIXTURE

2' X 2' LAY-IN TROFFER

2' X 4' LAY-IN TROFFER

LUMINAIRE POLE MOUNTED

R H — GO/NO-GO PANEL - STROBE AND HORN
R = RED LIGHT
G = GREEN LIGHT
H = HORN

R G — GO/NO-GO PANEL - SOLID

R — GO/NO-GO PANEL - STROBE

LUMINAIRE, EMERGENCY BATTERY-POWERED

LUMINAIRE, EMERGENCY/EXIT BATTERY-POWERED

LUMINAIRE, EMERGENCY BATTERY-POWERED REMOTE

LUMINAIRE, SURFACE OR PENDANT MOUNTED

LUMINAIRE, WALL MOUNTED

LUMINAIRE, FLOOD/SPOT

LUMINAIRE, EXIT ONE OR TWO FACES AS INDICATED. ARROW POINTS IN DIRECTION OF EGRESS.

SWITCHES/RECEPTACLES

SINGLE POLE SWITCH
a = CIRCUIT DESIGNATION
b = DEVICE SWITCHED DESIGNATED
c = TYPE
2 = DOUBLE POLE SWITCH
3 = THREE-WAY SWITCH
3P = THREE POSITION SWITCH
4 = FOUR-WAY SWITCH
K = KEY OPERATED SWITCH
F = SWITCH AND FUSESTAT HOLDER
P = SWITCH AND PILOT LIGHT
T = THERMOSTAT
D = DIMMER SWITCH
L = LOW VOLTAGE LIGHT SWITCH
M = MANUAL MOTOR STARTER
N = NETWORKED SINGLE OR MULTIPLE SWITCH LOCATIONS

REFER TO ABBREVIATIONS LEGEND FOR ALL OTHER DESIGNATIONS.

OCCUPANCY SENSOR
*REFERENCE LIGHTING CONTROL COMPONENT SCHEDULE
a = CIRCUIT DESIGNATION
b = DEVICE SWITCHED DESIGNATION
c = MOUNTING HEIGHT IN FEET TO BOTTOM OF SENSOR

PE — PHOTOCELL

SWITCH AND SINGLE RECEPTACLE
a = CIRCUIT DESIGNATION
b = DEVICE TYPE DESIGNATION

DUPLEX RECEPTACLE

QUADRUPLEX RECEPTACLE

IN FLOOR DUPLEX RECEPTACLE

IN FLOOR QUADRUPLEX RECEPTACLE

DUPLEX RECEPTACLE w/SPLIT WIRE

DEDICATED RECEPTACLE

SPECIAL PURPOSE RECEPTACLE

WELDING RECEPTACLE
a = CIRCUIT DESIGNATION
b = DISCONNECT TYPE

TWIST LOCK RECEPTACLE
a = AMP RATING

TELEPHONE OUTLET
a = CIRCUIT DESIGNATION
b = MOUNTING HEIGHT

DATA COMMUNICATIONS OUTLET
a = CIRCUIT DESIGNATION
b = MOUNTING HEIGHT

FIRE ALARM

SMOKE DETECTOR
a = TYPE
I = IONIZATION
P = PHOTOELECTRIC
d = DUCT DETECTOR

FACP — FIRE ALARM CONTROL PANEL

F — FIRE ALARM PULL STATION

F — FIRE ALARM HORN/STROBE COMBINATION

F — FIRE ALARM STROBE

F — FIRE SPRINKLER
F = FLOW SWITCH
T = TAMPER SWITCH

RACEWAY

EXPOSED CONDUIT

BREAK AND CONTINUATION IN CONDUIT RUN

EXPOSED CONDUIT HIDDEN BEHIND WALLS, FLOORS OR OTHER STRUCTURES

UNDERGROUND CONDUIT, DIRECT BURIED OR IN DUCT BANK

CONDUIT IN SLAB

CONDUIT VERTICAL CHANGE IN DIRECTION

CONDUIT CAP

J — JUNCTION BOX

CONDUIT SEAL

CONDUIT TEE

DUCT BANK
APPROXIMATE DIMENSIONS SHOWN ON DUCT BANK SECTIONS

CONDUIT SIZE AND CONDUCTORS

INDIVIDUAL CONDUCTORS

W"C-(3-X (Ø), 1-Y (N) & 1-Z (G))

W"C (WHERE INDICATED): W = CONDUIT TRADE SIZE

3-X (Ø):
3 = QUANTITY
X = SIZE OF CONDUCTORS
(Ø) = DESIGNATES PHASE CONDUCTORS

1-Y (N) (WHERE INDICATED):
1 = QUANTITY
Y = SIZE OF CONDUCTORS
(N) = DESIGNATES NEUTRAL CONDUCTORS

1-Z (G) (WHERE INDICATED):
1 = QUANTITY
Z = SIZE OF CONDUCTORS
(G) = DESIGNATES GROUND CONDUCTORS

U{3-X (Ø) & 1-X (G)}
U = NUMBER OF PARALLEL RUNS

VFD CONDUCTORS

U{[N/C-X (Ø) & INTEGRAL (G)]:VFD}
U = NUMBER OF PARALLEL RUNS
N/C = NUMBER OF PHASE CONDUCTORS IN CABLE
X = SIZE OF CONDUCTORS
VFD = VFD CABLE

MULTI CONDUCTOR CABLES

K/2/C#16S
K (WHERE INDICATED) = NUMBER OF PAIRS
2/C#16S = TWO CONDUCTOR, 16 GAUGE, TWISTED SHIELDED PAIR

K/3/C#16S
K (WHERE INDICATED) = NUMBER OF TRIPLETS
3/C#16S = THREE CONDUCTOR, 16 GAUGE, TWISTED SHIELDED TRIPLETS

U{[N/C-X (Ø) & INTEGRAL (G)]:MC}
U = NUMBER OF PARALLEL RUNS
MC = MULTICONDUCTOR CABLE
N/C = NUMBER OF PHASE CONDUCTORS IN THE CABLE
X = SIZE OF CONDUCTORS

FIBER OPTIC CABLES

FO/N
N = NUMBER OF INDIVIDUAL FIBERS

GROUNDING

UNDERGROUND GROUND CABLE
#4/0 SDBC UNLESS OTHERWISE NOTED

GROUND ROD

GROUND ROD AND GROUND WELL

ELECTRICAL ONE-LINE SYMBOLS

MEDIUM VOLTAGE

52 — CIRCUIT BREAKER, MEDIUM VOLTAGE
a = CIRCUIT BREAKER NUMBER
b = FRAME SIZE

ANSI RELAY DEVICE
a = ANSI DEVICE FUNCTION
b = QUANTITY

MEDIUM VOLTAGE DISCONNECT SWITCH NON-FUSED CUT OUT

MEDIUM VOLTAGE DISCONNECTING FUSE SINGLE FUSE CUT OUT

MEDIUM VOLTAGE DISCONNECTING FUSE DOUBLE FUSE CUT OUT

MEDIUM VOLTAGE SINGLE FUSE

MEDIUM VOLTAGE DOUBLE FUSE

MEDIUM VOLTAGE LIVE FRONT TERMINATOR

MEDIUM VOLTAGE ELBOW

MEDIUM VOLTAGE TEE

MEDIUM VOLTAGE CONTACTOR

MEDIUM VOLTAGE STARTER

MOV-ELBOW ARRESTER

LOW VOLTAGE

LOW VOLTAGE CIRCUIT BREAKER
a = TYPE
MCP = MOTOR CIRCUIT PROTECTOR
TM = THERMAL MAGNETIC
SS = SOLID STATE
b = FRAME SIZE (MANUFACTURER TO DETERMINE FRAME SIZE UNLESS INDICATED)
c = NUMBER OF POLES
d = TRIP SETTING (AT = AMP TRIP) (AC = MCP CONTINUOUS RATING)
e = DESIGNATION
f = INTERRUPTING RATING

LOW VOLTAGE CIRCUIT BREAKER AUXILIARY OPERATOR
* = S = SHUNT TRIP
= G = GROUND FAULT INTERRUPTER
= V = SOLENOID KEY RELEASE

A — DISCONNECT SWITCH
A = TYPE, REFER TO DISCONNECT SCHEDULE

B — FUSED DISCONNECT SWITCH
B = TYPE, REFER TO DISCONNECT SCHEDULE
b = FUSE RATING

FUSE

COMBINATION STARTER WITH CONTROL POWER TRANSFORMER
a = CIRCUIT BREAKER DISCONNECT, TYPE AS NOTED
b = STARTER TYPE REFER TO THE SPECIFICATIONS FOR STARTER DEFINITIONS.
c = NEMA STARTER SIZE
d = OVERLOAD

MOTOR STARTER/DRIVES:
a = DEVICE TYPE
VFD-6 = 6-PULSE VFD
VFD-18 = 18-PULSE VFD
VFD-RH = REDUCED HARMONIC VFD (18-PULSE OR ACTIVE FRONT END AS DEFINED IN THE SPECIFICATIONS)
RVSS = REDUCED VOLTAGE SOLID STATE STARTER
RVAT = REDUCED VOLTAGE AUTO TRANSFORMER
a/B = DEVICE WITH BYPASS STARTER. REFER TO THE SPECIFICATIONS

b = INPUT OPTIONS
LL = LINE REACTOR
PHF = PASSIVE HARMONIC FILTER

c = OUTPUT OPTIONS
LR = LOAD REACTOR
DV/DT = Dv/dt FILTER
SWF = SINE WAVE FILTER

EQUIPMENT ENCLOSURE

MISCELLANEOUS

HP — MOTOR
HP = HORSEPOWER RATING
FULL LOAD AMPS AS NOTED

PACKAGED EQUIPMENT
LOAD RATING AS INDICATED
a = RATED LOAD
b = UNIT(HP, KW, KVA) AS INDICATED

TRANSFORMER
a = DEVICE I.D.
b = KVA RATING
c = NUMBER OF PHASES
d = PRIMARY VOLTAGE
e = SECONDARY VOLTAGE
f,g = CONNECTION TYPE SYMBOL
h = IMPEDANCE

GROUNDED WYE CONNECTION

DELTA CONNECTION

G — ENGINE-GENERATOR RATINGS AS INDICATED ON THE DRAWINGS
a = KVA/KW
b = VOLTAGE/CONNECTION
c = PHASE
d = WIRE
e = PF

CURRENT TRANSFORMER WITH SHORTING TERMINAL BLOCK
a = QUANTITY
b = RATIO

POTENTIAL TRANSFORMER
a = QUANTITY
b = RATIO
c,d = CONNECTION TYPE SYMBOL

SSM — SOLID STATE MULTIFUNCTION METER

ATP — AMPERE TEST POINT

VTP — VOLTAGE TEST POINT

UTILITY METER

LIGHTNING ARRESTER

SPD — SURGE PROTECTIVE DEVICE

DRAWOUT CONNECTION

GROUND

CAPACITOR

BATTERY

K — KIRK KEY INTERLOCK

LOAD BANK

0

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED CE
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER ERIK M. BAHNEMAN No. E19683 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Erik M. Bahneman
Date: 2025.09.23 10:21:39 -07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

ELECTRICAL

LEGEND

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00GE01
SHEET NO. 20 OF 71

LAST SAVED BY: JLarrabee
PlotScale: 1:1
DesignScript: Carollo_Std_Pen_v0905.pen
ColorTable: gshade.ctb
Model: Layout1
User: svcPW
Plot Date: 10-SEP-2025 2:00:50 PM

PROJECT NO. 202431-100000 FILE NAME: 20243100GE01.dgn

ABBREVIATIONS

A	AMP
ABS	ABSOLUTE
AC	ALTERNATING CURRENT
ACK	ACKNOWLEDGE
ACTR	ACTUATOR
AF	AMP FRAME
AFC	AUTOMATIC FREQUENCY CONTROL
AIC	AMP INTERRUPTING CAPACITY
AM	AMMETER
ANN	ANNUNCIATOR
ANT	ANTENNA
APU	AUXILIARY POWER UNIT
ARM	ARMORED CABLE
AS	AMMETER SWITCH
ASYM	ASYMMETRICAL
AT	AMP TRIP
ATO	AUTOMATIC THROW OVER
ATP	AMMETER TEST POINT
ATS	AUTOMATIC TRANSFER SWITCH
AUTO XFMR	AUTOMATIC TRANSFORMER
AUX	AUXILIARY
AWG	AMERICAN WIRE GAGE
B	BELL
BAT	BATTERY
BFG	BELOW FINISHED GRADE
BHP	BRAKE HORSEPOWER
BKR	BREAKER
BRF	BELOW RAISED FLOOR
C	CONDUIT / CONTINUOUS LOAD
CB	CIRCUIT BREAKER
CCTV	CLOSED CIRCUIT TELEVISION
CCW	COUNTER CLOCKWISE
CKT	CIRCUIT
COAX	COAXIAL CABLE
COM	COMMON
COMM	COMMUNICATION
CPT	CONTROL POWER TRANSFORMER
CR	CONTROLLED RECEPTACLE
CS	CONTROL SWITCH
CT	CURRENT TRANSFORMER
CV	CONTROL VALVE
CW	CLOCKWISE / COOL WHITE
DC	DIRECT CURRENT
DCS	DISTRIBUTED CONTROL SYSTEM
DCU - X	DISTRIBUTED CONTROL UNIT NO. X
DEMO	DEMOLITION
DISC	DISCONNECT SWITCH
DM	DEMAND METER
DPDT	DOUBLE POLE DOUBLE THROW
DPST	DOUBLE POLE SINGLE THROW
DS	DOOR SWITCH
E/G	EMERGENCY GENERATOR
EM	EMERGENCY
EMT	ELECTRICAL METALLIC TUBING
ENCL	ENCLOSURE
ENG	ENGINE
ENT	ELECTRICAL NON-METALLIC TUBING
EP	EXPLOSION PROOF
ETM	ELAPSED TIME METER
F	SUB-FED
FA	FIRE ALARM
FACP	FIRE ALARM CONTROL PANEL
FDR	FEEDER
FLA	FULL LOAD AMPS
FLX	FLEXIBLE CONDUIT
FO	FIBER OPTIC
FRC	FIBERGLASS RIGID CONDUIT
FREQ	FREQUENCY
FU	FUSE
FU	SW FUSED SWITCH
FVNR	FULL VOLTAGE NON-REVERSING
FVR	FULL VOLTAGE REVERSING
FWD	FORWARD
G	GROUND / EQUIPMENT GROUND / GROUND FAULT
GEN	GENERATOR
GRC	GALVANIZED STEEL RIGID CONDUIT
GFCI	GROUND FAULT CIRCUIT INTERRUPTER (RECEPTACLE)
GFI	GROUND FAULT INTERRUPTER (BREAKER)
GFR	GROUND FAULT RELAY
H	HOT-LEG
HF	HIGH FREQUENCY
HP	HORSEPOWER
HPS	HIGH PRESSURE SODIUM
HR	HOUR
HSTAT	HUMIDISTAT
HV	HIGH VOLTAGE
HVAC	HEATING/VENTILATION/AIR CONDITIONING
HZ	HERTZ
I	INSTANTANEOUS / INTERMITTENT LOAD
IC	INTERRUPTING CAPACITY
IJB	INSTRUMENT JUNCTION BOX
IMC	INTERMEDIATE METAL CONDUIT
INST	INSTANTANEOUS
INT	INTERLOCK
INTERCOM	INTERCOMMUNICATION
J	JUNCTION BOX
K	KEY INTERLOCK
KA	KILOAMP
KV	KILOVOLT
KVA	KILOVOLT AMPERE
KVAR	KILOVAR (REACTANCE)
KW	KILOWATT
KWD	KILOWATT DEMAND
KWH	KILOWATT HOUR
L	LONG-TIME
L-B	LINE-BUS
L-G	LINE-GROUND
LA	LIGHTNING ARRESTOR
LBL	LABEL
LC	LIGHTING CONTACT OR
LCP- X	LOCAL CONTROL PANEL NO. X
LL	LEAD-LAG LOAD REACTOR
LP	LIGHT POLE
LP - X	LIGHTING PANEL NO. X
LTG	LIGHTING
LV	LOW VOLTAGE
LVL	LEVEL
M-X	MOTOR CONTROLLER NO. X
MA	MILLIAMPERE
MCA	MOTOR CIRCUIT AMPS
MCC - X	MOTOR CONTROL CENTER NO. X
MCP	MOTOR CIRCUIT PROTECTOR
MH	MANHOLE / MOUNTING HEIGHT
MLO	MAIN LUGS ONLY
MOD	MOTOR OPERATED DAMPER
MOV	METAL OXIDE VARISTOR
MPR	MOTOR PROTECTION RELAY
MS-X	MOTOR STARTER NO. X
MSP	MOTOR STARTING PANEL
MTO	MANUAL THROW OVER
MTR-X	MOTOR NO. X
MTS	MANUAL TRANSFER SWITCH
MV	MEGAVOLT
MVA	MEGAVOLT-AMPERES
MVS	MEDIUM VOLTAGE SWITCH
MW	MEGAWATT
N	NEUTRAL
NC	NORMALLY CLOSED
NEC	NATIONAL ELECTRICAL CODE
NFC	NONMETALLIC FLEXIBLE CONDUIT
NL	NIGHT LIGHT
NO	NORMALLY OPEN
NP	NAMEPLATE
O	OPEN OR OPENED
OH	OVERHEAD
OL	OVERLOAD RELAY
P	POLE
PA	PUBLIC ADDRESS
PB	PUSHBUTTON / PULL BOX
PCS	PVC COATED GALVANIZED STEEL CONDUIT
PCM	PROCESS CONTROL MODULE
PE	PHOTOCELL
PF	POWER FACTOR
PFCC	POWER FACTOR CORRECTION CAPACITOR
PFR	PHASE FAILURE RELAY
PH	PHASE
PNL	PANEL
PPX	POWER PANEL NO. X
PRI	PRIMARY
PT	POTENTIAL TRANSFORMER
PVC	POLYVINYL CHLORIDE RIGID PLASTIC CONDUIT
PWR	POWER
RAC	RIGID ALUMINUM CONDUIT
RECPT	RECEPTACLE
REV	REVERSE
RF	RADIO FREQUENCY
RMS	ROOT MEAN SQUARED
RVAT	REDUCED VOLTAGE AUTO TRANSFORMER
RVNR	REDUCED VOLTAGE NON-REVERSING
RVSS	REDUCED VOLTAGE SOLID STATE
S	SHIELD / SHORT-TIME
SA	SURGE ARRESTER
SC	SHORT CIRCUIT
SDBC	SOFT DRAWN BARE COPPER
SFL	SUB FEED LUGS
SLT	SEALTIGHT LIQUIDTIGHT FLEXIBLE CONDUIT
SM	SURFACE MOUNTED
SP	SINGLE POLE
SPD	SURGE PROTECTIVE DEVICE
SPDT	SINGLE POLE DOUBLE THROW
SPST	SINGLE POLE SINGLE THROW
SPKR	SPEAKER
SS	SOLID STATE
STB	SHORTING TERMINAL BLOCK
SW	SWITCH
SWBD	SWITCHBOARD
SWGR	SWITCHGEAR
SYM	SYMMETRICAL
TACH	TACHOMETER
TB - X	TERMINAL BLOCK - UNIT X
TC	THERMOCOUPLE / TIME CLOCK / TRAY CABLE
TD	TEMPERATURE DETECTOR RELAY
TE	TOTALLY ENCLOSED
TEFC	TOTALLY ENCLOSED FAN COOLED
TENV	TOTALLY ENCLOSED NON-VENTILATED
TERM	TERMINAL
TJB	TERMINAL JUNCTION BOX
TM	THERMAL MAGNETIC
TP	TWISTED PAIR
TS	TEMPERATURE SWITCH
TS1W	TWO SPEED CONSEQUENT POLE, ONE WINDING
TS2W	TWO SPEED SEPARATE WINDING
TSTAT	THERMOSTAT
UHF	ULTRA HIGH FREQUENCY
UNG	UNGROUNDED
UPS	UNINTERRUPTIBLE POWER SUPPLY
UVR	UNDER VOLTAGE RELAY
V	VOLT
VA	VOLT AMPERE
VAR	VARMETER
VCP	VENDOR CONTROL PANEL
VFD	VARIABLE FREQUENCY DRIVE
VHF	VERY HIGH FREQUENCY
VM	VOLTMETER
VP	VAPORPROOF
VR	VOLTAGE REGULATOR
VS	VOLTAGE SWITCH
VT	VOLTAGE TRANSFORMER
VTP	VOLTAGE TEST POINT
W	WATT / WEST
WT	WATER TIGHT
WP	WEATHER PROOF
XFMR	TRANSFORMER

NOTES:

1. REFER TO SPECIFICATIONS AND OTHER DRAWINGS FOR ADDITIONAL ABBREVIATIONS.

POWER DEVICE FUNCTION NUMBERS

1	MASTER ELEMENT
2	TIME-DELAY STARTING OR CLOSING RELAY
3	CHECKING OR INTERLOCKING RELAY
4	MASTER CONTACTOR
5	STOPPING DEVICE
6	STARTING CIRCUIT BREAKER
7	ANODE CIRCUIT BREAKER
8	CONTROL POWER DISCONNECTING DEVICE
9	REVERSING DEVICE
10	UNIT SEQUENCE SWITCH
11	MULTIFUNCTION DEVICE
12	OVER-SPEED DEVICE
13	SYNCHRONOUS-SPEED DEVICE
14	UNDER-SPEED DEVICE
15	SPEED OR FREQUENCY MATCHING DEVICE
16	DATA COMMUNICATIONS DEVICE
17	SHUNTING OR DISCHARGE SWITCH
18	ACCELERATING OR DECELERATING DEVICE
19	STARTING-TO-RUNNING TRANSITION CONTACTOR
20	ELECTRICALLY OPERATED VALVE
21	DISTANCE RELAY
22	EQUALIZER CIRCUIT BREAKER
23	TEMPERATURE CONTROL DEVICE
24	VOLTS PER HERTZ RELAY
25	SYNCHRONIZING OR SYNCHRONISM-CHECK DEVICE
26	APPARATUS THERMAL DEVICE
27	UNDERVOLTAGE RELAY
27N	GROUND FAULT UNDERVOLTAGE RELAY
28	FLAME DETECTOR
29	ISOLATING CONTACTOR
30	ANNUNCIATOR RELAY
31	SEPARATE EXCITATION DEVICE
32	DIRECTIONAL POWER RELAY
33	POSITION SWITCH
34	MASTER SEQUENCE DEVICE
35	BRUSH-OPERATING OR SLIP-RING SHORT-CIRCUITING DEVICE
36	POLARITY DEVICE
37	UNDERCURRENT OR UNDERPOWER RELAY
38	BEARING PROTECTIVE DEVICE
39	MECHANICAL CONDITION MONITOR
40	FIELD RELAY
41	FIELD CIRCUIT BREAKER
42	RUNNING CIRCUIT BREAKER
43	MANUAL TRANSFER OR SELECTOR DEVICE
44	UNIT SEQUENCE STARTING RELAY
45	ABNORMAL ATMOSPHERIC CONDITION MONITOR
46	REVERSE-PHASE OR BALANCE CURRENT RELAY
47	PHASE-BALANCE OR PHASE-SEQUENCE VOLTAGE RELAY
48	INCOMPLETE SEQUENCE RELAY
49	MACHINE OR TRANSFORMER THERMAL RELAY
50	INSTANTANEOUS OVERCURRENT RELAY
51	AC TIME OVERCURRENT RELAY
52	AC CIRCUIT BREAKER
53	FIELD EXCITATION RELAY
54	TURNING GEAR ENGAGING DEVICE
55	POWER FACTOR RELAY
56	FIELD APPLICATION RELAY
57	SHORT-CIRCUITING OR GROUNDING DEVICE
58	RECTIFICATION FAILURE RELAY
59	OVERVOLTAGE RELAY
60	VOLTAGE OR CURRENT BALANCE RELAY
61	DENSITY SWITCH OR SENSOR
62	TIME-DELAY STOPPING OR OPENING RELAY
63	PRESSURE SWITCH
64	GROUND DETECTOR RELAY
65	GOVERNOR
66	NOTCHING OR JOGGING DEVICE
67	AC DIRECTIONAL OVERCURRENT RELAY
68	BLOCKING OR OUT OF STEP RELAY
69	PERMISSIVE CONTROL DEVICE
70	RHEOSTAT
71	LIQUID LEVEL SWITCH
72	DC CIRCUIT BREAKER
73	LOAD-RESISTOR CONTACTOR
74	ALARM RELAY
75	POSITION CHANGING MECHANISM
76	DC OVERCURRENT RELAY
77	TELEMETERING DEVICE
78	PHASE-ANGLE MEASURING RELAY
79	AC RECLOSING RELAY
80	FLOW SWITCH
81	FREQUENCY RELAY
82	DC LOAD MEASURING RECLOSING RELAY
83	AUTOMATIC SELECTIVE CONTROL OR TRANSFER RELAY
84	OPERATING MECHANISM
85	PILOT COMMUNICATIONS, CARRIER OR PILOT-WIRE RELAY
86	LOCKOUT RELAY
87	DIFFERENTIAL PROTECTIVE RELAY
88	AUXILIARY MOTOR OR MOTOR GENERATOR
89	LINE SWITCH
90	REGULATING DEVICE
91	VOLTAGE DIRECTIONAL RELAY
92	VOLTAGE AND POWER DIRECTIONAL RELAY
93	FIELD-CHANGING CONTACTOR
94	TRIPPING OR TRIP-FREE RELAY

COMMONLY USED SUFFIX LETTERS APPLIED TO POWER DEVICE FUNCTION NUMBERS

A	ALARM ONLY
B	BUS PROTECTION
G	GROUND FAULT PROTECTION (RELAY CT IN A SYSTEM NEUTRAL CIRCUIT OR GENERATOR PROTECTION)
GS	GROUND FAULT PROTECTION (RELAY CT IN TOROIDAL OR GROUND SENSOR TYPE)
L	LINE PROTECTION
M	MOTOR PROTECTION
N	GROUND FAULT PROTECTION (RELAY COIL CONNECTED IN RESIDUAL CT CIRCUIT)
T	TRANSFORMER PROTECTION
V	VOLTAGE
P	PHASE PROTECTION

ABBREVIATIONS

AFD	- ARC FLASH DETECTOR
CLK	- CLOCK OR TIMING SOURCE
DDR	- DYNAMIC DISTURBANCE RECORDER
DFR	- DIGITAL FAULT RECORDER
ENV	- ENVIRONMENTAL DATA
HIZ	- HIGH IMPEDANCE FAULT DETECTOR
HMI	- HUMAN MACHINE INTERFACE
HST	- HISTORIAN
LGC	- SCHEME LOGIC
MET	- SUBSTATION METERING
PDC	- PHASOR DATA CONCENTRATOR
PMU	- PHASOR MEASUREMENT UNIT
PQM	- POWER QUALITY MONITOR
RIO	- REMOTE I/O DEVICE
RTU	- REMOTE TELEMETRY UNIT/REMOTE TERMINAL UNIT
SER	- SEQUENCE OF EVENTS RECORDER
TCM	- TRIP CIRCUIT MONITOR

0

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED CE
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER ERIK M. BAHNEMAN No. E19683 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Erik M. Bahneman
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.10 12:17:17 -07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
ELECTRICAL
ABBREVIATIONS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00GE02
SHEET NO. 21 OF 71

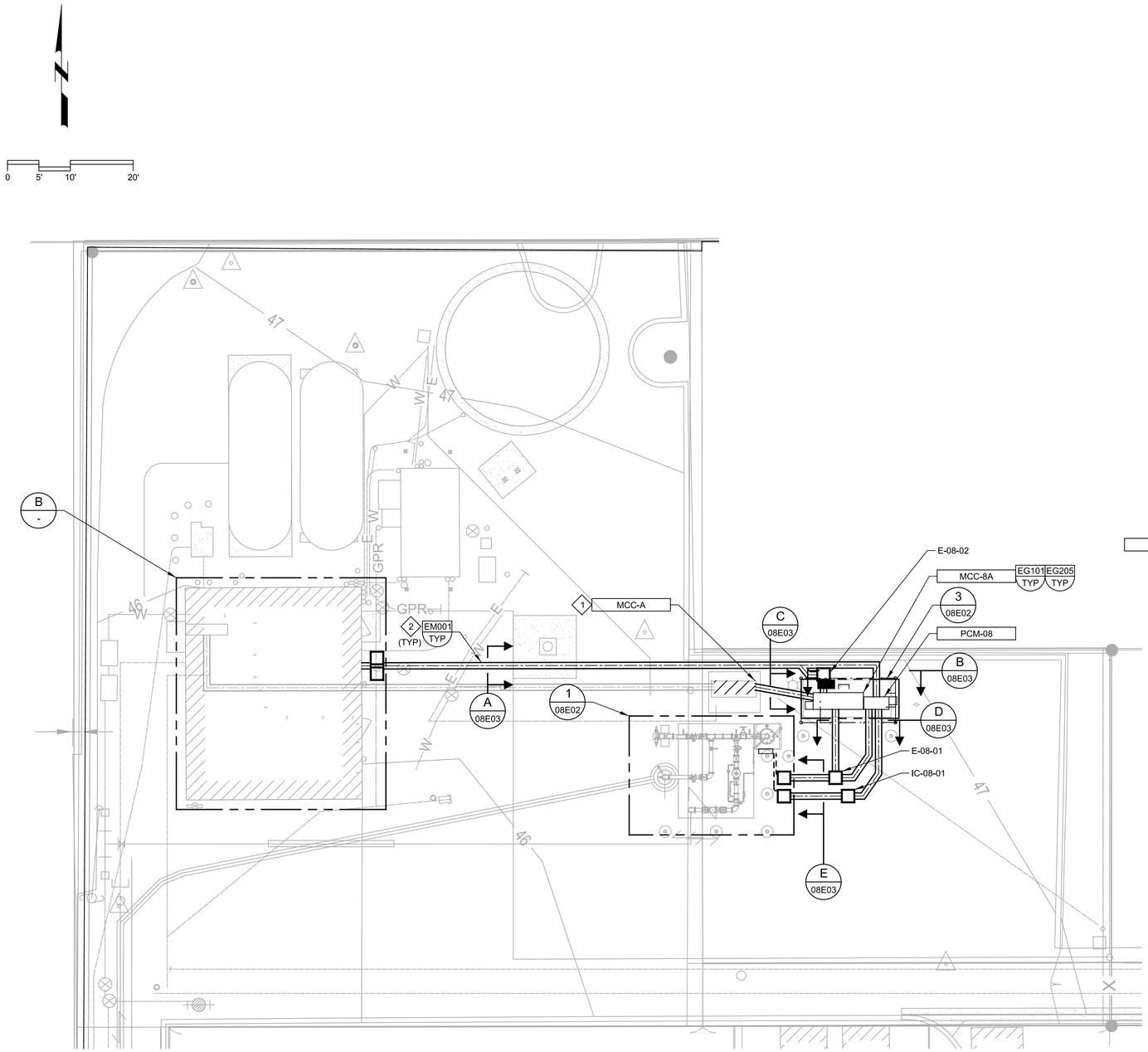
PROJECT NO. 202431-100000 FILE NAME: 20243100GE02.dgn

LAST SAVED BY: JLarrabee
Model: Layout1 ColorTable: gshade.ctb DesignScript: Carollo_Std_Pen_v0905.pen PlotScale: 1:1
Plot Date: 10-SEP-2025 2:01:02 PM
User: svcPW

Plot Date: 10-SEP-2025 2:00:27 PM
User: svcPW
PlotScale: 1:1
DesignScript: Carollo_Std_Pen_v0905.pen
ColorTable: gshade.ctb
Model: Layout1
LAST SAVED BY: JLarrabee

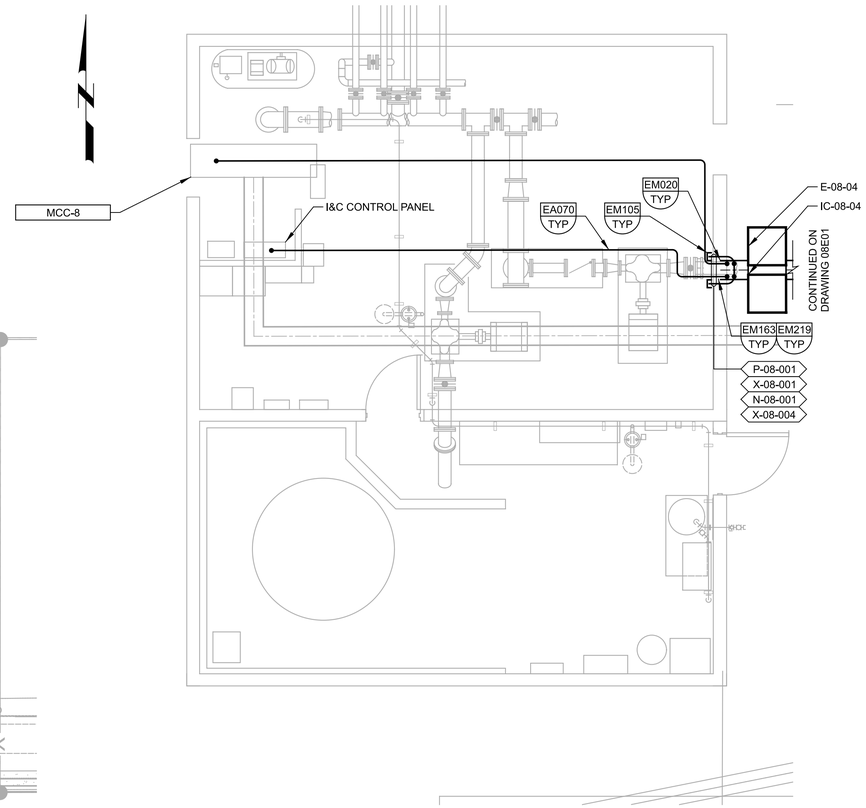
KEY NOTES:

1. EXISTING MCC-A WILL REMAIN IN SERVICE DURING INSTALLATION OF NEW MCC-8A. PROTECT EXISTING FEEDER CABLES FROM MCC-8 IN PLACE FOR REUSE, AFTER MCC-8A IS INSTALLED, DEMOLISH EXISTING MCC-A AND INSTALL SPLICE BOX IN PLACE OF MCC-A. DEMOLISH EXISTING MCC-A POWER CABLES FROM MCC-8 AND ABANDON CONDUIT IN PLACE. USING TERMINAL BLOCKS, EXTEND EXISTING MCC-A LOAD FEEDERS TO NEW MCC-8A.
2. FIELD VERIFY ALL CROSSING UTILITIES PRIOR TO EXCAVATING FOR THE DUCT BANK. ASSUME DUCT BANK WILL REQUIRE AT LEAST 48 INCHES OF COVER. IF AFTER VERIFYING EXISTING UTILITIES A SHALLOWER PATH THAT MEETS THE REQUIREMENTS IN THE TYPICAL DETAILS AND SPECIFICATIONS IS FOUND TO BE POSSIBLE, THEN USE THAT PATH.



A PLAN

SCALE: 1" = 10'-0"
FILE: 20243100E0102



B ENLARGED PLAN

SCALE: 1/4" = 1'-0"
FILE: 20243100E0102

REV	DATE	BY	DESCRIPTION

DESIGNED ZJA
DRAWN JJS
CHECKED EB
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER ERIK M. BAHNEMAN No. E19683 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Erik M. Bahneman
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.10 15:01:12-07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

ELECTRICAL

WELL 8 POWER & CONTROL PLAN

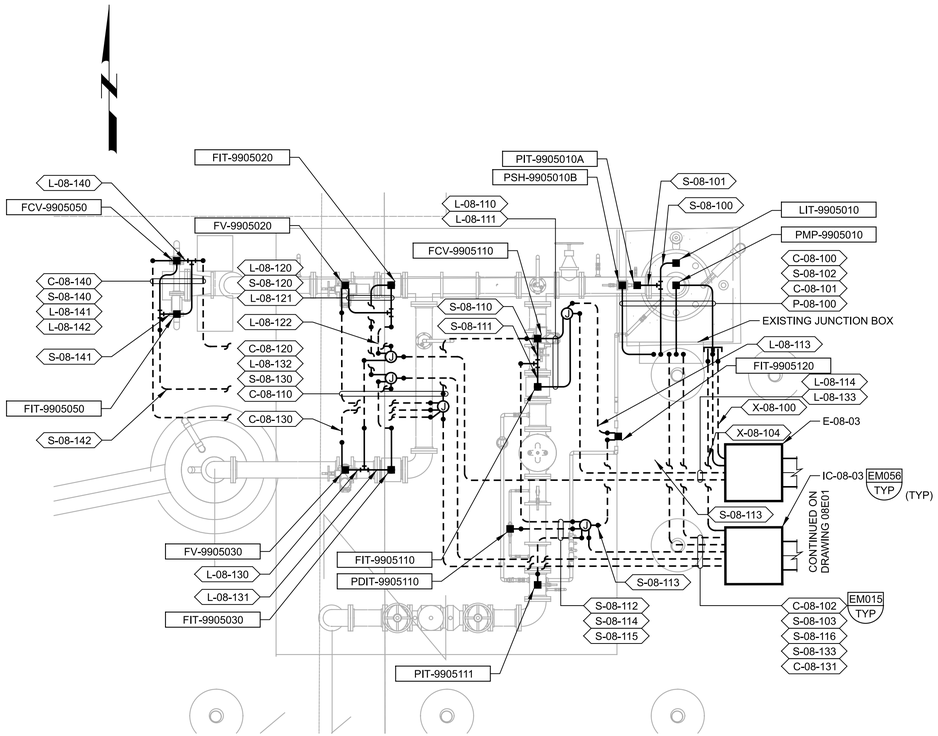
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08E01
SHEET NO. 22 OF 71

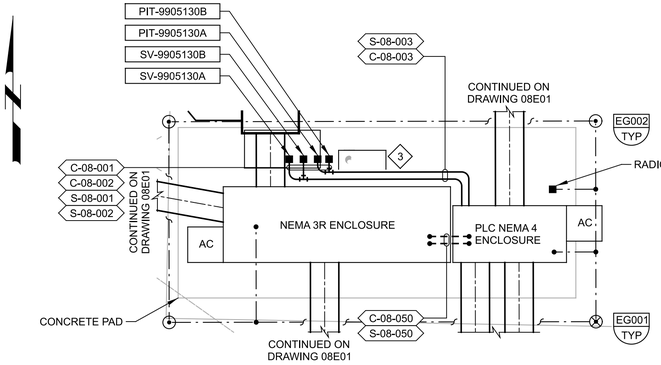
PROJECT NO. 202431-100000 FILE NAME: 202431008E01.dgn

KEY NOTES:

1. SUBMERSIBLE PUMP TERMINAL BOX.
2. SUBMERSIBLE PUMP CABLE.
3. NEMA 4X ENCLOSURE TO ALIGN WITH MECHANICAL AND I&C SHEETS.



1 DETAIL
08E01 SCALE: 3/8" = 1'-0"
FILE: 20243100E0102



2 DETAIL
08E01 SCALE: 3/8" = 1'-0"
FILE: 20243100E0102

0

REV	DATE	BY	DESCRIPTION

DESIGNED ZJA
DRAWN DPM
CHECKED EB
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER ERIK M. BAHNEMAN No. E19683 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Erik M. Bahneman
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.10 13:21:17 -07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

ELECTRICAL

WELL 8 POWER & CONTROL DETAILS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

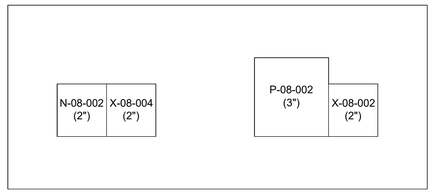
JOB NO. 202431
DRAWING NO. 08E02
SHEET NO. 23 OF 71

Plot Date: 10-SEP-2025 2:00:43 PM
User: svcPW
PlotScale: 1:1
DesignScript: Carollo_Std_Pen_v0905.pen
ColorTable: gshade.ctb
Model: Layout1
LAST SAVED BY: JLarrabee

Plot Date: 9/10/2025 8:24:03 AM

GENERAL NOTES:

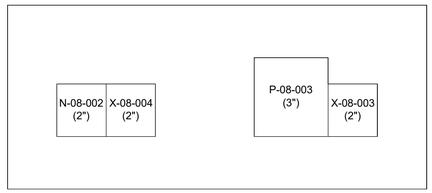
1. CONSTRUCT DUCT BANK PER DETAIL EM001/TYP UNLESS OTHERWISE INDICATED.



WIDTH: 3'-1"
HEIGHT: 1'-6"

A DUCT BANK SECTION

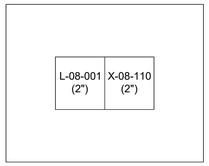
NO MATCHING REF DWGS FOUND



WIDTH: 3'-1"
HEIGHT: 1'-6"

B DUCT BANK SECTION

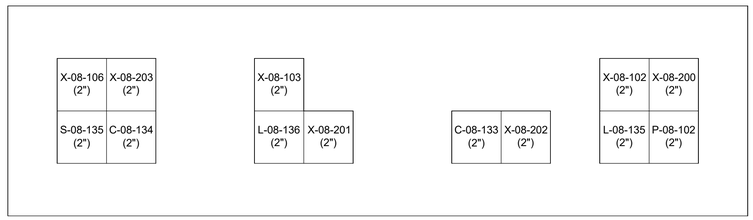
NO MATCHING REF DWGS FOUND



WIDTH: 1'-7"
HEIGHT: 1'-5"

C DUCT BANK SECTION

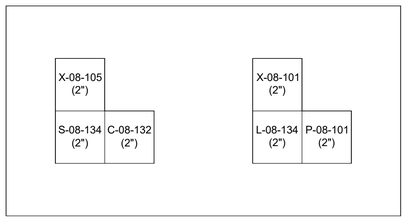
NO MATCHING REF DWGS FOUND



WIDTH: 5'-6"
HEIGHT: 1'-9"

D DUCT BANK SECTION

NO MATCHING REF DWGS FOUND



WIDTH: 3'-0"
HEIGHT: 1'-9"

E DUCT BANK SECTION

NO MATCHING REF DWGS FOUND

REV	DATE	BY	DESCRIPTION

DESIGNED ZJA
DRAWN DPM
CHECKED EB
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER
ERIK M. BAHNEMAN
No. E19683
ELECTRICAL
STATE OF CALIFORNIA

Digitally signed by Erik M. Bahneman
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.10 13:01:12 -07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

ELECTRICAL

WELL 8
DUCT BANK SECTIONS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08E03
SHEET NO. 24 OF 71

LAST SAVED BY: JLarrabee

PROJECT NO. 202431-100000 FILE NAME: 202431008E03.dwg

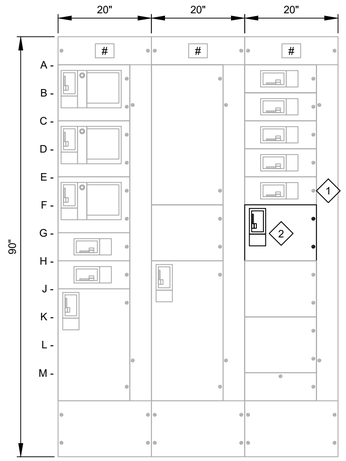
Plot Date: 4/9/2025 10:19:16 AM

GENERAL NOTES:

1. MCC IS A SQUARE D MODEL 6.

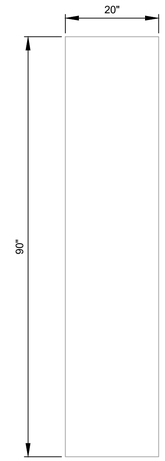
KEY NOTES:

1. DEMOLISH EXISTING CABLES TO MCC-A, AND RETAIN BREAKER AS SPARE.
2. REMOVE EXISTING BLANK AND PROVIDE A NEW BREAKER BUCKET.



FRONT VIEW

SCALE: 3/4" = 1'-0"



SIDE VIEW

SCALE: 3/4" = 1'-0"

1A- RECLAIM	2A- PNL-8	3A- XFMR-CL2 PNL-CL2
1C- AERATOR	2F- SPACE	3B- AIR COMPRESSOR
1E- SPARE	2G- XFMR-8	3C- PUMP 2
1G- XFMR-R PNL-R		3D- PUMP 1
1H- MOTOR SAVER		3E- SPARE
1J- MAIN BREAKER		3F- MCC-8A BELTZ 8 WELL MCC
		3H- SPACE
		3K- SPACE
		3M- SPACE

REV	DATE	BY	DESCRIPTION

DESIGNED ZJA
DRAWN ANV
CHECKED
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER
ERIK M. BAHNEMAN
No. E19683
ELECTRICAL
STATE OF CALIFORNIA

Digitally signed by Erik M. Bahneman
Contact Info: Carollo Engineers, Inc.
Date: 2025.04.09 10:19:16 -07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

ELECTRICAL

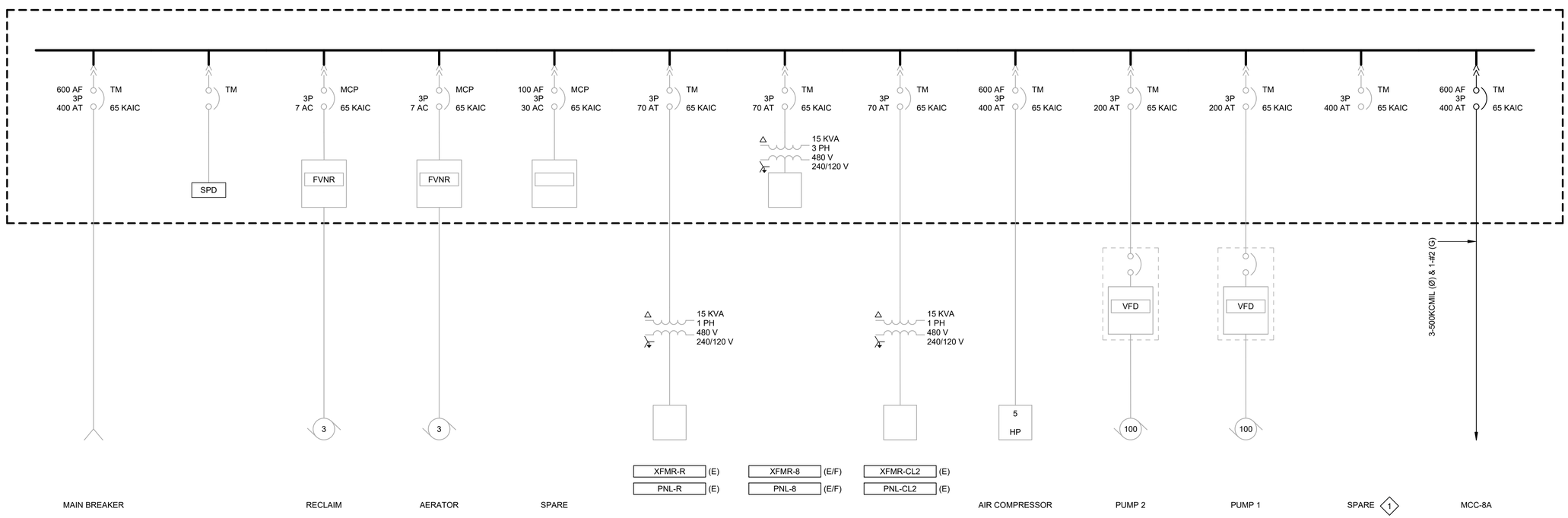
WELL 8 MCC-8 ELEVATION

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08E04
SHEET NO. 25 OF 71

LAST SAVED BY: JLarrabee

PROJECT NO. 202431-100000 FILE NAME: 202431008E04.dwg



KEY NOTES:

1. BREAKER IS CURRENTLY FEEDING MCC-A. RETAIN AS SPARE AFTER INSTALLATION OF NEW BREAKER.

Plot Date: 4/9/2025 10:19:16 AM

LAST SAVED BY: JLarrabee

REV	DATE	BY	DESCRIPTION

DESIGNED ZJA
DRAWN ANV
CHECKED
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER
ERIK M. BAHNEMAN
No. E19683
ELECTRICAL
STATE OF CALIFORNIA

Digitally signed by Erik M. Bahneman
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.22 13:01:13 -07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

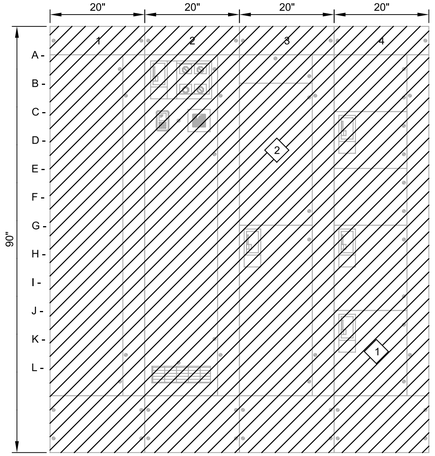
ELECTRICAL

WELL 8 MCC-8 ONE-LINE DIAGRAM

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08E05
SHEET NO. 26 OF 71

PROJECT NO. 202431-100000 FILE NAME: 202431008E05.dwg



FRONT VIEW

SCALE: 3/4" = 1'-0"
FILE:



SIDE VIEW

SCALE: 3/4" = 1'-0"
FILE:

KEY NOTES:

1. PROTECT EXISTING FEEDER CABLES FROM MCC-8 IN PLACE FOR REUSE. AFTER MCC-A DEMOLITION, SPLICE AND RECONNECT EXISTING FEED CABLES TO NEW MCC-8A MAIN BREAKER VIA NEW SPLICE BOX AND DUCT BANK.
2. PROTECT EXISTING EQUIPMENT FEEDERS IN PLACE FOR REUSE. AFTER MCC-A DEMOLITION, SPLICE AND RECONNECT EXISTING FEED CABLES TO NEW MCC-8A PANEL PNL-LPA AND PCM-08 PER PANEL SCHEDULE AND P&IDS VIA NEW SPLICE BOX AND DUCT BANK.

1A- CONTROL PANEL

2A- WELL PUMP A

3A- SPACE

3B- LIGHTING PANEL

3G- XFMR-A
PNL-A
LIGHTING PANEL

4A- SPACE

4C- SPARE DISCONNECT

4E- SURGE SUPPRESSOR

4G- GENERATOR RECEPTACLE

4J- MAIN BREAKER

REV	DATE	BY	DESCRIPTION

DESIGNED ZJA
DRAWN JJS
CHECKED EB
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER
ERIK M. BAHNEMAN
No. E19683
ELECTRICAL
STATE OF CALIFORNIA

Digitally signed by Erik M. Bahneman
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.10 13:01:37 -07'00'

carollo

CITY OF SANTA CRUZ

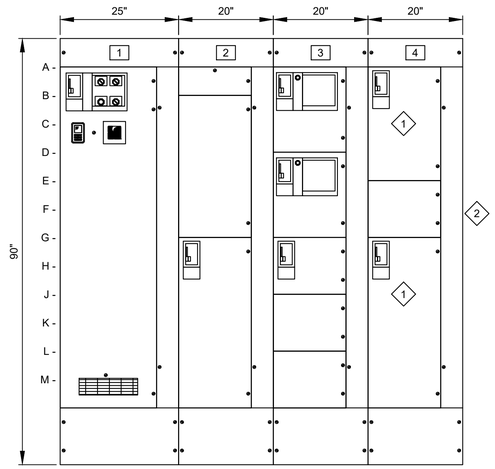
CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
ELECTRICAL
WELL 8 DEMOLITION MCC-A ELEVATION

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08E06
SHEET NO. 27 OF 71

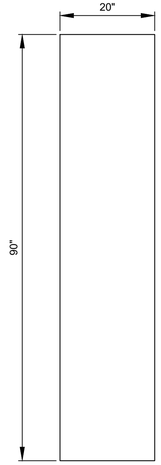
PROJECT NO. 202431-100000 FILE NAME: 202431008E06.dgn

Plot Date: 10-SEP-2025 2:00:33 PM
User: svcPW
Model: Layout1 ColorTable: gshade.ctb DesignScript: Carollo_Std_Pen_v0905.pen PlotScale: 1:1
LAST SAVED BY: JLarrabee



FRONT VIEW

SCALE: 3/4" = 1'-0"



SIDE VIEW

SCALE: 3/4" = 1'-0"

GENERAL NOTES:

1. PROVIDE A DRAW OUT BUCKET WITH BLANK DOOR FOR EACH BUCKET IDENTIFIED AS A SPACE LOCATION.

KEY NOTES:

1. PROVIDE KIRK KEY INTERLOCK FOR MAIN BREAKER AND GENERATOR RECEPTACLE BREAKER.
2. PROVIDE 480V, 200A GENERATOR DOCKING STATION AND MOUNT ON THE SIDE OF THE MCC WEATHER ENCLOSURE. PROVIDE PIN AND SLEEVE OR CAMLOCK DOCKING STATION THAT IS COMPATIBLE WITH EXISTING PORTABLE GEN SETS.

1A- MTR-9905010 WELL PUMP A

2A- SPACE

2B- PNL-LPA LIGHTING PANEL

2G- XFMR-LPA PNL-LPA LIGHTING PANEL

3A- PMP-9905310A SUMP PUMP A

3D- PMP-9905310B SUMP PUMP B

3G- SPARE

3J- SPACE

3L- SPACE

4A- GENERATOR RECEPTACLE

4E- SURGE SUPPRESSOR

4G- MAIN BREAKER

REV	DATE	BY	DESCRIPTION

DESIGNED ZJA
DRAWN DPM
CHECKED EB
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER ERIK M. BAHNEMAN No. E19683 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Erik M. Bahneman
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.22 13:21:12 -07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

ELECTRICAL

WELL 8 MCC-8A ELEVATION

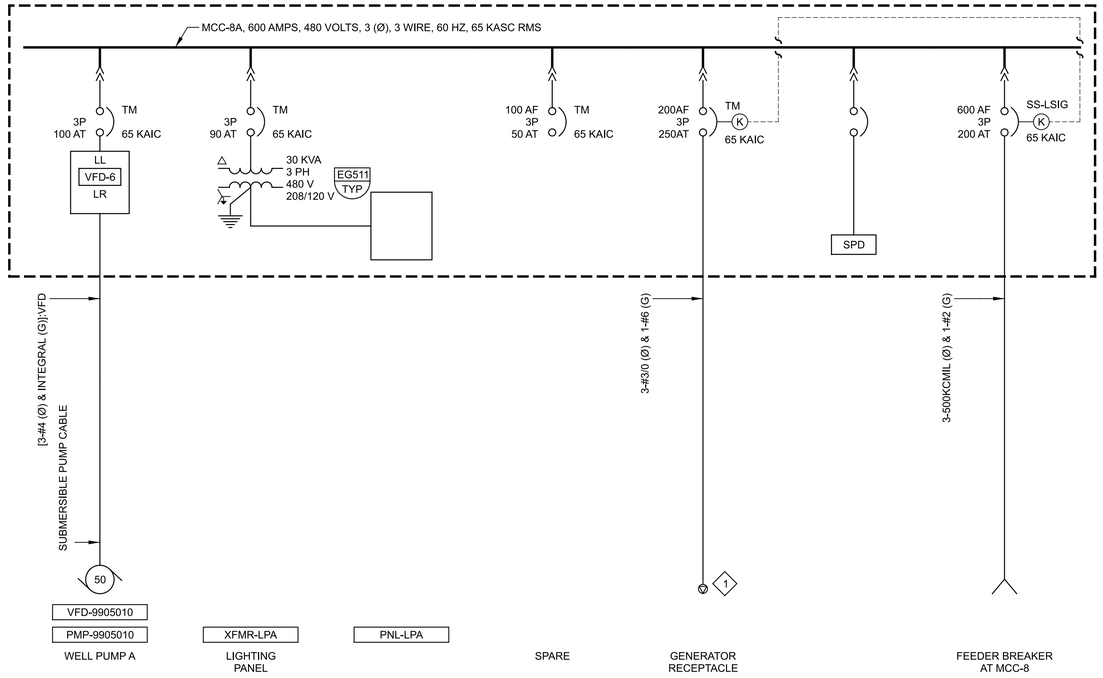
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08E07
SHEET NO. 28 OF 71

Plot Date: 10/5/2022 11:05:10 AM

LAST SAVED BY: JLarrabee

PROJECT NO. 202431-100000 FILE NAME: 202431008E07.dwg



KEY NOTES:

1. PROVIDE 480V, 200A GENERATOR DOCKING STATION AND MOUNT ON THE SIDE OF THE MCC WEATHER ENCLOSURE. PROVIDE PIN AND SLEEVE OR CAMLOCK DOCKING STATION THAT IS COMPATIBLE WITH EXISTING PORTABLE GEN SETS.

REV	DATE	BY	DESCRIPTION

DESIGNED ZJA
DRAWN JJS
CHECKED EB
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER ERIK M. BAHNEMAN No. E19683 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Erik M. Bahneman
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.10 13:01:14 -07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

ELECTRICAL

WELL 8 MCC-8A ONE LINE DIAGRAM

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08E08
SHEET NO. 29 OF 71

PROJECT NO. 202431-100000 FILE NAME: 202431008E08.dgn

Plot Date: 10-SEP-2025 2:01:02 PM
User: svcPW
Model: Layout1 ColorTable: gshade.ctb DesignScript: Carollo_Std_Pen_v0905.pen PlotScale: 1:1
LAST SAVED BY: JLarrabee

Plot Date: 10/5/2022 11:05:10 AM

PANEL PNL-LPA

9/9/2025

LOCATION: BELTZ 8
VOLTS: 208/120
PHASE & WIRE: 3 PH 4W
INTERRUPT: 10 KAIC
OPTIONS: SPD

NEMA: 3R
FEED: BOTTOM
MTG. MCC
BUS RATING: 100
MAIN: CB
MAIN RATING: 100 AF 100 AT

PH A WEIGHTED VA 5520
PH B WEIGHTED VA 5190
PH C WEIGHTED VA 5045
EQUIP SIZING VA 16560
PANEL AMPS 46.0

I/C/S	DESCRIPTION	LOAD (VA)	BKR	CIR	Ø	CIR	BKR	LOAD (VA)	DESCRIPTION	I/C/S	
C	COOLER	1200	15A-1P	1	A	2	20A-1P	1800	PCM-08 - PLC PANEL	C	
C	SHIPPING CONTAINER	1800	20A-1P	3	B	4	15A-1P		SPARE		
C	CONTROLS UPS RECEPTACLE	180	15A-1P	5	C	6	20A-1P	1800	AUTOMATIC GATE	C	1
C	FIT-9905050 - BACKWASH TO STORM DRAIN FLOW METER	240	15A-1P	7	A	8	20A-1P		PCM-08 AUX LOADS	C	
	SPARE		15A-1P	9	B	10	15A-1P		SPARE		
C	FV-9905020 - EXTRACTION FCV	1176	15A-1P	11	C	12	15A-1P	180	TELEPHONE GFI	C	1
C	FCV-9905110 - INJECTION FCV	1176	15A-1P	13	A	14	20A-1P		SPARE		
C	FV-9905030 - FLUSH TO STORM DRAIN MOV	1176	15A-1P	15	B	16	20A-1P		SPARE		
C	AREA LIGHT	300	15A-1P	17	C	18	15A-1P	400	C-TRAIN LIGHTS	C	1
	SPARE		15A-1P	19	A	20	20A-1P		SPARE		
C	FCV-9905050 - BACKWASH TO STORM DRAIN MOV	1176	15A-1P	21	B	22	20A-1P		SPARE		
	SPARE		20A-1P	23	C	24	20A-1P		SPARE		

1

KEY NOTES:

1. EXISTING LOAD. REFEED FROM NEW SPLICE BOX.

ELECTRICAL HANDHOLE AND MANHOLE SCHEDULE

9/4/2025

TAG NO	MINIMUM INTERIOR DIMENSIONS (INCHES)			CONSTRUCTION	TYPICAL DETAIL	SURFACE LOADING	COMMENTS
	WIDTH	LENGTH	DEPTH				
E-08-01	24	24	24	PRECAST CONCRETE	EM056	ROADWAY	STAMPED "ELECTRICAL"
E-08-02	24	24	24	PRECAST CONCRETE	EM056	ROADWAY	STAMPED "ELECTRICAL"
E-08-03	24	24	24	PRECAST CONCRETE	EM056	ROADWAY	STAMPED "ELECTRICAL"
E-08-04	24	24	24	PRECAST CONCRETE	EM056	ROADWAY	STAMPED "ELECTRICAL"
IC-08-01	24	24	24	PRECAST CONCRETE	EM056	ROADWAY	STAMPED "CONTROLS"
IC-08-02	24	24	24	PRECAST CONCRETE	EM056	ROADWAY	STAMPED "CONTROLS"
IC-08-03	24	24	24	PRECAST CONCRETE	EM056	ROADWAY	STAMPED "CONTROLS"
IC-08-04	24	24	24	PRECAST CONCRETE	EM056	ROADWAY	STAMPED "CONTROLS"

NOTES:
1. SEE SPECIFICATION 33_71_21 FOR PRECAST ELECTRICAL HANDHOLES AND MANHOLES.

REV	DATE	BY	DESCRIPTION

DESIGNED ZJA
DRAWN DPM
CHECKED EB
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER ERIK M. BAHNEMAN No. E19683 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Erik M. Bahneman
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.22 13:21:12 -07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

ELECTRICAL

WELL 8 SCHEDULES

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08E09
SHEET NO. 30 OF 71

LAST SAVED BY: JLarrabee

PROJECT NO. 202431-100000 FILE NAME: 202431008E09.dwg

Plot Date: 10/5/2022 11:05:10 AM

CONDUIT SCHEDULE AREA 08

9/9/25

BELTZ WELL 8 ASR DESIGN

BELTZ WELL 8

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
C-08-001	08E02	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: SV-9905130A TO: TEE 2 #14 >> SV-9905130A CONTROL	C-08-003
C-08-002	08E02	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: SV-9905130B TO: TEE 2 #14 >> SV-9905130B CONTROL	C-08-003
C-08-003	08E02	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: TEE TO: PCM-08 2 #14 >> SV-9905130A CONTROL 2 #14 >> SV-9905130B CONTROL	C-08-001 C-08-002
C-08-050	08E02	1.5"	26	#14	XHHW-2	1	#14	XHHW-2	FR: MCC-8A TO: PCM-08 6 #14 >> LCP-9905310 CONTROL 6 #14 >> LCP-9905310B CONTROL 14 #14 >> PMP-9905010 CONTROL	
C-08-100	08E02	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: PSH-9905010B TO: EXISTING JUNCTION BOX 2 #14 >> PSH-9905010B CONTROL	
C-08-101	08E02	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: PMP-9905010 TO: EXISTING JUNCTION BOX 2 #14 >> MSH-PMP-9905010 2 #14 >> TSH-PMP-9905010	C-08-102
C-08-102	08E02	1"	4	#14	XHHW-2	1	#14	XHHW-2	FR: EXISTING JUNCTION BOX TO: IC-08-03 2 #14 >> MSH-PMP-9905010 2 #14 >> TSH-PMP-9905010	C-08-132 C-08-101 C-08-101
C-08-110	08E02	1"	2	#14	XHHW-2	1	#14	XHHW-2	FR: FCV-9905110 TO: J-BOX 2 #14 >> FCV-9905110 CONTROL	C-08-131
C-08-120	08E02	1"	2	#14	XHHW-2	1	#14	XHHW-2	FR: FV-9905020 TO: J-BOX 2 #14 >> FV-9905020 CONTROL	C-08-131
C-08-130	08E02	1"	2	#14	XHHW-2	1	#14	XHHW-2	FR: FV-9905030 TO: J-BOX 2 #14 >> FV-9905030 CONTROL	C-08-131
C-08-131	08E02	1"	14	#14	XHHW-2	1	#14	XHHW-2	FR: J-BOX TO: IC-08-03 2 #14 >> FCV-9905110 CONTROL 2 #14 >> FV-9905020 CONTROL 2 #14 >> FV-9905030 CONTROL 8 #14 >> FCV-9905050 CONTROL	C-08-132 C-08-110 C-08-120 C-08-130 C-08-140
C-08-132	08E03	2"	18	#14	XHHW-2	1	#14	XHHW-2	FR: IC-08-03 TO: IC-08-01 2 #14 >> MSH-PMP-9905010 2 #14 >> TSH-PMP-9905010 2 #14 >> FCV-9905110 CONTROL 2 #14 >> FV-9905020 CONTROL 2 #14 >> FV-9905030 CONTROL 8 #14 >> FCV-9905050 CONTROL	C-08-102 C-08-102 C-08-131 C-08-131 C-08-131 C-08-131
C-08-133	08E03	2"	4	#14	XHHW-2	1	#14	XHHW-2	FR: IC-08-01 TO: MCC-8A 4 #14 >> HSU-9905010 CONTROL	
C-08-134	08E03	2"	6	#14	XHHW-2	1	#14	XHHW-2	FR: IC-08-01 TO: PCM-08 2 #14 >> FCV-9905110 CONTROL 2 #14 >> FV-9905020 CONTROL 2 #14 >> FV-9905030 CONTROL	
C-08-140	08E02	1"	8	#14	XHHW-2	1	#14	XHHW-2	FR: FCV-9905050 TO: J-BOX 8 #14 >> FCV-9905050 CONTROL	C-08-131
L-08-001	08E03	2"	12	#8	XHHW-2	1	#12	XHHW-2	FR: MCC-A SPLICEBOX TO: PNL-LPA (MCC-8A) 2 #8 >> COOLER POWER SPLICE 2 #8 >> SHIPPING CONTAINER POWER SPLICE 2 #8 >> CONTROLS UPS RECPT POWER SPLICE 2 #8 >> AUTOMATIC GATE POWER SPLICE 2 #8 >> TELEPHONE GFI POWER SPLICE 2 #8 >> C-TRAIN LIGHTS POWER SPLICE	

CONDUIT SCHEDULE AREA 08

9/5/25

BELTZ WELL 8 ASR DESIGN

BELTZ WELL 8

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
L-08-110	08E02	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: FCV-9905110 TO: J-BOX 2 #12 >> FCV-9905110 POWER	L-08-114
L-08-111	08E02	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: FIT-9905110 TO: J-BOX 2 #12 >> FIT-9905110 POWER	L-08-114
L-08-113	08E02	1"	2	#12	XHHW-2	1	#12	XHHW-2	FR: FIT-9905120 TO: J-BOX 2 #12 >> FIT-9905120 POWER	L-08-114
L-08-114	08E02	1"	6	#12	XHHW-2	1	#12	XHHW-2	FR: J-BOX TO: E-08-03 2 #12 >> FCV-9905110 POWER 2 #12 >> FIT-9905110 POWER 2 #12 >> FIT-9905120 POWER	L-08-134 L-08-110 L-08-111 L-08-113
L-08-120	08E02	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: FV-9905020 TO: TEE 2 #12 >> FV-9905020 POWER	L-08-122
L-08-121	08E02	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: FIT-9905020 TO: TEE 2 #12 >> FIT-9905020 POWER	L-08-122
L-08-122	08E02	1"	4	#12	XHHW-2	1	#12	XHHW-2	FR: TEE TO: J-BOX 2 #12 >> FV-9905020 POWER 2 #12 >> FIT-9905020 POWER	L-08-133 L-08-120 L-08-121
L-08-130	08E02	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: FV-9905030 TO: TEE 2 #12 >> FV-9905030 POWER	L-08-132
L-08-131	08E02	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: FIT-9905030 TO: TEE 2 #12 >> FIT-9905030 POWER	L-08-132
L-08-132	08E02	1"	8	#12	XHHW-2	1	#12	XHHW-2	FR: TEE TO: J-BOX 2 #12 >> FV-9905030 POWER 2 #12 >> FIT-9905030 POWER 2 #12 >> FCV-9905050 POWER 2 #12 >> FIT-9905050 POWER	L-08-133 L-08-130 L-08-131 L-08-142 L-08-142
L-08-133	08E02	1"	12	#12	XHHW-2	1	#12	XHHW-2	FR: J-BOX TO: E-08-03 2 #12 >> FV-9905020 POWER 2 #12 >> FIT-9905020 POWER 2 #12 >> FV-9905030 POWER 2 #12 >> FIT-9905030 POWER 2 #12 >> FCV-9905050 POWER 2 #12 >> FIT-9905050 POWER	L-08-134 L-08-122 L-08-122 L-08-132 L-08-132 L-08-132 L-08-132
L-08-134	08E03	2"	18	#12	XHHW-2	1	#12	XHHW-2	FR: E-08-03 TO: E-08-01 2 #12 >> FCV-9905110 POWER 2 #12 >> FIT-9905110 POWER 2 #12 >> FIT-9905120 POWER 2 #12 >> FV-9905020 POWER 2 #12 >> FIT-9905020 POWER 2 #12 >> FV-9905030 POWER 2 #12 >> FIT-9905030 POWER 2 #12 >> FCV-9905050 POWER 2 #12 >> FIT-9905050 POWER	L-08-114 L-08-114 L-08-114 L-08-133 L-08-133 L-08-133 L-08-133 L-08-133 L-08-133
L-08-135	08E03	2"	6	#12	XHHW-2	1	#12	XHHW-2	FR: E-08-01 TO: PNL-LPA IN MCC-8A 2 #12 >> FCV-9905110 POWER 2 #12 >> FV-9905020 POWER 2 #12 >> FV-9905030 POWER	
L-08-136	08E03	2"	8	#12	XHHW-2	1	#12	XHHW-2	FR: E-08-01 TO: PCM-08 2 #12 >> FIT-9905110 POWER 2 #12 >> FIT-9905120 POWER 2 #12 >> FIT-9905020 POWER 2 #12 >> FIT-9905030 POWER	
L-08-140	08E02	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: FCV-9905050 TO: TEE 2 #12 >> FCV-9905050 POWER	L-08-142

REV	DATE	BY	DESCRIPTION

DESIGNED ZJA
DRAWN DPM
CHECKED EB
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER ERIK M. BAHNEMAN No. E19683 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Erik M. Bahneman
Date: 2025.09.12 10:47:39 -07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

ELECTRICAL

WELL 8 CONDUIT SCHEDULES 1

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08E10
SHEET NO. 31 OF 71

LAST SAVED BY: JLarrabee

PROJECT NO. 202431-100000 FILE NAME: 202431008E10.dwg

CONDUIT SCHEDULE AREA 08

9/10/25

BELTZ WELL 8 ASR DESIGN

BELTZ WELL 8

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
L-08-141	08E02	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: FIT-9905050 TO: TEE 2 #12 >> FIT-9905050 POWER	L-08-142
L-08-142	08E02	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: TEE TO: J-BOX 2 #12 >> FCV-9905050 POWER 2 #12 >> FIT-9905050 POWER	L-08-132 L-08-140 L-08-141
N-08-001	08E01	0.75"	1		CAT6	1	#14	XHHW-2	FR: I&C CONTROL PANEL TO: IC-08-04 1 CAT6 >> WELL 8 NETWORK	
N-08-002	08E03	2"	1		CAT6	1	#14	XHHW-2	FR: IC-08-04 TO: PCM-08 1 CAT6 >> WELL 8 NETWORK	
P-08-001	08E01	3"	3	500	XHHW-2	1	#2	XHHW-2	FR: MCC-8 TO: E-08-04 3 500 >> MCC-8A POWER	P-08-002
P-08-002	08E03	3"	3	500	XHHW-2	1	#2	XHHW-2	FR: E-08-04 TO: E-08-02 3 500 >> MCC-8A POWER	P-08-003 P-08-001
P-08-003	08E03	3"	3	500	XHHW-2	1	#2	XHHW-2	FR: E-08-02 TO: MCC-8A 3 500 >> MCC-8A POWER	P-08-002
P-08-100	08E02	2"	1	3/C-#4:VFD	VFD			INTEGRAL	FR: PMP-9905010 TO: E-08-04 1 3/C-#4:VFD >> PMP-9905010 POWER	P-08-101
P-08-101	08E03	2"	1	3/C-#4:VFD	VFD			INTEGRAL	FR: E-08-03 TO: E-08-01 1 3/C-#4:VFD >> PMP-9905010 POWER	P-08-102 P-08-100
P-08-102	08E03	2"	1	3/C-#4:VFD	VFD			INTEGRAL	FR: E-08-01 TO: MCC-8A 1 3/C-#4:VFD >> PMP-9905010 POWER	P-08-101
S-08-001	08E02	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: PIT-9905130A TO: TEE 1 2/CS-#16 >> PIT-9905130A SIGNAL	S-08-003
S-08-002	08E02	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: PIT-9905130B TO: TEE 1 2/CS-#16 >> PIT-9905130B SIGNAL	S-08-003
S-08-003	08E02	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: TEE TO: PCM-08 1 2/CS-#16 >> PIT-9905130A SIGNAL 1 2/CS-#16 >> PIT-9905130B SIGNAL	S-08-001 S-08-002
S-08-050	08E02	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: MCC-8A TO: PCM-08 2 2/CS-#16 >> PMP-9905010 SIGNAL	
S-08-100	08E02	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: LIT-9905010 TO: TEE 1 2/CS-#16 >> LIT-9905010 SIGNAL	S-08-102
S-08-101	08E02	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: PIT-9905010A TO: TEE 1 2/CS-#16 >> LIT-9905010 SIGNAL	S-08-102
S-08-102	08E02	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: TEE TO: EXISTING JUNCTION BOX 1 2/CS-#16 >> LIT-9905010 SIGNAL 1 2/CS-#16 >> LIT-9905010 SIGNAL	S-08-103 S-08-100 S-08-101
S-08-103	08E02	1"	2	2/CS-#16		1	#14	XHHW-2	FR: EXISTING JUNCTION BOX TO: IC-08-03 1 2/CS-#16 >> LIT-9905010 SIGNAL 1 2/CS-#16 >> LIT-9905010 SIGNAL	S-08-135 S-08-102 S-08-102
S-08-110	08E02	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: FCV-9905110 TO: TEE 2 2/CS-#16 >> FCV-9905110 SIGNAL	S-08-112
S-08-111	08E02	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: FIT-9905110 TO: TEE 1 2/CS-#16 >> FIT-9905110 SIGNAL	S-08-112

CONDUIT SCHEDULE AREA 08

9/5/25

BELTZ WELL 8 ASR DESIGN

BELTZ WELL 8

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
S-08-112	08E02	1"	3	2/CS-#16		1	#14	XHHW-2	FR: TEE TO: J-BOX 2 2/CS-#16 >> FCV-9905110 SIGNAL 1 2/CS-#16 >> FIT-9905110 SIGNAL	S-08-116 S-08-110 S-08-111
S-08-113	08E02	1"	1	2/CS-#16		1	#14	XHHW-2	FR: FIT-9905120 TO: J-BOX 1 2/CS-#16 >> FIT-9905120 SIGNAL	S-08-116
S-08-114	08E02	1"	1	2/CS-#16		1	#14	XHHW-2	FR: PDIT-9905110 TO: J-BOX 1 2/CS-#16 >> PDIT-9905110 SIGNAL	S-08-116
S-08-115	08E02	1"	1	2/CS-#16		1	#14	XHHW-2	FR: PIT-9905111 TO: J-BOX 1 2/CS-#16 >> PIT-9905111 SIGNAL	S-08-116
S-08-116	08E02	1.5"	6	2/CS-#16		1	#14	XHHW-2	FR: J-BOX TO: IC-08-03 2 2/CS-#16 >> FCV-9905110 SIGNAL 1 2/CS-#16 >> FIT-9905110 SIGNAL 1 2/CS-#16 >> FIT-9905120 SIGNAL 1 2/CS-#16 >> PDIT-9905110 SIGNAL 1 2/CS-#16 >> PIT-9905111 SIGNAL	S-08-135 S-08-112 S-08-112 S-08-113 S-08-114 S-08-115
S-08-120	08E02	1"	1	2/CS-#16		1	#14	XHHW-2	FR: FIT-9905020 TO: J-BOX 1 2/CS-#16 >> FIT-9905020 SIGNAL	S-08-133
S-08-130	08E02	1"	1	2/CS-#16		1	#14	XHHW-2	FR: FIT-9905030 TO: J-BOX 1 2/CS-#16 >> FIT-9905030 SIGNAL	S-08-133
S-08-133	08E02	1.5"	5	2/CS-#16		1	#14	XHHW-2	FR: J-BOX TO: IC-08-03 1 2/CS-#16 >> FIT-9905020 SIGNAL 1 2/CS-#16 >> FIT-9905030 SIGNAL 2 2/CS-#16 >> FCV-9905050 SIGNAL 1 2/CS-#16 >> FIT-9905050 SIGNAL	S-08-134 S-08-120 S-08-130 S-08-142 S-08-142
S-08-134	08E03	2"	5	2/CS-#16		1	#14	XHHW-2	FR: IC-08-03 TO: IC-08-01 1 2/CS-#16 >> FIT-9905020 SIGNAL 1 2/CS-#16 >> FIT-9905030 SIGNAL 2 2/CS-#16 >> FCV-9905050 SIGNAL 1 2/CS-#16 >> FIT-9905050 SIGNAL	S-08-135 S-08-133 S-08-133 S-08-133 S-08-133
S-08-135	08E03	2"	13	2/CS-#16		1	#14	XHHW-2	FR: IC-08-01 TO: PCM-08 1 2/CS-#16 >> LIT-9905010 SIGNAL 1 2/CS-#16 >> LIT-9905010 SIGNAL 2 2/CS-#16 >> FCV-9905110 SIGNAL 1 2/CS-#16 >> FIT-9905110 SIGNAL 1 2/CS-#16 >> FIT-9905120 SIGNAL 1 2/CS-#16 >> PDIT-9905110 SIGNAL 1 2/CS-#16 >> PIT-9905111 SIGNAL 1 2/CS-#16 >> FIT-9905020 SIGNAL 1 2/CS-#16 >> FIT-9905030 SIGNAL 2 2/CS-#16 >> FCV-9905050 SIGNAL 1 2/CS-#16 >> FIT-9905050 SIGNAL	S-08-103 S-08-103 S-08-116 S-08-116 S-08-116 S-08-116 S-08-116 S-08-134 S-08-134 S-08-134 S-08-134
S-08-140	08E02	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: FCV-9905050 TO: TEE 2 2/CS-#16 >> FCV-9905050 SIGNAL	S-08-142
S-08-141	08E02	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: FIT-9905050 TO: TEE 1 2/CS-#16 >> FIT-9905050 SIGNAL	S-08-142
S-08-142	08E02	1"	3	2/CS-#16		1	#14	XHHW-2	FR: TEE TO: J-BOX 2 2/CS-#16 >> FCV-9905050 SIGNAL 1 2/CS-#16 >> FIT-9905050 SIGNAL	S-08-133 S-08-140 S-08-141
X-08-001	08E01	2"	1	PULL	ROPE				FR: STUB UP AT ELECTRICAL ROOM TO: E-08-04 1 PULL >> PULL ROPE	
X-08-002	08E03	2"	1	PULL	ROPE				FR: E-08-04 TO: E-08-02 1 PULL >> PULL ROPE	

REV	DATE	BY	DESCRIPTION

DESIGNED ZJA
DRAWN DPM
CHECKED EB
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER ERIK M. BAHNEMAN No. E19683 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Erik M. Bahneman
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.22 13:23:57 -07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

ELECTRICAL

WELL 8 CONDUIT SCHEDULES 2

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08E11
SHEET NO. 32 OF 71

Plot Date: 10/5/2022 11:05:10 AM

LAST SAVED BY: JLarrabee

PROJECT NO. 202431-100000 FILE NAME: 202431008E11.dwg

CONDUIT SCHEDULE AREA 08

9/5/25

BELTZ WELL 8 ASR DESIGN

BELTZ WELL 8

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
X-08-003	08E03	2"	1	PULL	ROPE				FR: E-08-02 TO: MCC-8A 1 PULL >> PULL ROPE	
X-08-004	08E01 08E03	2"	1	PULL	ROPE				FR: STUB UP AT ELECTRICAL ROOM TO: PCM-08 1 PULL >> PULL ROPE	
X-08-100	08E02	2"	1	PULL	ROPE				FR: STUB UP AT WELL TO: E-08-03 1 PULL >> PULL ROPE	
X-08-101	08E03	2"	1	PULL	ROPE				FR: E-08-03 TO: E-08-01 1 PULL >> PULL ROPE	
X-08-102	08E03	2"	1	PULL	ROPE				FR: E-08-01 TO: MCC-8A 1 PULL >> PULL ROPE	
X-08-103	08E03	2"	1	PULL	ROPE				FR: E-08-01 TO: PCM-08 1 PULL >> PULL ROPE	
X-08-104	08E02	2"	1	PULL	ROPE				FR: STUB UP AT WELL TO: IC-08-03 1 PULL >> PULL ROPE	
X-08-105	08E03	2"	1	PULL	ROPE				FR: IC-08-03 TO: IC-08-01 1 PULL >> PULL ROPE	
X-08-106	08E03	2"	1	PULL	ROPE				FR: IC-08-01 TO: PCM-08 1 PULL >> PULL ROPE	
X-08-110	08E03	2"	1	PULL	ROPE				FR: MCC-A SPLICEBOX TO: MCC-8A 1 PULL >> PULL ROPE	
X-08-200	08E03	2"	1	PULL	ROPE				FR: E-08-01 TO: MCC-8A 1 PULL >> PULL ROPE	
X-08-201	08E03	2"	1	PULL	ROPE				FR: E-08-01 TO: PCM-08 1 PULL >> PULL ROPE	
X-08-202	08E03	2"	1	PULL	ROPE				FR: IC-08-01 TO: MCC-8A 1 PULL >> PULL ROPE	
X-08-203	08E03	2"	1	PULL	ROPE				FR: IC-08-01 TO: PCM-08 1 PULL >> PULL ROPE	

END OF CONDUIT SCHEDULE

REV	DATE	BY	DESCRIPTION

DESIGNED ZJA
DRAWN DPM
CHECKED EB
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER ERIK M. BAHNEMAN No. E19683 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Erik M. Bahneman
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.22 13:01:12 -07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

ELECTRICAL

WELL 8 CONDUIT SCHEDULES 3

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08E12
SHEET NO. 33 OF 71

Plot Date: 10/5/2022 11:05:10 AM

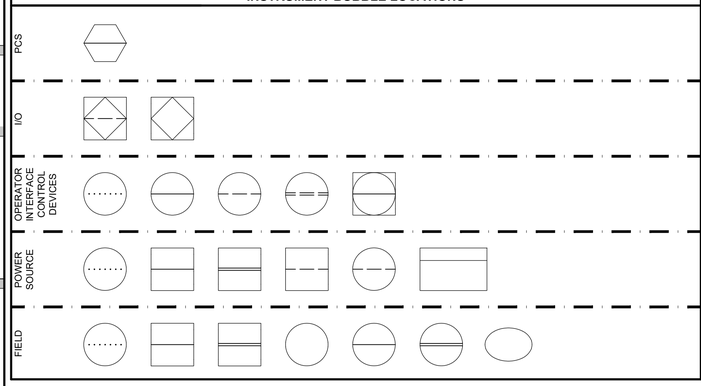
LAST SAVED BY: JLarrabee

PROJECT NO. 202431-100000 FILE NAME: 202431008E12.dwg

SYMBOL	DRAWING VISIBLE FIELDS	FIELD - 1	FIELD - 2	FIELD - 3	FIELD - 4	FIELD - 5	FIELD - 6	FIELD - 7	FIELD - 8
HMI/SCADA SYSTEM OPERATOR INTERFACE TERMINAL	1 - TAG 2 - LOOP NUMBER 3 - FUNCTION 4 - DESCRIPTION 5 - DESCRIPTION 6 - EXISTING/FUTURE	REFER 1 2	REFER 3	ACTION ALARM SP - NUMERIC STATUS - SET POINT TREND	DESCRIPTION 2 5	DESCRIPTION	E - EXISTING F - FUTURE		
HARDWIRED I/O POINT	1 - TAG 2 - LOOP NUMBER 3 - FUNCTION 4 - DESCRIPTION 5 - LOCATION 6 - EXISTING/FUTURE 7 - IO TABLE	REFER 1 2 4	REFER 3	AI - ANALOG INPUT AO - ANALOG OUTPUT DI - DISCRETE INPUT DO - DISCRETE OUTPUT RTD - RTD INPUT	DESCRIPTION	PAC - PROGRAMMABLE AUTOMATION CONTROLLER NO. PLC - PROGRAMMABLE LOGIC CONTROLLER NO. RIO - REMOTE I/O VCP - VENDOR CONTROL PANEL NO.	E - EXISTING F - FUTURE		
NETWORK / SOFT I/O	1 - TAG 2 - LOOP NUMBER 3 - PROTOCOL 4 - PANEL 5 - PLC 6 - EXISTING/FUTURE 7 - IO TABLE 8 - SWITCH/SEGMENT	REFER 1 2	REFER 3	COMMUNICATION PROTOCOL CNET - CONTROLNET DNET - DEVICENET EIP - ETHERNET/IP FF - FOUNDATION FIELDBUS HART-IP - HART OVER ETHERNET MANF - MFR. PROPRIETARY MBRTU - MODBUS RTU MB+ - MODBUS PLUS MBTCP - MODBUS TCP DP - PROFIBUS DP PA - PROFIBUS PA PNET - PROFINET SNMP - SNMPv3 HTTP - WEB SERVER (TCP/IP)	DESCRIPTION	PAC - PROGRAMMABLE AUTOMATION CONTROLLER NO. PLC - PROGRAMMABLE LOGIC CONTROLLER NO. RIO - REMOTE I/O VCP - VENDOR CONTROL PANEL NO.	E - EXISTING F - FUTURE		
LOCAL OPERATOR INTERFACE	1 - TAG 2 - LOOP NUMBER 3 - FUNCTION 4 - DESCRIPTION 5 - LOCATION 6 - EXISTING/FUTURE	REFER 1 2	REFER 3	ACTION ALARM SP - NUMERIC STATUS - SET POINT TREND	DESCRIPTION	LOI - LOCAL OPERATOR INTERFACE NO. LCP - LOCAL CONTROL PANEL NO. PCM - PROCESS CONTROL MODULE NO. VCP - VENDOR CONTROL PANEL NO.	E - EXISTING F - FUTURE		
PILOT DEVICE OPERATOR INTERFACE	1 - TAG 2 - LOOP NUMBER 3 - FUNCTION 4 - DESCRIPTION 5 - LOCATION 6 - EXISTING/FUTURE	REFER 1 2	REFER 3	AM - AUTO/MANUAL BYPASS - BY PASS ESD - EQUIPMENT SHUTDOWN HOA - HAND/OFF/AUTO LOR - LOCAL/OFF/REMOTE LOS - LOCK OUT STOP LS - LEAD/STANDBY LSR - LOCAL/STOP/REMOTE OC - OPEN/CLOSE OO - OFF/ON OSC - OPEN/STOP/CLOSE RST - RESET SEL - SELECT SPD - SPEED SS - START/STOP ST - STOP	DESCRIPTION 2 5	LCP - LOCAL CONTROL PANEL NO. MCC - MOTOR CONTROL CENTER NO. PCM - PROCESS CONTROL MODULE NO. RVSS - REDUCED VOLTAGE SOLID STARTER NO. VCP - VENDOR CONTROL PANEL NO. VFD - VARIABLE FREQUENCY DRIVE NO.	E - EXISTING F - FUTURE		
POWER DEVICE PRIMARY FUNCTION OPERATOR ACCESSIBLE	1 - TAG 2 - LOOP NUMBER 3 - FUNCTION 4 - VOLTAGE-POLE 5 - LOCATION 6 - EXISTING/FUTURE	CB - CIRCUIT BREAKER DISC - DISCONNECT FU - FUSE	REFER 3	TM - THERMAL MAGNETIC CIRCUIT BREAKER	24VDC - 1P 24VDC - 2P 24VAC - 1P 48VDC - 2P 120VAC - 1P 208VAC - 2P 208VAC - 3P 240VAC - 2P 240VAC - 3P 480VAC - 3P 2400VAC - 3P 4160VAC - 3P	DP - DISTRIBUTION PANEL NO. LCP - LOCAL CONTROL PANEL NO. LP - LIGHTING PANEL NO. MCC - MOTOR CONTROL CENTER NO. PCM - PROCESS CONTROL MODULE NO. PP - POWER PANEL NO. VCP - VENDOR CONTROL PANEL NO.	E - EXISTING F - FUTURE		
POWER DEVICE AUXILIARY FUNCTION OPERATOR ACCESSIBLE	1 - TAG 2 - LOOP NUMBER 3 - DESCRIPTION 4 - DESCRIPTION 5 - DESCRIPTION 6 - EXISTING/FUTURE	DISC - DISCONNECT	REFER 3	DESCRIPTION	DESCRIPTION	DESCRIPTION	E - EXISTING F - FUTURE		
POWER DEVICE PRIMARY FUNCTION OPERATOR INACCESSIBLE	1 - TAG 2 - LOOP NUMBER 3 - FUNCTION 4 - VOLTAGE-POLE 5 - LOCATION 6 - EXISTING/FUTURE	CB - CIRCUIT BREAKER FU - FUSE	REFER 3	MCP - MOTOR CIRCUIT PROTECTOR SS - SOLID STATE CIRCUIT BREAKER TM - THERMAL MAGNETIC CIRCUIT BREAKER	24VDC - 1P 24VDC - 2P 24VAC - 1P 48VDC - 2P 120VAC - 1P 208VAC - 2P 208VAC - 3P 240VAC - 2P 240VAC - 3P 480VAC - 3P 2400VAC - 3P 4160VAC - 3P	DP - DISTRIBUTION PANEL NO. LCP - LOCAL CONTROL PANEL NO. LP - LIGHTING PANEL NO. MCC - MOTOR CONTROL CENTER NO. PCM - PROCESS CONTROL MODULE NO. PP - POWER PANEL NO. VCP - VENDOR CONTROL PANEL NO.	E - EXISTING F - FUTURE		
FIELD EQUIPMENT STARTER / DRIVE CUBICLE / CABINET	1 - TAG 2 - LOOP NUMBER 3 - TYPE 4 - VOLTAGE-POLE 5 - POWER SOURCE 6 - EXISTING/FUTURE	MS - MOTOR STARTER RVAT - REDUCED VOLTAGE AUTO TRANSFORMER STARTER RVSS - REDUCED VOLTAGE SOLID STATE STARTER VFD - VARIABLE FREQUENCY DRIVE	REFER 3	FVNR - FULL VOLTAGE NON-REVERSING STARTER FVR - FULL VOLTAGE REVERSING STARTER PWS - PART-WINDING STARTER RVAT - REDUCED VOLTAGE AUTO RVSS - REDUCED VOLTAGE SOLID STATE STARTER TS1W - TWO SPEED SINGLE WINDING TS2W - TWO SPEED TWO WINDINGS VFD - VARIABLE FREQUENCY DRIVE	120VAC - 1P 208VAC - 2P 208VAC - 3P 240VAC - 2P 240VAC - 3P 480VAC - 3P 2400VAC - 3P 4160VAC - 3P	LCP - LOCAL CONTROL PANEL NO. MCC - MOTOR CONTROL CENTER NO. PCM - PROCESS CONTROL MODULE NO. VCP - VENDOR CONTROL PANEL NO.	E - EXISTING F - FUTURE		

SYMBOL	DRAWING VISIBLE FIELDS	FIELD - 1	FIELD - 2	FIELD - 3	FIELD - 4	FIELD - 5	FIELD - 6	FIELD - 7	FIELD - 8
INSTRUMENT PRIMARY ELEMENT	1 - TAG 2 - LOOP NUMBER 3 - FUNCTION 4 - FURNISHED BY 5 - LOCATION 6 - EXISTING/FUTURE	REFER 1	REFER 3	DESCRIPTION 5	DESCRIPTION 6 7	AREA NO. BUILDING NO. ROOM NO.	E - EXISTING F - FUTURE		
INSTRUMENT/ CONTROL ELEMENT PRIMARY FUNCTION OPERATOR ACCESSIBLE	1 - TAG 2 - LOOP NUMBER 3 - FUNCTION 4 - FURNISHED BY 5 - DESCRIPTION 6 - EXISTING/FUTURE	REFER 1	REFER 3	DESCRIPTION 5	DESCRIPTION 6 7	DESCRIPTION INT - INTEGRAL REM - REMOTE	E - EXISTING F - FUTURE		OUT - OUTDOOR
INSTRUMENT/ CONTROL ELEMENT AUXILIARY FUNCTION OPERATOR ACCESSIBLE	1 - TAG 2 - LOOP NUMBER 3 - FUNCTION 4 - FURNISHED BY 5 - LOCATION 6 - EXISTING/FUTURE	REFER 1	REFER 3	DESCRIPTION	DESCRIPTION 6 7	DESCRIPTION	E - EXISTING F - FUTURE		
INSTRUMENT/ CONTROL ELEMENT PRIMARY FUNCTION OPERATOR INACCESSIBLE	1 - TAG 2 - LOOP NUMBER 3 - FUNCTION 4 - FURNISHED BY 5 - LOCATION 6 - EXISTING/FUTURE	REFER 1 3 XR - PROTECTION RELAY CR - CONTROL RELAY XR - INTERPOSING RELAY	REFER 3	DESCRIPTION	DESCRIPTION 6 7	DESCRIPTION	E - EXISTING F - FUTURE		
INSTRUMENT/ CONTROL ELEMENT AUXILIARY FUNCTION OPERATOR INACCESSIBLE	1 - TAG 2 - LOOP NUMBER 3 - FUNCTION 4 - FURNISHED BY 5 - LOCATION 6 - EXISTING/FUTURE	REFER 1 3 XR - PROTECTION RELAY CR - CONTROL RELAY XR - INTERPOSING RELAY	REFER 3	DESCRIPTION	DESCRIPTION 6 7	DESCRIPTION	E - EXISTING F - FUTURE		
FIELD EQUIPMENT NON-POWERED	1 - TAG 2 - LOOP NUMBER 3 - FUNCTION/SIZE 4 - FURNISHED BY 5 - LOCATION 6 - EXISTING/FUTURE	REFER 1	REFER 3	DESCRIPTION	DESCRIPTION 6 7	AREA NO. BUILDING NO. ROOM NO.	E - EXISTING F - FUTURE		
FIELD EQUIPMENT PRIMARY FUNCTION POWERED	1 - TAG 2 - LOOP NUMBER 3 - FUNCTION 4 - FURNISHED BY 5 - LOCATION 6 - EXISTING/FUTURE	REFER 1	REFER 3	DESCRIPTION	DESCRIPTION 6 7	AREA NO. BUILDING NO. ROOM NO.	E - EXISTING F - FUTURE		
FIELD EQUIPMENT AUXILIARY FUNCTION POWERED	1 - TAG 2 - LOOP NUMBER 3 - FUNCTION 4 - FURNISHED BY 5 - LOCATION 6 - EXISTING/FUTURE	MWH - MOTOR WINDING HEATER TSH - TEMPERATURE SWITCH XSH - TORQUE SWITCH	REFER 3	DESCRIPTION	DESCRIPTION 6 7	DESCRIPTION	E - EXISTING F - FUTURE		

INSTRUMENT BUBBLE LOCATIONS



NOTES

1. INSTRUMENT TAG IDENTIFICATION LETTERS TABLE
2. OPERATOR PILOT DEVICE LEGEND
3. EQUIPMENT TAGGING TABLE
4. I/O TYPE DESIGNATIONS
5. INSTRUMENT TYPE DESIGNATIONS TABLE
6. FURNISHED BY:
   - FBO FURNISHED BY OWNER
   - FBV FURNISHED BY VENDOR
7. PROVIDED BY:
   - PBO PROVIDED BY OWNER
   - PBV PROVIDED BY VENDOR

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED CS
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER DANIEL ROBINSON No. 20405 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Daniel S. Robinson
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 10:12:57-07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

INSTRUMENTATION

SYMBOLS AND ABBREVIATIONS 1

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00GN01
SHEET NO. 34 OF 71

LAST SAVED BY: wchristgen

PROJECT NO. 202431-100000 FILE NAME: 20243100GN01.dwg

INSTRUMENT TAG IDENTIFICATION LETTERS

	INSTRUMENTATION FUNCTION / MEASURED VARIABLE	ELEMENT	TRANSMITTER	INDICATING TRANSMITTER	CONVERTER TRANSDUCER, RELAY SPECIAL DEVICES	INDICATOR	RECORDER	CONTROL/COMMAND	INDICATING CONTROLLER	RECORDING CONTROLLER	SWITCH	SWITCH LOW LOW	SWITCH LOW	SWITCH HIGH	SWITCH HIGH HIGH	SWITCH COMBINATION HIGH LOW	ACTION	ALARM LOW LOW	ALARM LOW	ALARM HIGH	ALARM HIGH HIGH	TOTALIZE INDICATOR TRANSMITTER	VALVE	GAUGE	LIGHT	SPEED SETTING
A	ANALYSIS	AE	AT	AIT	AY	AI	AR	AC	AIC	ARC	AS	ASLL	ASL	ASH	ASHH	ASHL		AALL	AAL	AAH	AAHH				AL	
C	CONDUCTIVITY	CE	CT	CIT	CY	CI	CR	CC	CIC	CRC	CS	CSLL	CSL	CSH	CSHH	CSHL		CALL	CAL	CAH	CAHH				CL	
D	DENSITY	DE	DT	DIT	DY	DI	DR	DC	DIC	DRC	DS	DSLL	DSL	DSH	DSHH	DSHL		DALL	DAL	DAH	DAHH				DL	
E	VOLTAGE												ESL													
F	FLOW	FE	FT	FIT	FY	FI	FR	FC	FIC	FRC	FS	FSLL	FSL	FSH	FSHH	FSHL		FALL	FAL	FAH	FAHH	FQI	FCV	FG	FL	
H	HAND (MANUAL)*							HC			HS*						HA*						HV		HL	HSS
I	CURRENT		IT	IIT	IY	II	IR	IC	IIC	IRC	IS	ISLL	ISL	ISH	ISHH			IALL	IAL	IAH	IAHH				IL	
J	POWER					JS																				
K	TIME				KY	KI	KR	KC	KIC	KRC	KS	KSLL	KSL	KSH	KSHH			KALL	KAL	KAH	KAHH		KV		KL	
L	LEVEL	LE	LT	LIT	LY	LI	LR	LC	LIC	LRC	LS	LSLL	LSL	LSH	LSHH	LSHL		LALL	LAL	LAH	LAHH		LCV	LG	LL	
M	MOISTURE OR HUMIDITY	ME	MT	MIT	MY	MI	MR	MC	MIC	MRC	MS	MSLL	MSL	MSH	MSHH			MALL	MAL	MAH	MAHH				ML	
N	USER'S CHOICE																									
P	PRESSURE OR VACUUM	PE	PT	PIT	PY	PI	PR	PC	PIC	PRC	PS	PSLL	PSL	PSH	PSHH	PSHL		PALL	PAL	PAH	PAHH		PCV		PL	
PD	DIFFERENTIAL PRESSURE		PDT	PDIT	PDY	PDI	PDR	PDC	PDIC	PDRC	PDS	PDSLL	PDSL	PDSH	PDSHH			PDALL	PDAL	PDAH	PDAHH		PDCV		PDL	
Q	QUANTITY	QE	QT	QIT	QY	QI	QR				QS	QSLL	QSL	QSH	QSHH			QALL	QAL	QAH	QAHH					
R	RADIATION																									
S	SPEED	SE	ST	SIT	SY	SI	SR	SC	SIC	SRC	SS	SSLL	SSL	SSH	SSHH			SALL	SAL	SAH	SAHH					
T	TEMPERATURE	TE	TT	TIT	TY	TI	TR	TC	TIC	TRC	TS	TSLL	TSL	TSH	TSHH	TSHL		TALL	TAL	TAH	TAHH		TCV		TL	
TD	DIFFERENTIAL TEMPERATURE		TDT	TDIT	TDY	TDI	TDR	TDC	TDIC	TDRC	TDS	TDSLL	TDSL	TDSH	TDSHH			TDALL	TDAL	TDAH	TDAHH		TDCV		TDL	
U	MULTIVARIABLE					UI	UR	UC	UIC	URC	US														UL	
V	VISCOSITY	VE	VT	VIT	VY	VI	VR	VC	VIC	VRC	VS	VSLL	VSL	VSH	VSHH			VALL	VAL	VAH	VAHH				VL	
W	WEIGHT	WE	WT	WIT	WY	WI	WR				WS	WSLL	WSL	WSH	WSHH			WALL	WAL	WAH	WAHH					
X	UNCLASSIFIED	XE	XT	XIT	XY	XI	XR	XC	XIC	XRC	XS	XSLL	XSL	XSH	XSHH			XALL	XAL	XAH	XAHH		XCV	XG	XL	
XV	VIBRATION	XVE	XVT		XVY	XVI	XVR				XVS			XVSH	XVSHH					XVAH	XVAHH				XVL	
Y	STATUS					YI																			YL	
Z	POSITION	ZE	ZT	ZIT	ZY	ZI		ZC**			ZS**												ZV		ZL**	

OPERATOR PILOT DEVICE LEGEND

DEVICE TYPE / PILOT DEVICE FUNCTION	LOCAL-OFF-REMOTE (LOR) OR LOCAL-STOP-REMOTE (LSR)	STOP(SP)	START (ST)	HAND-OFF-AUTO (HOA) HAND-OFF-REMOTE (HOR)	OFF-ON (OO)	SELECT (SEL)	OPEN-STOP-CLOSE (OSC)	JOG OPEN-HOLD-CLOSE (JOHC)	SEMIAUTO-AUTO-MANUAL (SAAM)	LEAD-LAG-STANDBY (LLGS)	AUTO-MANUAL (AM)	OPEN-CLOSE (OC)	LOW-HIGH (LH)	RESET (RST)	SPEED (SPD)	START-STOP (STSP)	EQUIPMENT SHUTDOWN (ESD)	BYPASS (BYP)			SILENCE	POSITION (POS)
PILOT DEVICE TAG (HAND SWITCHES)	HSA	HSB	HSC	HSD	HSE	HSF	HSG	HSH	HIS	HSJ	HSM	HSO	HSQ	HSR	HSS	HST	HSU	HSV	HSW	HSX	HSY	HSZ

I/O TYPE DESIGNATIONS

RNG	RUNNING	SPDC	SPEED COMMAND
FAIL	FAILED/FAULT	SPDF	SPEED FEEDBACK
FWD	RUNNING FORWARD	REM	LOR IN REMOTE
FAST	RUNNING HIGH	LOC	LOR IN LOCAL
SLOW	RUNNING LOW	AUTO	HOA IN AUTO
REV	RUNNING REVERSE	HAND	HOA IN HAND
SVC	SOLENOID VALVE CLOSE	RST	RESET
SVO	SOLENOID VALVE OPEN		
RUN	RUN		
SLWC	MOTOR START LOW		
REVC	MOTOR START REVERSE		

INSTRUMENT TYPE DESIGNATIONS

CGD	COMBUSTIBLE GAS DETECTOR	PTOF	PULSE TIME OF FLIGHT
COND	CONDUCTIVITY	RTD	RESISTANCE TEMP DETECTOR
DO	DISSOLVED OXYGEN	SC	STREAMING CURRENT
FMCW	FREQ. MODULATED CONT. WAVE	SD	SLUDGE DEPTH
IS	INTRINSIC SAFETY BARRIER	TDR	TIME DOMAIN REFLECTOMETRY
LEL	LOWER EXPLOSIVE LIMIT	TOC	TOTAL ORGANIC CARBON
MLSS	MIXED LIQUOR SUSPENDED SOLIDS	TSS	TOTAL SUSPENDED SOLIDS
ORG	UV 504	TURB	TURBIDITY
ORP	OXIDATION REDUCTION POTENTIAL	ULT	ULTRASONIC
PSUB	PRESSURE SUBMERSIBLE	UVI	UV INTENSITY
PC	PARTICLE COUNTER	UVT	UV TRANSMITTANCE

SPECIFIC ABBREVIATIONS

HTR	HEATER
HTU	HEAT TRACE UNIT
MWH	MOTOR WINDING HEATER
SV	SOLENOID VALVE
SPD	SURGE PROTECTIVE DEVICE
UPS	UNINTERRUPTIBLE POWER SUPPLY
YLA	STATUS AUTO PILOT LIGHT
YLR	STATUS REMOTE PILOT LIGHT
YL1	STATUS RUNNING PILOT LIGHT
YL2	ALARM FAILED/FAULT PILOT LIGHT

P&ID LINE SYMBOLS

- INSTRUMENT OR CONNECTION TO PROCESS
- PNEUMATIC SIGNAL
- ELECTRIC SIGNAL
- HYDRAULIC SIGNAL
- CAPILLARY TUBE
- INTERNAL SYSTEM LINK (SOFTWARE OR DATA LINK)

PROCESS LINE SYMBOLS

- PRIMARY PROCESS FLOW IN PIPE
- SECONDARY PROCESS FLOW IN PIPE
- PRIMARY PROCESS FLOW IN CHANNEL
- SECONDARY PROCESS FLOW IN CHANNEL
- HEAT TRACE

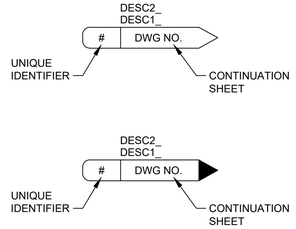
DESIGNATIONS

- EQUIPMENT ENCLOSURE
- EXISTING
- FUTURE



MISCELLANEOUS P&ID SYMBOLS

- PROCESS CONTINUATION
- SIGNAL CONTINUATION

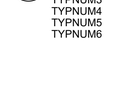


- PIPE CALLOUT

- SCHEMATIC DETAIL



- TYPICAL DETAIL



REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED CS
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER — DANIEL ROBINSON — No. 20405 — ELECTRICAL — STATE OF CALIFORNIA

Digitally signed by Daniel S. Robinson
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 10:10:58-07'00'

carollo®

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
INSTRUMENTATION
SYMBOLS AND ABBREVIATIONS 2

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

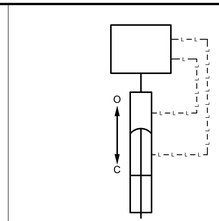
JOB NO. 202431
DRAWING NO. 00GN02
SHEET NO. 35 OF 71

LAST SAVED BY: wchristgen

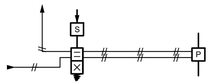
PROJECT NO. 202431-100000 FILE NAME: 20243100GN02.dwg

ACTUATORS

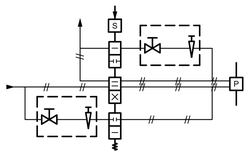
- DIAPHRAGM
- ELECTRIC HYDRAULIC
- ELECTRIC
- HAND
- HYDRAULIC
- MOTOR
- PNEUMATIC
- SOLENOID



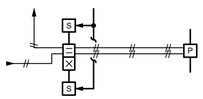
HYDRAULIC MODULATING



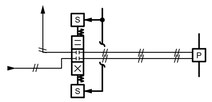
PNEUMATIC SINGLE SOLENOID OPEN/CLOSE



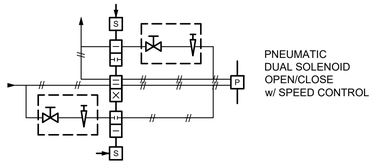
PNEUMATIC SINGLE SOLENOID w/ SPEED CONTROL



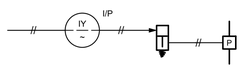
PNEUMATIC DUAL SOLENOID OPEN/CLOSE



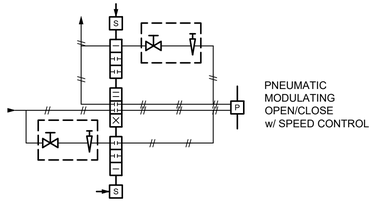
PNEUMATIC DUAL SOLENOID OPEN/HOLD/CLOSE



PNEUMATIC DUAL SOLENOID OPEN/CLOSE w/ SPEED CONTROL



PNEUMATIC MODULATING



PNEUMATIC MODULATING OPEN/CLOSE w/ SPEED CONTROL

PIPING

- AIR GAP
- BLIND FLANGE
- CAPPED OR PLUGGED
- CONCENTRIC INCREASER
- CONCENTRIC REDUCER
- DRAIN
- ECCENTRIC INCREASER
- FLANGED CONNECTION
- TEE
- UNION
- ECCENTRIC REDUCER
- EXPANSION COUPLING
- EXPANSION JOINT VIBRATION CENTER
- FLEXIBLE CONNECTION
- QUICK DISCONNECT

PUMPS

- AIR DRIVEN
- CENTRIFUGAL
- CHEMICAL FEED DIAPHRAGM
- DIAPHRAGM
- GEAR
- LOBE
- PERISTALTIC OR HOSE
- PISTON
- PROGRESSIVE CAVITY

OR SUBMERSIBLE

- VERTICAL TURBINE
- VERTICAL CHOPPER
- WATER CHAMP

BLOWERS/ COMPRESSORS/FANS

- CENTRIFUGAL SINGLE STAGE BLOWER/FAN
- CENTRIFUGAL MULTI STAGE BLOWER
- RECIPROCATING COMPRESSOR
- SCREW COMPRESSOR
- FAN
- LIQUID RING COMPRESSOR
- ROTARY LOBE BLOWER

CHECK VALVES

- BACK FLOW PREVENTER
- BALL
- DIAPHRAGM CHECK
- DOUBLE FLAP
- FLAPPER
- SLANTING CHECK VALVE
- SPRING LOADED GENERAL
- SPRING LOADED SWING
- SWING

PRESSURE VALVES

- BACKPRESSURE REGULATING SELF CONTAINED
- BACKPRESSURE REGULATING EXTERNAL TAP
- PRESSURE REDUCING SELF CONTAINED
- PRESSURE REDUCING EXTERNAL PRESSURE TAP
- REGULATING
- PRESSURE RELIEF
- VACUUM RELIEF

VALVES

- 3-WAY
- 3-WAY PLUG
- 4-WAY
- AIR-RELIEF
- ANGLE
- BALL
- BALL V-NOTCH
- BUTTERFLY
- BUTTERFLY-BURIED VALVE BOX
- CONE
- DIAPHRAGM
- FLOAT
- GATE
- GATE-BURIED VALVE BOX
- GLOBE
- HOSE
- MISCELLANEOUS
- MUD
- NEEDLE
- PINCH
- PLUG ECCENTRIC
- PLUG ECCENTRIC w-VALVE BOX
- PLUG ECCENTRIC LUBRICATED
- PLUG ECCENTRIC LUBRICATED BURIED VALVE BOX
- PLUG CONCENTRIC
- PLUG CONCENTRIC -BURIED VALVE BOX
- PLUG CONCENTRIC LUBRICATED
- PLUG CONCENTRIC LUBRICATED BURIED VALVE BOX
- PUMP DISCHARGE
- TELESCOPING

VALVE DESIGNATIONS	
NO	NORMALLY OPEN
NC	NORMALLY CLOSED
FO	FAIL OPEN
FC	FAIL CLOSE
FLP	FAIL LAST POSITION

MISC

- AIR / CHEMICAL DIFFUSER
- BASKET STRAINER
- BLOW-OFF SILENCER
- CALIBRATION COLUMN
- COALESCER
- DESICCANT DRYER
- EDUCTOR/EJECTOR
- EQUIPMENT/ INSTRUMENT LOCATOR
- EYEWASH
- FILTER
- FILTER SEPARATOR
- FINE FILTER
- FIRE ALARM/SENSOR
- FLAME ARRESTER
- FLAME ARRESTER w/THERMALLY OPERATED VALVE
- FLOW CONDITIONER
- GAS CANNON
- GRINDER
- HEAT EXCHANGER
- HOIST
- HORIZONTAL MIXER
- HOSE CONNECTION
- INLET STRAINER
- INLINE STATIC MIXER
- INLINE DUCT BALANCING DAMPER
- LOUVER OR BACKDRAFT DAMPER
- MATERIAL CHANGE
- MIXER
- NOZZLE
- ORIFICE RESTRICTION
- PERISTALTIC COMPOSITE SAMPLER

OR PULSATION DAMPENER

- REFRIGERATED DRYER
- RUPTURE DISK
- SAMPLE PORT
- ROSSUM SAND TESTER
- SIGHT TUBE
- SMOKE DETECTOR
- STRAINER - MECHANICALLY CLEANED
- STRAINER WITH BLOW OFF
- STRAINER WYE TYPE
- VAPOR HEATER
- VAPORIZER
- VENT
- VENT TO ATMOSPHERE

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED CS
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER DANIEL ROBINSON No. 20405 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Daniel S. Robinson
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 10:11:35-0700

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

INSTRUMENTATION

SYMBOLS AND ABBREVIATIONS 3

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00GN03
SHEET NO. 36 OF 71

LAST SAVED BY: wchristgen

PROJECT NO. 202431-100000 FILE NAME: 20243100GN03.dwg

FLOW

- CORIOLIS
- MAGNETIC
- ORIFICE
- PADDLE WHEEL
- PISTON
- ANNUBAR
- PITOT TUBE
- POSITIVE-DISPLACEMENT
- PROPELLER-TURBINE
- ROTAMETER
- SHUTTLE
- THERMAL
- ULTRASONIC
- ULTRASONIC BIOGAS
- V-CONE
- VENTURI TUBE OR FLOW NOZZLE
- VORTEX

FLUMES

- LEOPOLD-LAGCO
- PALMER-BOWLUS
- PARSHALL
- REGULAR CUTTHROAT
- TRAPEZOIDAL

GATES

SIDE VIEW	PLAN VIEW
	FLAP
	KNIFE
SLIDE	SLIDE
SLUICE	SLUICE
STOP	STOP
	WEIR
	BUTTERFLY

LEVELS

- BUBBLER
- CAPACITANCE
- DIFFERENTIAL PRESSURE (TANK)
- DISPLACEMENT
- ELECTRODE
- BALL FLOAT
- INVERTED COLUMN
- PROBE
- RADAR PTOF
- RADAR (FREQUENCY MODULATED CONTINUOUS WAVE)
- RADAR TDR
- SUSPENDED/ SUBMERSIBLE
- TUNING FORK
- ULTRASONIC

NETWORKS

CABLE CALLOUTS AND ABBREVIATIONS

- 24/FO-SM — FIBER LINE REPRESENTS ONE 24-STRAND FIBER OPTIC CABLE
- (2) 24/FO-SM — FIBER LINE REPRESENTS TWO 24-STRAND FIBER OPTIC CABLES
- (1) 24/FO-SM EA. — EACH FIBER LINE REPRESENTS ONE 24-STRAND FIBER OPTIC CABLE
- (4) — COPPER LINE REPRESENTS FOUR COPPER ETHERNET CABLES
- (2) EA. — EACH COPPER LINE REPRESENTS TWO COPPER ETHERNET CABLES

FIBER ABBREVIATIONS

##/FO-XX
- ## = STRAND COUNT
- FO = FIBER OPTIC

XX = MODE
- SM = SINGLE MODE
- MM = MULTIMODE

NETWORK ABBREVIATIONS

BMS	= BUILDING MANAGEMENT SYSTEM
BSN	= BUSINESS NETWORK
FCN	= FIELD CONTROL NETWORK
MIN	= MAINTENANCE INFORMATION NETWORK
PCN	= PROCESS CONTROL NETWORK
PLCN	= PLC NETWORK
SCN	= SECURITY CONTROL NETWORK
PCN-W	= WIRELESS PROCESS CONTROL NETWORK
NR	= NETWORK RACK
NP	= NETWORK PANEL
ES	= ETHERNET SWITCH
FPP	= FIBER PATCH PANEL

VLAN SYMBOLS

- = BUSINESS NETWORK
- = SECURITY CONTROL NETWORK
- = BUILDING MANAGEMENT SYSTEM
- = PROCESS CONTROL NETWORK
- = WIRELESS PROCESS CONTROL NETWORK
- = MAINTENANCE INFORMATION NETWORK
- = PLC NETWORK
- = FIELD CONTROL NETWORK

PRESSURE/VACUUM

PRESSURE

- PI — GAUGE
- PSH / PE — PRESSURE SWITCH
- PIT / PE — PRESSURE TRANSMITTER
- MANOMETER

DIFFERENTIAL PRESSURE

- PDI — GAUGE DIFFERENTIAL INDICATOR
- PDSL / PDE — DIFFERENTIAL PRESSURE SWITCH
- PDIT / PDE — DIFFERENTIAL PRESSURE TRANSMITTER

PRESSURE SEALS

- SEAL ANNULAR
- SEAL DIAPHRAGM
- SEAL SANITARY

EXAMPLE

PSH / PE — PRESSURE SWITCH

TEMPERATURE

- TEMPERATURE w/THERMOWELL
- TEMPERATURE GAUGE
- T — THERMOMETER

WEIGHT

- PLATFORM SCALE

WEIRS

SIDE VIEW	PLAN VIEW
RECTANGULAR w/o END CONTRACTIONS	RECTANGULAR w/o END CONTRACTIONS
RECTANGULAR w/ END CONTRACTIONS	RECTANGULAR w/ END CONTRACTIONS
V-NOTCH (TRIANGULAR)	V-NOTCH (TRIANGULAR)
TRAPEZOIDAL (CIPOLLETTI)	TRAPEZOIDAL (CIPOLLETTI)

NETWORK LINE SYMBOLS

- COPPER ETHERNET — C C C C C C
- DUPLEX FIBER PATCH — FP FP FP FP FP FP
- FIBER OPTIC ETHERNET — F F F F F F
- WIRELESS — W W W W W W
- PROFIBUS DP — PBD PBD PBD PBD PBD PBD
- PROFIBUS PA — PBA PBA PBA PBA PBA PBA
- SERIAL DATA — o o o o o o o o o o o o

MISCELLANEOUS NETWORK SYMBOLS

NETWORK CABLE CONTINUATIONS

TOP OF PAGE STYLE CONTINUATION

DESC 3
DESC 2
DESC 1
DWG NO.
(#)
— CONTINUATION SHEET
— UNIQUE IDENTIFIER

BOTTOM/LEFT OF PAGE STYLE CONTINUATION

(#)
DWG NO.
DESC 1
DESC 2
DESC 3
— UNIQUE IDENTIFIER
— CONTINUATION SHEET

FIELD NETWORK DEVICE

PLC TAG / PANEL TAG — PROTOCOL / SEGMENT #
DEVICE SPECIFIC SYMBOL
TAG
DESC 1
DESC 2
DESC 3
P&ID DRAWING REFERENCE

NETWORK EQUIPMENT CALLOUT

TAG
DESC 1

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED CS
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER — DANIEL ROBINSON — No. 20405 — ELECTRICAL — STATE OF CALIFORNIA

Digitally signed by Daniel S. Robinson
Contact Info: Carollo Engineers, Inc.
Date: 2025.08.27 10:10:44-07'00'

carollo®

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

INSTRUMENTATION

SYMBOLS AND ABBREVIATIONS 4

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 — 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00GN04
SHEET NO. 37 OF 71

LAST SAVED BY: wchristgen

PROJECT NO. 202431-100000 FILE NAME: 20243100GN04.dwg

PROCESS SWITCHES

- LEVEL SWITCH — CLOSE ON RISING LEVEL
- LEVEL SWITCH — OPEN ON RISING LEVEL
- PRESSURE SWITCH — CLOSE ON RISING PRESSURE
- PRESSURE SWITCH — OPEN ON RISING PRESSURE
- TEMPERATURE SWITCH — CLOSE ON RISING TEMPERATURE
- TEMPERATURE SWITCH — OPEN ON RISING TEMPERATURE
- FLOW SWITCH — CLOSE ON INCREASE IN FLOW
- FLOW SWITCH — OPEN ON INCREASE IN FLOW
- VIBRATION SWITCH — OPEN ON RISING VIBRATION
- VIBRATION SWITCH — CLOSE ON RISING VIBRATION
- TORQUE SWITCH — OPEN ON HIGH TORQUE
- TORQUE SWITCH — CLOSE ON HIGH TORQUE
- NORMALLY CLOSED — LIMIT SWITCH
- NORMALLY CLOSED — HELD OPEN LIMIT SWITCH
- NORMALLY OPEN — LIMIT SWITCH
- NORMALLY OPEN — HELD CLOSED LIMIT SWITCH

HAND SWITCHES

- NORMALLY OPEN — MOMENTARY PUSHBUTTON
- NORMALLY CLOSED — MOMENTARY PUSHBUTTON
- THREE POSITION SELECTOR SWITCH — x - DENOTES POSITION CONTACTS CLOSED IN
- TWO POSITION SELECTOR SWITCH — x - DENOTES POSITION CONTACTS CLOSED IN
- MUSHROOM HEAD PUSHBUTTON
- PUSH-PULL PUSHBUTTON — MAINTAINED CONTACT
- PADLOCK SWITCH — x - DENOTES POSITION CONTACTS CLOSED IN
- PULL CORD SWITCH
- STOP-LOCKOUT PUSHBUTTON
- SPRING-RETURN — x - DENOTES POSITION CONTACTS CLOSED IN

INDICATORS

- PILOT LIGHT — a = LENS COLOR: R = RED, G = GREEN, W = WHITE, A = AMBER, B = BLUE, Y = YELLOW, C = CLEAR
- BEACON — a = LENS COLOR: R = RED, G = GREEN, W = WHITE, A = AMBER, B = BLUE, M = MAGENTA, C = CLEAR
- HORN

RELAYS

RELAY COIL (d / a / b / c)
- a = TYPE
  - CR- CONTROL RELAY
  - TD- TIME DELAY RELAY
  - M - MOTOR STARTER COIL
  - L - MOTOR STARTER COIL - LOW SPEED
  - H - MOTOR STARTER COIL - HIGH SPEED
  - F - MOTOR STARTER COIL - FORWARD
  - R - MOTOR STARTER COIL - REVERSE
- b = TDON - TIME DELAY ON ENERGIZATION; TDOFF - TIME DELAY ON DEENERGIZATION
- c = TIMING RANGE/SETTING
- d = DESCRIPTION

- NORMALLY OPEN — CONTROL CONTACT
- NORMALLY CLOSED — CONTROL CONTACT
- NOTC — TIME DELAY CONTACT, NORMALLY OPEN, TIMED CLOSING
- NCTO — TIME DELAY CONTACT, NORMALLY CLOSED, TIMED OPENING
- NOTO — TIME DELAY CONTACT, NORMALLY OPEN, TIMED OPENING
- NCTC — TIME DELAY CONTACT, NORMALLY CLOSED, TIMED CLOSING

TERMINAL BLOCKS

- TERMINAL — IN PLC/PCM PANEL
- TERMINAL — IN MOTOR CONTROL CENTER
- TERMINAL — IN LOCAL STARTER CONTROL PANEL
- TERMINAL — AT FIELD DEVICE
- TERMINAL — IN RTU
- TERMINAL — IN FIELD PANEL
- TERMINAL — IN (USER CHOICE)
- DIGITAL BUS CONNECTOR
  - * = D - DEVICENET
  - * = PA - PROFIBUS PA
  - * = DP - PROFIBUS DP
  - * = H1 - FOUNDATION FIELDBUS H1
  - * = H2 - FOUNDATION FIELDBUS H2
  - * = E - ETHERNET

I/O

- a — PLC DISCRETE; a = INPUT OR OUTPUT AS INDICATED
- ANALOG a — PLC ANALOG; a = INPUT OR OUTPUT AS INDICATED
- DIGITAL BUS — DIGITAL BUS

MISC

- SOLENOID
- CIRCUIT BREAKER
- DISCONNECT
- FUSE
- TRANSIENT SURGE PROTECTION
- MWH-* — MOTOR WINDING HEATER; * - MOTOR TAG I.D.
- VARISTOR
- CAPACITOR
- RESISTOR
- BATTERY
- DIODE
- MOTOR OVERLOAD HEATERS
- OVERLOAD CONTACT
- DRAWOUT CONNECTION
- GROUND
- LIGHTNING ARRESTOR
- H1 H3 H2 H4 / X1 X2 — CONTROL POWER TRANSFORMER
- ETM — ELAPSED TIME METER
- RTD

MISC

- MISC PORT
- ETHERNET PORT
- SPD — SURGE PROTECTION DEVICE
- TRANSFORMER LINE/LOAD REACTOR
- MOTOR - 1 PHASE
- MOTOR - 3 PHASE
- SPEED SWITCH

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED CS
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER — DANIEL ROBINSON — No. 20405 — ELECTRICAL — STATE OF CALIFORNIA

Digitally signed by Daniel S. Robinson
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 10:10:31-07'00'

carollo

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

INSTRUMENTATION

SCHEMATIC SYMBOLS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 — 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00GN05
SHEET NO. 38 OF 71

LAST SAVED BY: wchristgen

PROJECT NO. 202431-100000 FILE NAME: 20243100GN05.dwg

MCC-1201

PCM-300

TERMINAL | PANEL | PLC

PMP-210
UTILITY WATER PUMP
MOTOR:
25HP, 480VAC, 3Ø
INV. DUTY, TEFC
TOSHIBA MODEL: XYZ

PUMP
200 GPM @ 20 FT TDH
900-1800 RPM
GOULD MODEL: XYZ

P-01-001 J-BOX P-01-002

MWH H C
PMP T1 T2 T3
TSH NC C

(TSH210-H/VFD210-33)
(TSH210-C/VFD210-X2)
(PMP210-T1/VFD210-T1)
(PMP210-T2/VFD210-T2)
(PMP210-T3/VFD210-T3)

C-01-003 J-BOX

(TSH210-NC/PCM300-CB1300H1)
(TSH210-C/PCM300-I001)

C-01-001

PE/PSH-210
UTILITY WATER HIGH PRESSURE
MODEL: XYZ
RANGE: 0-200 PSIG
SETPOINT: 50 PSIG

PE PSH 1 2

(PSH210-1/PCM300-CB1300H2)
(PSH210-2/PCM300-C0001)

L-01-001

L N G

FE/FIT/FQT-210
UTILITY WATER FLOW METER
ENDRESS HAUSER
CAT NO.: XYZ
FLOW RANGE: 200-2500 GPM
FLOW TOTAL: 1 PULSE/500 GAL

FM FE FIT FQT 1 2 4 5

S-01-001 J-BOX S-01-003

S-01-002

LCP-210
HSS P1 P2 P3
HSA OFF LOCAL REMOTE xoo oox 1 2 3 4
STOP
HSB 5 6
START
HSC 7 8

C-01-002

(LCP210-P1/VFD210-1)
(LCP210-P2/VFD210-2)
(LCP210-P3/VFD210-3)
(LCP210-1/VFD210-5)
(LCP210-2/VFD210-6)
(LCP210-5/VFD210-7)
(LCP210-6/VFD210-8)
(LCP210-7/VFD210-9)
(LCP210-8/VFD210-10)

VFD-210
SECTION - 3
CUBICLE - 2
30HP, 480VAC, 42 AMPS

33 X2 TSH-210 MOTOR WINDING HEATER
T1 T2 T3 MOTOR CONNECTION
SS-210 VFD SPEED OUT 11 12
SB-210 REMOTE SPEED IN 13 14
MSP-210 REMOTE STOP 15 16
E-STOP 23 34
MS-210 REMOTE START 17 18
AUX1-210 RUNNING 19 20
AUX2-210 FAIL 21 22
1 2 3 4 LOCAL SPEED IN
5 6 HSAL-210 LOCAL MODE
7 8 HSB-210 LOCAL STOP
9 10 HSC-210 LOCAL START

(VFD210-11,12/PCM300-AQ001)
(VFD210-13,14/PCM300-AI001)
(TSH210-NC/PCM300-FU1300H1)
(TSH210-NC/PCM300-I001)
(VFD210-15/PCM300-Q001A)
(VFD210-16/PCM300-Q001B)
(PSH210-1/PCM300-FU1300H2)
(VFD210-23/PCM300-C0002)
(VFD210-24/PCM300-C0003)
(PSH210-1/PCM300-C001)
(VFD210-17/PCM300-Q002A)
(VFD210-18/PCM300-Q002B)
(FIT210-L/PCM300-CB1210H)
(FIT210-N/PCM300-CB1210N)
(FIT210-1,2/PCM300-AI002)
(FQT210-4,5/PCM300-FU1300P3; C0004)
(VFD210-19/PCM300-FU13000H3)
(VFD210-20/PCM300-I003)
(VFD210-21/PCM300-FU1300H4)
(VFD210-22/PCM300-I004)
(LCP210-3/PCM300-FU1300H5)
(LCP210-4/PCM300-I006)

AQ0001+ <BLK-1>
AQ0001- <WHT-1>
SHLD FU1300-P1
AI001+ <BLK-1>
FU1300-M1 <WHT-1>
SHLD FU1300-H1
I001 <BLK>
Q001A <BLK>
Q001B <RED>
FU1300-H2
C0002
C0003
C0001
Q002A <BLU>
Q002B
CB1-210H
CB1-210N
GND
FU1300-P2
AI002+ <BLK-2>
FU1300-M2 <WHT-2>
SHLD FU1300-P3
C0004
SHLD
FU1300-H3
I003 <BLU>
FU1300-H4
I004 <ORG>
FU1300-H5
I006 <YEL>

120VAC

(C0002) (C0003) (C0001) (CB1300-H6)
PHOENIX MODEL: XYZ 120 VAC
CR1 1 2 3 4 5 6
(CB1-300N1) (I005)

(FU1300-M3)
(C0004) (CB1300-H7)
CR2 1 2 3 4 5 6
(I002)
PHOENIX MODEL: XYZ 120 VAC

FU1-300M FU1-300P CB1-300H
24 VDC
(FU1300-P) (CB1300-H)
120 VAC
CB1-300N (CB1300-N)

PLC:
SS %AQ001 SPEED_OUT RACK 1 SLOT 2
SB %AI001 SPEED_IN RACK 1 SLOT 3
TSH %I001 MTR_TEMP RACK 1 SLOT 4
MSP %Q001 STOP RACK 1 SLOT 5
PSH %I005 HI_PRESS RACK 1 SLOT 4
MS %Q002 START RACK 1 SLOT 5
F %AI002 FLOW RACK 1 SLOT 2
FQ %I002 FLOW_TOT RACK 1 SLOT 4
AUX1 %I003 RUNNING RACK 1 SLOT 4
AUX2 %I004 FAIL RACK 1 SLOT 4
HSAR %I006 REMOTE RACK 1 SLOT 4

THE ABOVE DRAWING IS INCLUDED AS AN EXAMPLE ONLY AND IS NOT PROJECT SPECIFIC. CONTRACTOR SHALL FURNISH LOOP DIAGRAMS FOR THE ENTIRE FACILITY. PRELIMINARY DETAILED LOOP DIAGRAMS TO BE SUBMITTED FOR REVIEW PRIOR TO BEGINNING CONSTRUCTION. THE LOOP DIAGRAM SHOWN ABOVE DISPLAYS THE LEVEL OF EXPECTED DETAIL.

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED CS
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER DANIEL ROBINSON No. 20405 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Daniel S. Robinson
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 10:10:13-07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
INSTRUMENTATION
SAMPLE LOOP DRAWING

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00GN06
SHEET NO. 39 OF 71

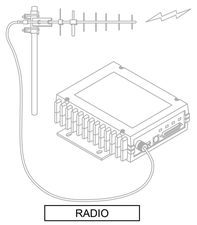
LAST SAVED BY: wchristgen

PROJECT NO. 202431-100000 FILE NAME: 20243100GN06.dwg

GENERAL NOTES:

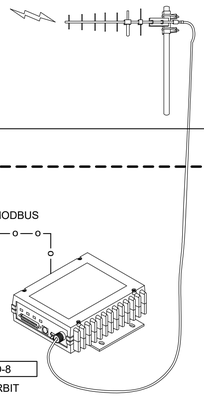
1. ALL COPPER CONNECTIONS FROM DEVICES EXTERNAL TO THE ENCLOSURE SHALL BE MADE THROUGH COPPER PATCH PANELS (NOT SHOWN FOR CLARITY) OR SURGE PROTECTION DEVICE AND PATCHED THROUGH TO DEVICES AS SHOWN.
2. COMMUNICATION PROTOCOL SHALL BE MODBUS TCP, UNLESS NOTED OTHERWISE.
3. PROVIDE ADDITIONAL HARDWARE AND CONFIGURATION AS NEEDED FOR A FULLY FUNCTIONAL SYSTEM.

GRAHAM HILL
WATER TREATMENT PLANT (GHWTP)



RADIO

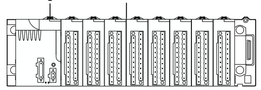
BELTZ WELL 8



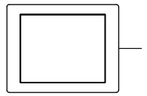
PCM-8

MODBUS

C



PLC-8
SCHNEIDER M340



OIT-8
MAGELIS XBTG



ESW-8
ETHERNET SWITCH

RADIO-8
GE MDS ORBIT

REV	DATE	BY	DESCRIPTION

DESIGNED DSR
DRAWN LMB
CHECKED CS
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER
DANIEL ROBINSON
No. 20405
ELECTRICAL
STATE OF CALIFORNIA

Digitally signed by Daniel S. Robinson
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 10:09:56-07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

INSTRUMENTATION

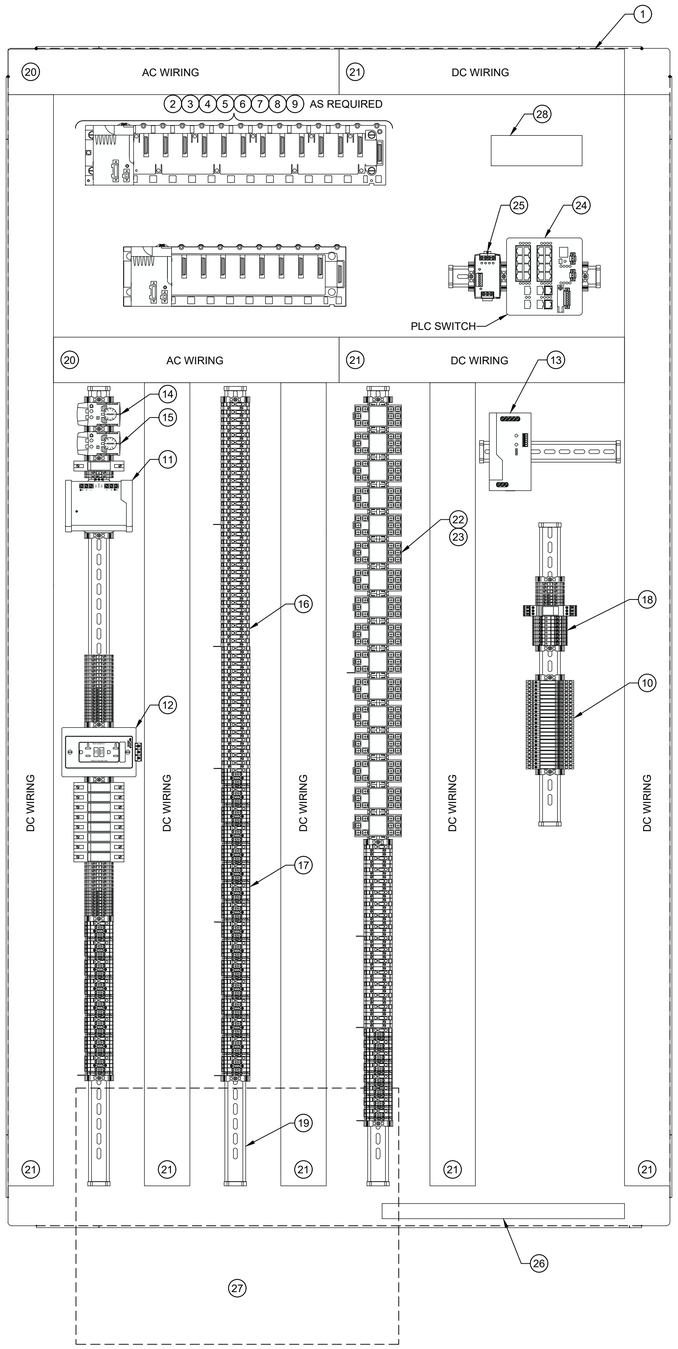
WELL 8 COMMUNICATIONS DIAGRAM

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 03N01
SHEET NO. 40 OF 71

$$$$DATE$$$$
$$$$USER$$$$
$$$$PLOT_INFO$$$$
LAST SAVED BY: wchristgen

PROJECT NO. 202431-100000 FILE NAME: 20243103N01.dwg



GENERAL NOTES:

1. ENCLOSURE DRAWING REPRESENTS DESIGN INTENT. CONTRACTOR TO SUPPLY AS-BUILT DRAWINGS SHOWING FINAL ENCLOSURE LAYOUT WITH ALL EQUIPMENT, MANUFACTURERS, AND PART NUMBERS.
2. REFER TO ELECTRICAL PLANS FOR LOCATION OF ALL ENCLOSURES. CONSTRUCT PANEL TO MEET THE FULL INTENT OF ARTICLE 409 OF THE NATIONAL ELECTRIC CODE.
3. FOLLOW ALL UL 508 AND 508A SUPPLEMENT SB REQUIREMENTS TO DETERMINE SHORT CIRCUIT RATINGS.
4. CIRCUIT BREAKERS SHALL BE COORDINATED TO TRIP BRANCH CIRCUIT BREAKER PRIOR TO THE MAIN PANEL CIRCUIT BREAKER.
5. ALL TIE WRAPS SHALL BE LOCATED OUTSIDE OF THE WIRE DUCTS. INSTALLATION OF ALL NYLON TIE WRAPS SHALL BE TENSIONED AND TRIMMED FLUSH.
6. ELEVATE ALL TERMINAL BLOCK DIN RAIL A MINIMUM OF 2 INCHES OFF OF BACK PANEL.
7. NO 480VAC CIRCUITS SHALL TERMINATE IN OR PASS THROUGH CONTROL CABINETS.
8. NO CAMERA OR TELEPHONE CABLES SHALL TERMINATE IN OR PASS THROUGH CONTROL CABINETS.
9. ALL CONDUIT PENETRATIONS SHALL BE LOCATED AT THE TOP OR BOTTOM OF THE ENCLOSURE. NO SIDE, FRONT, OR REAR PENETRATIONS ALLOWED.
10. QUANTITY OF COMPONENTS VARY AS REQUIRED FOR EACH CABINET.
11. REFER TO INSTRUMENTATION TYPICAL DETAILS FOR PANEL CONSTRUCTION AND WIRING REQUIREMENTS.
12. REFER TO DETAILS NE101/TYP, NE102/TYP, NE104/TYP, NE105/TYP, NE304/TYP, NE305/TYP, NE306/TYP, NE307/TYP, NE308/TYP, NE310/TYP, NE311/TYP, NE314/TYP, NE315/TYP, NE350/TYP, NE351/TYP, NE352/TYP, NE353/TYP, NE354/TYP.

MAJOR EQUIPMENT SCHEDULE

ITEM	DESCRIPTION
1	BACK PANEL
2	PLC BACKPLANE
3	PLC PROCESSOR
4	PLC POWER SUPPLY
5	PLC ETHERNET COMMUNICATION MODULES
6	PLC DI MODULES
7	PLC DO MODULES
8	PLC AI MODULES
9	PLC AO MODULES
10	SIGNAL CONDITIONERS
11	120VAC PANEL SURGE PROTECTOR
12	RECEPTACLE, 5A
13	24VDC POWER SUPPLY
14	HVAC CONTROL
15	ENCLOSURE TEMPERATURE SWITCH
16	DISCRETE TERMINAL BLOCKS
17	ANALOG TERMINAL BLOCKS
18	24VDC FUSED TERMINAL BLOCKS
19	DIN RAIL
20	GRAY WIRE DUCT
21	WHITE WIRE DUCT
22	TIMER/CONTROL RELAYS
23	INTERPOSING RELAYS
24	ETHERNET SWITCH
25	ELECTRONIC CIRCUIT PROTECTOR
26	GROUND BAR
27	UPS MOUNTED ON ENCLOSURE BOTTOM
28	RADIO

REV	DATE	BY	DESCRIPTION

DESIGNED DSR
DRAWN CGR
CHECKED CS
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER DANIEL ROBINSON No. 20405 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Daniel S. Robinson
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 10:09:13-07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

INSTRUMENTATION

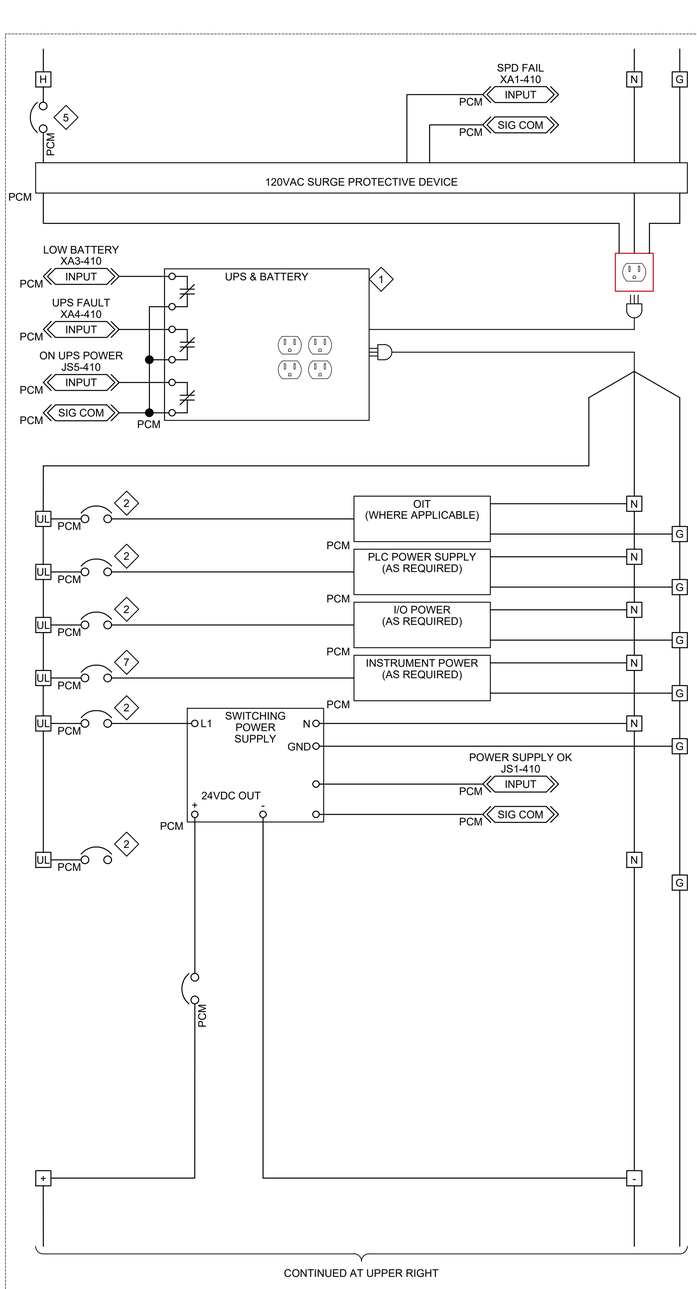
WELL 8 CONTROL PANEL ELEVATION AND BACK PANEL LAYOUT

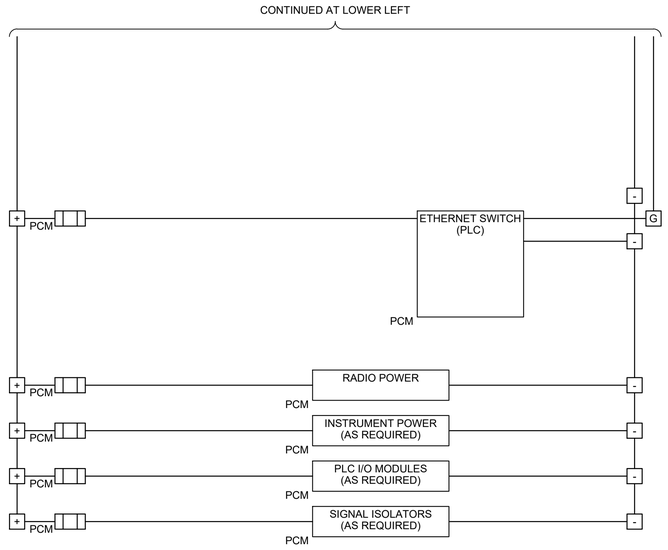
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

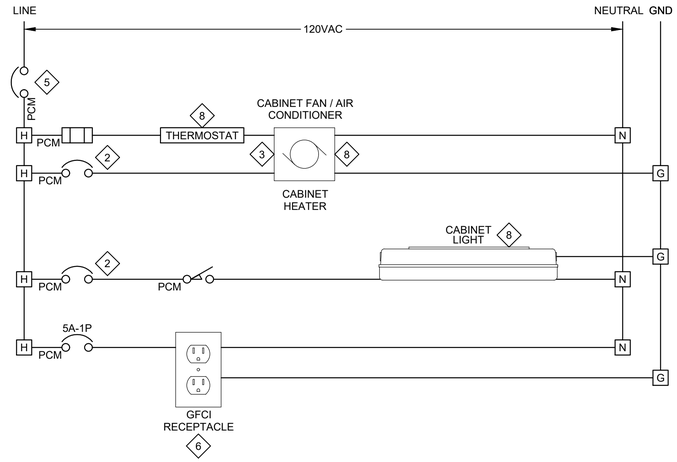
JOB NO. 202431
DRAWING NO. 05N01
SHEET NO. 41 OF 71

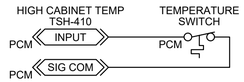
$$$$DATE$$$$
$$$$USER$$$$
$$$$PLOT_INFO$$$$
LAST SAVED BY: wchristgen

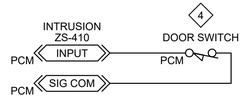
PROJECT NO. 202431-100000 FILE NAME: 20243105N01.dwg











GENERAL NOTES:

1. SCHEMATIC ILLUSTRATES DESIGN INTENT ONLY. PROVIDE ALL NECESSARY COMPONENTS TO MEET PROJECT REQUIREMENTS.

KEY NOTES:

1. SIZE UPS AND BATTERY BASED ON UPS SPECIFICATION REQUIREMENTS.
2. SIZE BASED ON PROTECTION NEEDS.
3. VERIFY LOADS BASED ON TEMPERATURE CALCULATIONS. PROVIDE ADDITIONAL CIRCUIT IF REQUIRED.
4. INSTALL SWITCH ON OUTERMOST DOOR OF OVERLAPPING DOORS. PROVIDE ADDITIONAL SWITCHES, WIRED IN SERIES, FOR NON-OVERLAPPING DOORS.
5. SIZE BASED ON LOAD REQUIREMENT.
6. PROVIDE QUANTITY REQUIRED PER SPECIFICATIONS. SIZE RECEPTACLE FOR LAPTOP.
7. SIZE BASED ON PROTECTION NEEDS. PROVIDE SEPARATE CIRCUIT BREAKERS FOR EACH INSTRUMENT POWERED FROM THE PCM CABINET.
8. PROVIDE QUANTITY REQUIRED PER SPECIFICATIONS.

TERMINAL BLOCK LEGEND

H	120VAC
N	NEUTRAL
G	GROUND
UL	UPS 120VAC
+	24VDC (+)
-	24VDC (-)

DISCRETE-ANALOG PCM CABINET PLC AND INSTRUMENT POWER

1 CONTROL SCHEMATIC

LOCATION LEGEND

PCM	PCM OR DCS
MCC	MOTOR CONTROL CENTER
FLD	FIELD DEVICE
LCP	LOCAL CONTROL PANEL
STR	FREE-STANDING STARTER
VFD	FREE-STANDING VFD

REV	DATE	BY	DESCRIPTION

DESIGNED DSR
DRAWN CGR
CHECKED CS
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER — DANIEL ROBINSON — No. 20405 — ELECTRICAL — STATE OF CALIFORNIA

Digitally signed by Daniel S. Robinson
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 10:12:45-07'00'

carollo®

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

INSTRUMENTATION

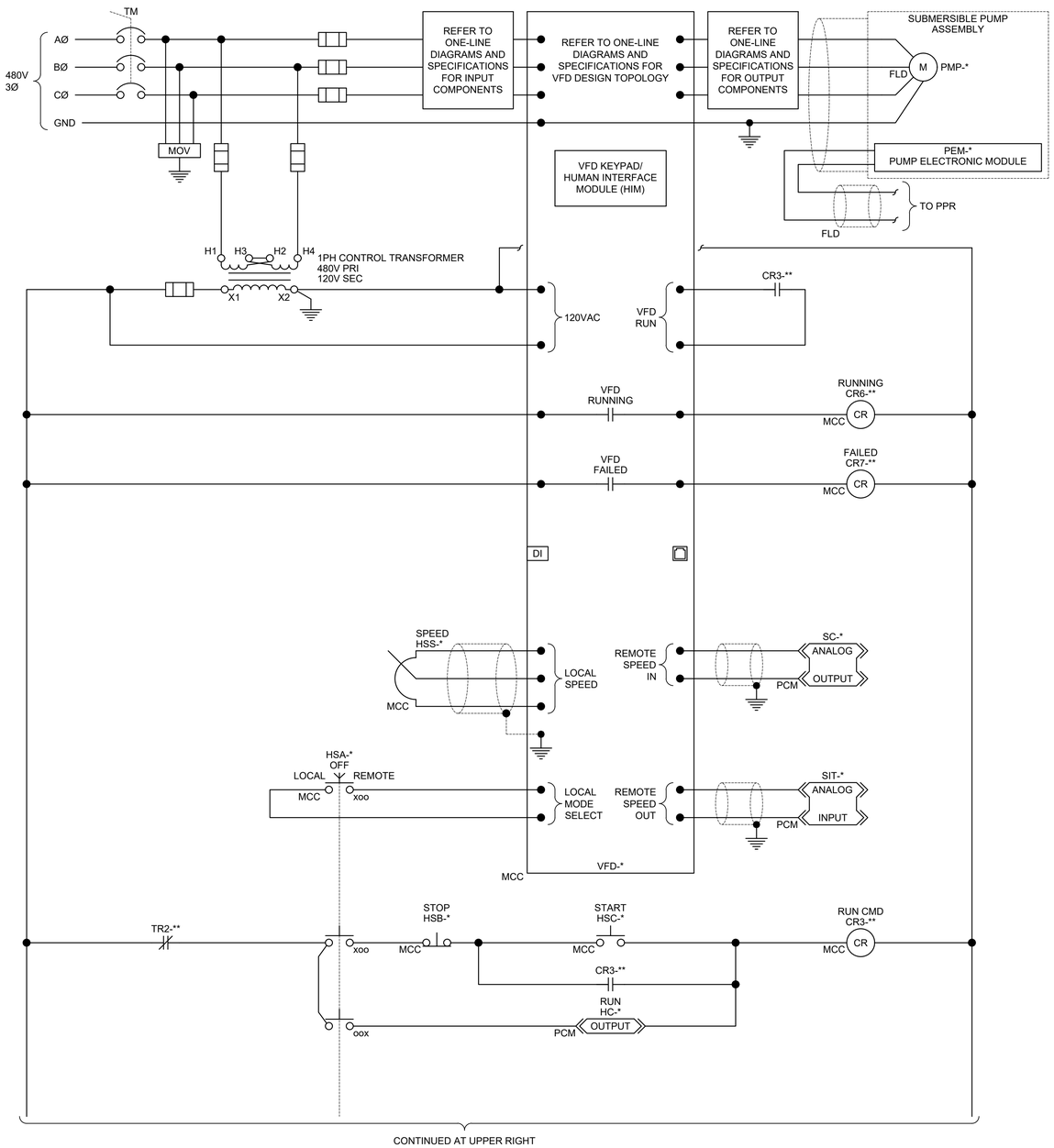
WELL 8 CONTROL PANEL SCHEMATICS

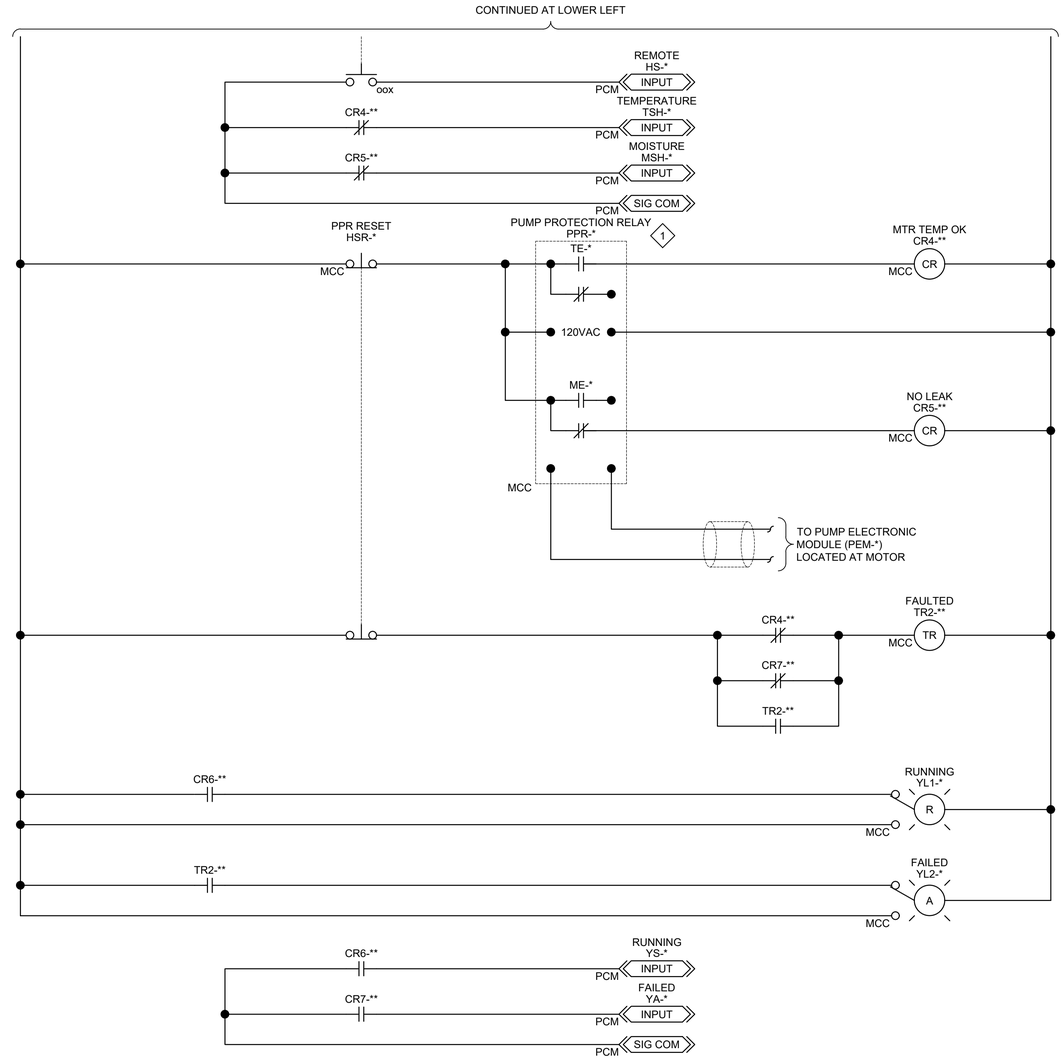
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 06N01
SHEET NO. 42 OF 71

LAST SAVED BY: wchristgen

PROJECT NO. 202431-100000 FILE NAME: 20243106N01.dwg





KEY NOTES:

1. CR4 AND CR5 ARE ENERGIZED UNDER NORMAL OPERATING CONDITIONS.

TAG ◄► LOOP
** = 010, * = 9905010 ◄► PMP-9905010

REFERENCE DWG.
08N05

LOCATION LEGEND

PCM	PCM OR DCS
MCC	MOTOR CONTROL CENTER
FLD	FIELD DEVICE

SUBMERSIBLE PUMP - VFD WITH PUMP PROTECTION RELAY

2 CONTROL SCHEMATIC

REV	DATE	BY	DESCRIPTION

DESIGNED DSR
DRAWN KIK
CHECKED CS
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER — DANIEL ROBINSON — No. 20405 — ELECTRICAL — STATE OF CALIFORNIA

Digitally signed by Daniel S. Robinson
Contact Info: Carollo Engineers, Inc.
Date: 2025.08.12 10:12:36-07'00'

carollo®

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
INSTRUMENTATION
WELL 8 PUMP CONTROL SCHEMATICS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 06N03
SHEET NO. 43 OF 71

LAST SAVED BY: wchristgen

PROJECT NO. 202431-100000 FILE NAME: 20243106N03.dwg

SCADA

CONTROL PANEL
PLC I/O

OPERATOR INTERFACE/
CONTROL DEVICES

POWER
SOURCE

FIELD

PAH 9905111 ALARM
PR 9905111 TREND
PAL 9905111 ALARM
PI 9905111 NUM
PDR 9905110 TREND
PDAH 9905110 ALARM
PDI 9905110 NUM
PDAL 9905110 ALARM
FAH 9905120 ALARM
FR 9905120 TREND
FAL 9905120 ALARM
FI 9905120 NUM
FAH 9905110 ALARM
FR 9905110 TREND
FAL 9905110 ALARM
FI 9905110 NUM
YR 9905110 STATUS REMOTE
YOC 9905110 STATUS OC
ZI 9905110 NUM POSITION

PIT 9905111 AI — PLC-8
PDIT 9905110 AI — PLC-8
FIT 9905120 AI — PLC-8
FIT 9905110 AI — PLC-8

YA 9905110 DI FAILED — PLC-8
HS 9905110 DI REMOTE — PLC-8
ZSO 9905110 DI OPENED — PLC-8
ZSC 9905110 DI CLOSED — PLC-8
ZC 9905110 AO POSITION — PLC-8
ZIT 9905110 AI POSITION — PLC-8

PI 9905111 NUM — OIT-8
PAL 9905111 ALARM — OIT-8 SP
QPL 9905111 OIT-8
PAH 9905111 ALARM — OIT-8 SP
QPH 9905111 OIT-8

PDI 9905110 NUM — OIT-8
PDAL 9905110 ALARM — OIT-8 SP
QPDL 9905110 OIT-8
PDAH 9905110 ALARM — OIT-8 SP
QPDH 9905110 OIT-8

FI 9905120 NUM — OIT-8
QFH 9905120 OIT-8 SP
QFL 9905120 OIT-8 SP
FAH 9905120 ALARM — OIT-8 ALARM
FAL 9905120 OIT-8 ALARM

FI 9905110 NUM — OIT-8
QFH 9905110 OIT-8 SP
QFL 9905110 OIT-8 SP
FAH 9905110 ALARM — OIT-8 ALARM
FAL 9905110 OIT-8 ALARM

ZI 9905110 NUM POSITION — OIT-8
YOC 9905110 STATUS OC — OIT-8
YR 9905110 STATUS REMOTE — OIT-8
HAK 9905110 ACTION JOG OC — OIT-8
HAD 9905110 ACTION MOA — OIT-8

CB TM 120VAC-1P — PCM-8
CB TM 120VAC-1P — PCM-8
CB 13 TM 120VAC-1P — PNL-LPA

FIT 9905120 INT MAGNETIC
FE 9905120
FIT 9905110 INT MAGNETIC
FE 9905110

ZSOC 9905110
ZT 9905110
OSC
HSA 9905110
LSR
HS 9905110
FCV 9905110
DISC 9905110

PIT 9905111 INT PRESSURE
PE 9905111
PDIT 9905110 INT PRESS DIFF
PE 9905110
PI 9905112

DISTRIBUTION SYSTEM
10" W
6" W
6" BACKFLOW PREVENTER
SDI SAMPLE PORT (SIDE)
6" W
1" W
H-STRAINER
PRV/CHK 9905110
MM FM-9905110
M BFV 9905110
INJECTION WELL A 08N05
6" W
WELLHEAD B 08N05
1" TF
FI 9905120
CARTRIDGE FILTER WITH CLEAR CASE FOR VISUAL INSPECTION
1" BACKFLOW PREVENTER
1" TF
TRICKLE FLOW
1 WELL VOL CHANGE PER DAY
(5 GPM, RANGE 2-10 GPM)
PE-9905111 INJECTION LINE PRESS TRANSMITTER 0-150 PSI — * TYP NP501
PI-9905112 INJECTION LINE PRESS GAUGE 0-150 PSIG
MM FM-9905120
ADJ. FLOW CNTL GLOBE VALVE
PE-9905110 INJECTION LINE PRESSURE DIFFERENTIAL 0-150 PSIG — * TYP NP189
FE-9905120 1" FLOW METER 0-25 GPM 1" — * TYP NF130 NF136
FE-9905110 6" INJECTION FLOW METER 0-1000 GPM 6" — * TYP NF130 NF136
FCV-9905110 INJECTION FCV 0.5HP 120VAC 1PH
FI-9905120 TRICKLE FLOW ROTAMETER 5 GPM, RANGE 0-20 GPM

REV	DATE	BY	DESCRIPTION

DESIGNED DSR
DRAWN DKI
CHECKED CS
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER — DANIEL ROBINSON — No. 20405 — ELECTRICAL — STATE OF CALIFORNIA

Digitally signed by Daniel S. Robinson
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 10:12:22-07'00'

carollo®

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

INSTRUMENTATION

WELL 8 WELL PUMP P&ID 1

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 — 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08N03
SHEET NO. 44 OF 71

LAST SAVED BY: wchristgen

PROJECT NO. 202431-100000 FILE NAME: 20243108N03.dwg

SCADA

CONTROL PANEL
PLC I/O

OPERATOR INTERFACE/
CONTROL DEVICES

POWER
SOURCE

FIELD

PR 9905130A TREND
PAL 9905130A ALARM
PI 9905130A NUM
PAH 9905130A ALARM

PR 9905130B TREND
PAL 9905130B ALARM
PI 9905130B NUM
PAH 9905130B ALARM

KEY NOTES:

1. VENDOR PANEL VCP-9905130 CONTROLS THE DOWN-HOLE CONTROL VALVE DHCV-9905130 SHOWN ON DRAWING 08N05.
2. DOWNHOLE CONTROL PANEL PRESSURE RANGE IS 0-500 PSI.

XCO 9905130B DO OPEN (DEFLATE) PLC-8
XCC 9905130A DO CLOSE (INFLATE) PLC-8
PIT 9905130A AI PLC-8
PIT 9905130B AI PLC-8

HAD 9905130B ACTION HOA OIT-8
HAO 9905130B ACTION OC OIT-8
HAD 9905130A ACTION HOA OIT-8
HAO 9905130A ACTION OC OIT-8

PI 9905130A NUM OIT-8
PAL 9905130A ALARM OIT-8
PAH 9905130A ALARM OIT-8
QPL 9905130A SP OIT-8
QPH 9905130A SP OIT-8

PI 9905130B NUM OIT-8
PAL 9905130B ALARM OIT-8
PAH 9905130B ALARM OIT-8
QPL 9905130B SP OIT-8
QPH 9905130B SP OIT-8

PIT 9905130A
PE 9905130A PRESSURE

PIT 9905130B
PE 9905130B PRESSURE

VENDOR DOWNHOLE
FLOW CONTROL VALVE
CONTROLLER

TANK 1 HIGH PI 9905130B FBV
TANK 1 INLET LOW PI 9905130C FBV
TANK 2 HIGH PI 9905130D FBV
TANK 2 INLET LOW PI 9905130E FBV

PRV
PRV

NITROGEN CYLINDERS
TANK 2

SV 9905130A
SV 9905130B

PI 9905130A FBV
DRILLED AND TAPPED SOLID METAL MANIFOLDS (TYP. 3)

VCP 9905130 NITROGEN VCP FBV

NITROGEN 1/4" N D 08N05
NITROGEN 1/4" N C 08N05

NITROGEN DEPRESSURIZATION (BLEED LINE TO ATMOSPHERE)

PI-9905130B
TANK 1 HIGH PRESS GAUGE
0-4000 PSI

PI-9905130C
TANK 1 INLET LOW PRESS GAUGE
0-600 PSI

PI-9905130D
TANK 2 HIGH PRESS GAUGE
0-4000 PSI

PI-9905130E
TANK 2 INLET LOW PRESS GAUGE
0-600 PSI

SV-9905130B
FCV OPEN (DEFLATE)

SV-9905130A
FCV CLOSE (INFLATE)

VCP-9905130
NITROGEN VCP

PI-9905130A
VALVE INFLATION PRESS GAUGE
0 - 500 PSI

PE-9905130A
NITROGEN REGULATOR PRESS TRANSMITTER
0 - 500 PSI
* NP501 TYP

PE-9905130B
VALVE INFLATION PRESS TRANSMITTER
0 - 500 PSI
* NP501 TYP

REV	DATE	BY	DESCRIPTION

DESIGNED DSR
DRAWN DKI
CHECKED CS
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER
DANIEL ROBINSON
No. 20405
ELECTRICAL
STATE OF CALIFORNIA

Digitally signed by Daniel S. Robinson
Contact Info: Carollo Engineers, Inc.
Date: 2025.08.27 10:58:22-07'00'

carollo

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

INSTRUMENTATION

WELL 8 WELL PUMP P&ID 2

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08N04
SHEET NO. 45 OF 71

LAST SAVED BY: wchristgen

PROJECT NO. 202431-100000 FILE NAME: 20243108N04.dwg

SCADA

CONTROL PANEL PLC I/O

OPERATOR INTERFACE/ CONTROL DEVICES

POWER SOURCE

FIELD

LAH 9905010 ALARM
LR 9905010 TREND
LAL 9905010 ALARM
LI 9905010 NUM
YC 9905010 OFF MODE COMMAND
HAR 9905010 ACTION RESET ETM
YA 9905010 ALARM FAILED
TAH 9905010 ALARM TEMP
MAH 9905010 ALARM
KI 9905010 NUM ETM
YS 9905010 STATUS RUNNING
YR 9905010 STATUS REMOTE
SIB 9905010 NUM SPEED
PR 9905010A TREND
PAH 9905010A ALARM
PI 9905010A NUM
PAL 9905010A ALARM
PAH 9905010B ALARM

LIT 9905010 AI PLC-8
SIT 9905010 AI SPEED FBK PLC-8
SC 9905010 AO SPEED CMD PLC-8
YS 9905010 DI RUNNING PLC-8
YA 9905010 DI FAILED PLC-8
HS 9905010 DI REMOTE PLC-8
TSH 9905010 DI HI TEMP PLC-8
MSH 9905010 DI MOISTURE PLC-8
HC 9905010 DO RUN PLC-8
PIT 9905010A AI PLC-8
PSH 9905010B DI PLC-8
HC 9905010A DI RUN COMMAND PLC-8

LI 9905010 NUM OIT-8
LAL 9905010 ALARM OIT-8
QLL 9905010 SP OIT-8
LAH 9905010 ALARM OIT-8
QLH 9905010 SP OIT-8
TAH 9905010 ALARM OIT-8
MAH 9905010 ALARM OIT-8
HAD 9905010 ACTION HOA OIT-8
QS 9905010 SP SPEED OIT-8
KI 9905010 NUM ETM OIT-8
YR 9905010 STATUS REMOTE OIT-8
SIB 9905010 NUM SPEED OIT-8
YS 9905010 STATUS RUNNING OIT-8
YA 9905010 ALARM FAILED OIT-8
PI 9905010A NUM OIT-8
PAL 9905010A ALARM OIT-8
QPL 9905010A SP OIT-8
PAH 9905010A ALARM OIT-8
QPH 9905010A SP OIT-8
PAH 9905010B ALARM OIT-8

VFD-9905010
VFD-6
480VAC-3P
MCC-8A

MTR 9905010 MOISTURE MSH 9905010
TEMP TSH 9905010

1 DESICCANT
LIT 9905010 INT
LE 9905010 PSUB
NITROGEN C 08N04 1/4" N
NITROGEN D 08N04 1/4" N
TRICKLE FLOW POTABLE WATER B 08N03 1" TF
TAP FOR ROSSIUM SAND TESTER
EXTRACTION
INJECTION
6" W/ RAW
PIT 9905010A PRESSURE PE 9905010A
PSH 9905010B PRESS SW PE 9905010B
GV 9905010
SDI SAMPLE PORT (SIDE)
DISTRIBUTION A 08N03 6" W
(CAV)
DRAIN (BOTTOM)
CKS 9905010
6" RAW
BELTZ WTP AERATION TANK E 08N06
CR 9905010A RELAY DRIVER WELL 8 RUN COMMAND
BWTP (EXISTING) RTU 20

STATIC WSE
PUMPING WSE
TRICKLE FLOW
1" SOUNDING TUBE
1"
DHCV 9905130
PUMP BOWLS
INLET SCREEN
MOTOR M
PMP-9905010

LE-9905010 LEVEL TRANSMITTER 0-300 FT * TYP NL132
DHCV-9905130 DOWNHOLE CONTROL VALVE
MTR-9905010 WELL PUMP A 50HP 480VAC 3PH 2 06N03
PE-9905010A PRESSURE TRANSMITTER RANGE 0-150 PSI START 92 PSI, STOP 100 PSI * TYP NP501
PE-9905010B PRESSURE SWITCH HIGH ~110 PSI (RANGE 0-150 PSI) * TYP NP501

KEY NOTES:

1. CABLE TERMINATION BOX. PROVIDE DESICCANT IF NEEDED PER MFR RECOMMENDATION.
2. WELL PUMP VFD IS LOCATED IN SECTION 1 OF MCC-8A.
3. CONTROL VALVE DHCV-9905130 IS CONTROLLED BY VENDOR PANEL VCP-9905130 ON DRAWING 08N04.

REV	DATE	BY	DESCRIPTION

DESIGNED DSR
DRAWN DKI
CHECKED CS
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER DANIEL ROBINSON No. 20405 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Daniel S. Robinson
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 10:11:22-07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

INSTRUMENTATION

WELL 8 WELL PUMP P&ID 3

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08N05
SHEET NO. 46 OF 71

LAST SAVED BY: wchristgen

PROJECT NO. 202431-100000 FILE NAME: 20243108N05.dwg

SCADA

CONTROL PANEL
PLC I/O

OPERATOR INTERFACE/
CONTROL DEVICES

POWER
SOURCE

FIELD

FAH 9905020 ALARM TREND FR 9905020
FAL 9905020 ALARM NUM FI 9905020
YR 9905020 STATUS REMOTE
YOC 9905020 STATUS OC
FAH 9905030 ALARM TREND FR 9905030
FAL 9905030 ALARM NUM FI 9905030
YR 9905030 STATUS REMOTE
YOC 9905030 STATUS OC

FIT 9905020 AI — PLC-8
ZCO 9905020 DO OPEN — PLC-8
ZCC 9905020 DO CLOSE — PLC-8
HS 9905020 DI REMOTE — PLC-8
YA 9905020 DI FAILED — PLC-8
ZSO 9905020 DI OPENED — PLC-8
ZSC 9905020 DI CLOSED — PLC-8
FIT 9905030 AI — PLC-8
ZCO 9905030 DO OPEN — PLC-8
ZCC 9905030 DO CLOSE — PLC-8
HS 9905030 DI REMOTE — PLC-8
YA 9905030 DI FAILED — PLC-8
ZSO 9905030 DI OPENED — PLC-8
ZSC 9905030 DI CLOSED — PLC-8

FI 9905020 NUM — OIT-8
QFH 9905020 SP — OIT-8
QFL 9905020 SP — OIT-8
FAH 9905020 ALARM — OIT-8
FAL 9905020 ALARM — OIT-8
YOC 9905020 STATUS OC — OIT-8
YR 9905020 STATUS REMOTE — OIT-8
HAG 9905020 ACTION OSC — OIT-8
HAD 9905020 ACTION MOA — OIT-8
FI 9905030 NUM — OIT-8
QFH 9905030 SP — OIT-8
QFL 9905030 SP — OIT-8
FAH 9905030 ALARM — OIT-8
FAL 9905030 ALARM — OIT-8
YOC 9905030 STATUS OC — OIT-8
YR 9905030 STATUS REMOTE — OIT-8
HAG 9905030 ACTION OSC — OIT-8
HAD 9905030 ACTION MOA — OIT-8

CB TM 120VAC-1P PCM-8
CB 11 TM 120VAC-1P PNL-LPA
CB TM 120VAC-1P PCM-8
CB 15 TM 120VAC-1P PNL-LPA

FIT 9905020 INT MAGNETIC
FE 9905020
HS 9905020 LSR
HSA 9905020 OSC
ZSOC 9905020
FV 9905020
DISC 9905020
FIT 9905030 INT MAGNETIC
FE 9905030
HS 9905030 LSR
HSA 9905030 OSC
ZSOC 9905030
FV 9905030
DISC 9905030

(CAV)
6" FLUSH
MM FM-9905020
MM FM-9905030
M BFV 9905020
M BFV 9905030
E GV 9905021
GV 9905022
WELL PUMP E 08N05
6" W/ RAW
6" RAW
6" RAW
TO RECLAIM TANK L 08N07
BELTZ WTP AERATION TANK
BACKWASH/RECLAIM TANK AND MIXING PUMP 08N07 G
2" BF
DECHLORINATION TABLET BASKET
AIR GAP
STORM DRAIN MAINTENANCE HOLE AND AIR GAP
OFFSITE STORM DRAIN
12" FL
(ADDITIVE BID ITEM)

FE-9905020
6" EXTRACTION TO WTP FLOW METER
0-1000 GPM
6"
* TYP NF130 NF136

FV-9905020
EXTRACTION FCV
0.5HP 120VAC 1PH

FE-9905030
6" FLUSH TO STORM DRAIN METER
0-1000 GPM
6"
* TYP NF130 NF136

FV-9905030
FLUSH TO STORM DRAIN MOV
0.5HP 120VAC 1PH

REV	DATE	BY	DESCRIPTION

DESIGNED DSR
DRAWN DKI
CHECKED CS
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER DANIEL ROBINSON No. 20405 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Daniel S. Robinson
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 10:11:33-07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

INSTRUMENTATION

WELL 8 WELL PUMP P&ID 4

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08N06
SHEET NO. 47 OF 71

LAST SAVED BY: wchristgen

PROJECT NO. 202431-100000 FILE NAME: 20243108N06.dwg

SCADA

CONTROL PANEL
PLC I/O

OPERATOR INTERFACE/
CONTROL DEVICES

POWER
SOURCE

FIELD

YR 9905050 STATUS REMOTE
YOC 9905050 STATUS OC
ZI 9905050 NUM POSITION
FAH 9905050 ALARM
FR 9905050 TREND
FAL 9905050 ALARM
FI 9905050 NUM

YA 9905050 DI FAILED PLC-8
HS 9905050 DI REMOTE PLC-8
ZSO 9905050 DI OPENED PLC-8
ZSC 9905050 DI CLOSED PLC-8
ZC 9905050 AO POSITION PLC-8
ZIT 9905050 AI POSITION PLC-8
FIT 9905050 AI PLC-8

ZI 9905050 NUM POSITION OIT-8
YOC 9905050 STATUS OC OIT-8
YR 9905050 STATUS REMOTE OIT-8
HAD 9905050 ACTION MOA OIT-8
FI 9905050 NUM OIT-8
QFH 9905050 SP OIT-8
FAH 9905050 ALARM OIT-8
QFL 9905050 SP OIT-8
FAL 9905050 ALARM OIT-8

CB 17 TM 120VAC-1P PNL-LPA
CB TM 120VAC-1P PCM-8

ZSOC 9905050
ZT 9905050
HSA 9905050 OSC
HS 9905050 LSR
FCV 9905050
DISC 9905050
FIT 9905050 INT
FE 9905050 MAGNETIC

M
BFV 9905050
MM
FM-9905050

STORM DRAIN
AIR-GAP STRUCTURE
2" BF
G 08N06

BACKWASH
RECLAIMED TANK
MIXING PUMP
(EXISTING)

TREATMENT PLANT
AERATION BASIN (EXISTING)

BELTZ WTP
AERATION TANK
L 08N06

TREATMENT PLANT
(EXISTING)
6" FLUSH

AERATION TANK
DRAIN (EXISTING)

OPERATION BLDG AND
FLOOR DRAINS (EXISTING)

BACKWASH/RECLAIM
TANK (EXISTING)

BACKWASH TO STORM DRAIN VALVE

EXISTING FLOW METER

FCV-9905050
BACKWASH TO STORM DRAIN MOV
0.5HP 120VAC 1PH

SEWER
AIR-GAP
(EXISTING)

FE-9905050
2" BACKWASH TO STORM DRAIN
0 - 100 GPM
2"
NF130
NF136

GRAVITY SEWER ON
ROLAND DRIVE (EXISTING)

REV	DATE	BY	DESCRIPTION

DESIGNED DSR
DRAWN DKI
CHECKED CS
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER
DANIEL ROBINSON
No. 20405
ELECTRICAL
STATE OF CALIFORNIA

Digitally signed by Daniel S. Robinson
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 11:53:26-07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

INSTRUMENTATION

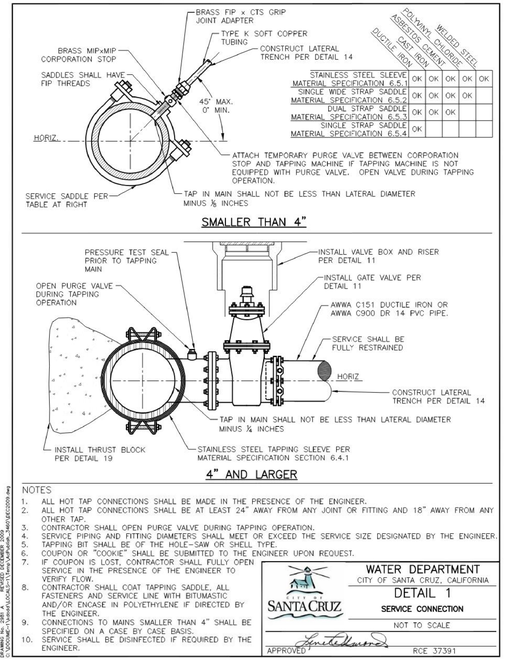
BELTZ WTP BACKWASH TANK P&ID

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 08N07
SHEET NO. 48 OF 71

LAST SAVED BY: wchristgen

PROJECT NO. 202431-100000 FILE NAME: 20243108N07.dwg

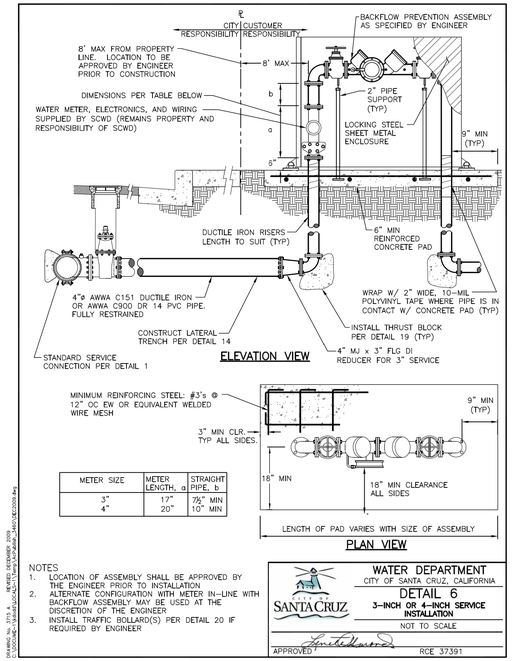


NOTES:
1. ALL HOT TAP CONNECTIONS SHALL BE MADE IN THE PRESENCE OF THE ENGINEER.
2. ALL HOT TAP CONNECTIONS SHALL BE AT LEAST 24" AWAY FROM ANY JOINT OR FITTING AND 18" AWAY FROM ANY OTHER TAP.
3. CONTRACTOR SHALL OPEN PURGE VALVE DURING TAPPING OPERATION.
4. SERVICE PIPING AND FITTING DIAMETERS SHALL MEET OR EXCEED THE SERVICE SIZE DESIGNATED BY THE ENGINEER.
5. TAPPING BIT SHALL BE OF THE HOLE-SAW OR SHELL TYPE
6. COUPON OR "COOKIE" SHALL BE SUBMITTED TO THE ENGINEER UPON REQUEST.
7. IF COUPON IS LOST, CONTRACTOR SHALL FULLY OPEN SERVICE IN THE PRESENCE OF THE ENGINEER TO VERIFY FLOW.
8. CONTRACTOR SHALL COAT TAPPING SADDLE, ALL FASTENERS AND SERVICE LINE WITH BITUMASTIC AND/OR ENCASE IN POLYETHYLENE IF DIRECTED BY THE ENGINEER.
9. CONNECTIONS TO MAINS SMALLER THAN 4" SHALL BE SPECIFIED ON A CASE BY CASE BASIS.
10. SERVICE SHALL BE DISINFECTED IF REQUIRED BY THE ENGINEER.

DRAWING No. 2994 A REVISED DECEMBER 2019
C:\DOCUME~1\RAMJR\LOCALS~1\Temp\AcPublish_5460\SEC0001.dwg

WATER DEPARTMENT
CITY OF SANTA CRUZ, CALIFORNIA
DETAIL 1
SERVICE CONNECTION
NOT TO SCALE
APPROVED: RCE 37391

62



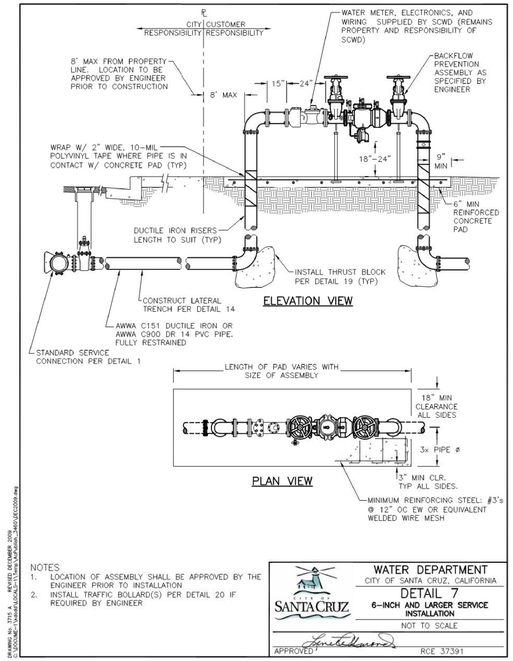
METER SIZE	METER LENGTH, a	STRAIGHT PIPE, b
3"	17"	7½" MIN
4"	20"	10" MIN

NOTES
1. LOCATION OF ASSEMBLY SHALL BE APPROVED BY THE ENGINEER PRIOR TO INSTALLATION.
2. ALTERNATE CONFIGURATION WITH METER IN-LINE WITH BACKFLOW ASSEMBLY MAY BE USED AT THE DISCRETION OF THE ENGINEER
3. INSTALL TRAFFIC BOLLARD(S) PER DETAIL 20 IF REQUIRED BY ENGINEER

DRAWING No. 3714 A REVISED DECEMBER 2019
C:\DOCUME~1\RAMJR\LOCALS~1\Temp\AcPublish_5460\SEC0009.dwg

WATER DEPARTMENT
CITY OF SANTA CRUZ, CALIFORNIA
DETAIL 6
3-INCH OR 4-INCH SERVICE INSTALLATION
NOT TO SCALE
APPROVED: RCE 37391

67

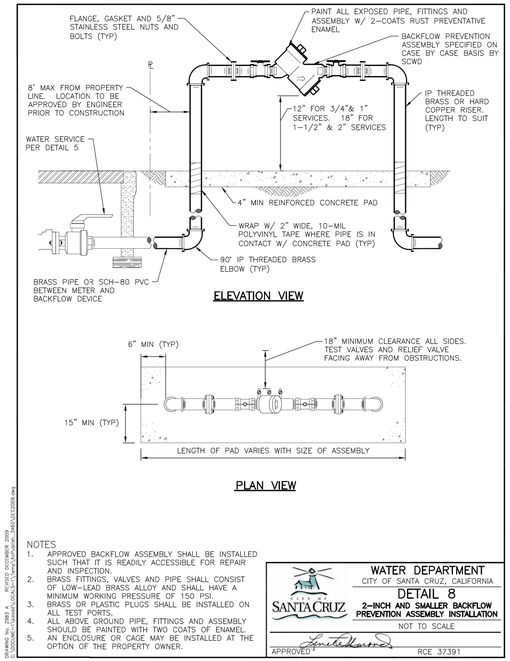


NOTES
1. LOCATION OF ASSEMBLY SHALL BE APPROVED BY THE ENGINEER PRIOR TO INSTALLATION.
2. INSTALL TRAFFIC BOLLARD(S) PER DETAIL 20 IF REQUIRED BY ENGINEER

DRAWING No. 3715 A REVISED DECEMBER 2019
C:\DOCUME~1\RAMJR\LOCALS~1\Temp\AcPublish_5460\SEC0010.dwg

WATER DEPARTMENT
CITY OF SANTA CRUZ, CALIFORNIA
DETAIL 7
6-INCH AND LARGER SERVICE INSTALLATION
NOT TO SCALE
APPROVED: RCE 37391

68

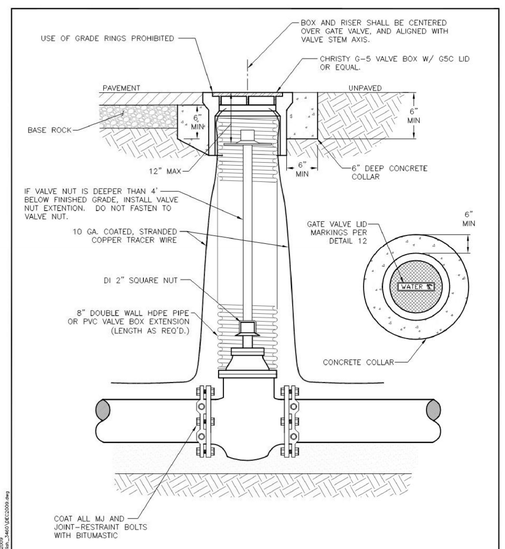


NOTES:
1. APPROVED BACKFLOW ASSEMBLY SHALL BE INSTALLED SUCH THAT IT IS READILY ACCESSIBLE FOR REPAIR AND INSPECTION.
2. BRASS FITTINGS, VALVES AND PIPE SHALL CONSIST OF LOW-LEAD BRASS ALLOY AND SHALL HAVE A MINIMUM WORKING PRESSURE OF 150 PSI.
3. BRASS OR PLASTIC PLUGS SHALL BE INSTALLED ON ALL TEST PORTS.
4. ALL ABOVE GROUND PIPE, FITTINGS AND ASSEMBLY SHOULD BE PAINTED WITH TWO COATS OF ENAMEL.
5. AN ENCLOSURE OR CAGE MAY BE INSTALLED AT THE OPTION OF THE PROPERTY OWNER.

DRAWING No. 2965 A REVISED DECEMBER 2019
C:\DOCUME~1\RAMJR\LOCALS~1\Temp\AcPublish_5460\SEC0008.dwg

WATER DEPARTMENT
CITY OF SANTA CRUZ, CALIFORNIA
DETAIL 8
2-INCH AND SMALLER BACKFLOW PREVENTION ASSEMBLY INSTALLATION
NOT TO SCALE
APPROVED: RCE 37391

69

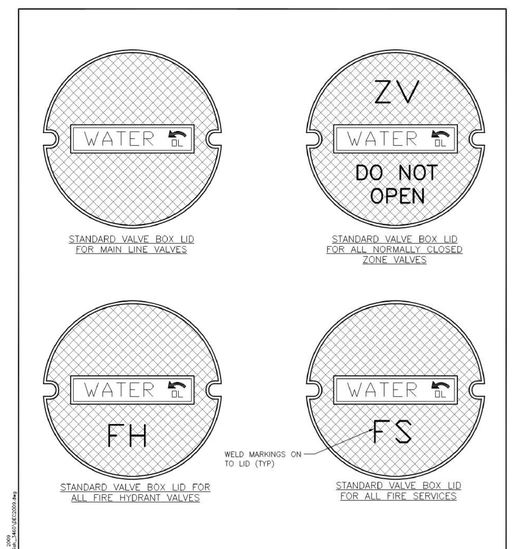


NOTES:
1. VALVE BOX LID SHALL BE OILED PRIOR TO PAVING OR CLEANING TO ENSURE THAT LID MARKINGS ARE LEGIBLE.
2. INSTALL VALVE BOX LID FLUSH WITH FINAL PAVING OR GROUND SURFACE.
3. INSTALL BLOCKING UNDER VALVE IF REQUIRED.

DRAWING No. 3944 A REVISED JANUARY 2019
C:\DOCUME~1\RAMJR\LOCALS~1\Temp\AcPublish_5460\SEC0005.dwg

WATER DEPARTMENT
CITY OF SANTA CRUZ, CALIFORNIA
DETAIL 11
GATE VALVE INSTALLATION
NOT TO SCALE
APPROVED: RCE 37391

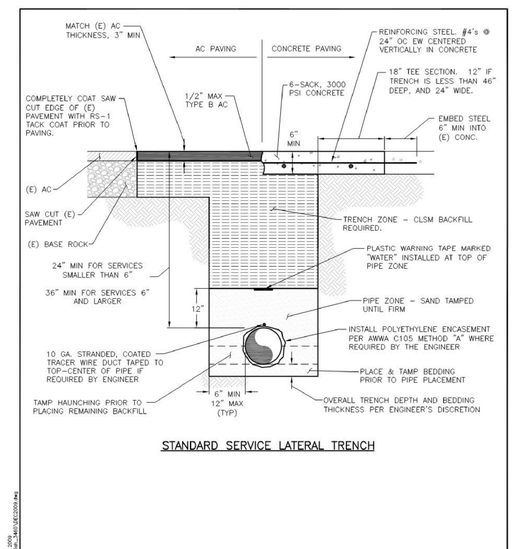
72



DRAWING No. 3944 A REVISED DECEMBER 2019
C:\DOCUME~1\RAMJR\LOCALS~1\Temp\AcPublish_5460\SEC0004.dwg

WATER DEPARTMENT
CITY OF SANTA CRUZ, CALIFORNIA
DETAIL 12
VALVE BOX LID MARKINGS
NOT TO SCALE
APPROVED: RCE 37391

73



STANDARD SERVICE LATERAL TRENCH

NOTES
1. IF ANY PORTION OF (E) PAVEMENT WITHIN SAWCUT LIMITS IS CONCRETE AT THE SURFACE, ENTIRE TRENCH SHALL BE RE-PAVED WITH CONCRETE AS SHOWN.
2. WHERE WATER SERVICES 6" AND LARGER CANNOT MEET MINIMUM COVER REQUIREMENTS, THE ENGINEER MAY APPROVE ALTERNATE INSTALLATION PER DETAIL 16.
3. ALL JOINTS ON SERVICE LATERALS SHALL BE RESTRAINED.

DRAWING No. 3717 A REVISED DECEMBER 2019
C:\DOCUME~1\RAMJR\LOCALS~1\Temp\AcPublish_5460\SEC0011.dwg

WATER DEPARTMENT
CITY OF SANTA CRUZ, CALIFORNIA
DETAIL 14
STANDARD SERVICE LATERAL TRENCH
NOT TO SCALE
APPROVED: RCE 37391

75

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED JP
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER MICHAEL E. DUCKER No. 63626 CIVIL STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:40:04-07'00'

carollo

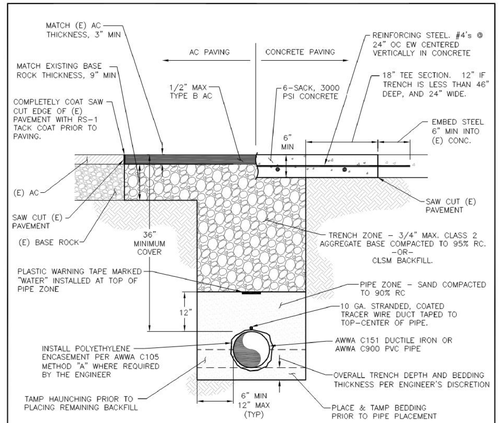
CITY OF SANTA CRUZ

CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
TYPICAL DETAILS
CITY WATER DEPARTMENT STANDARD DETAILS 1

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00TC01
SHEET NO. 49 OF 71

PROJECT NO. 202431-100000 FILE NAME: 20243100TC01.dgn

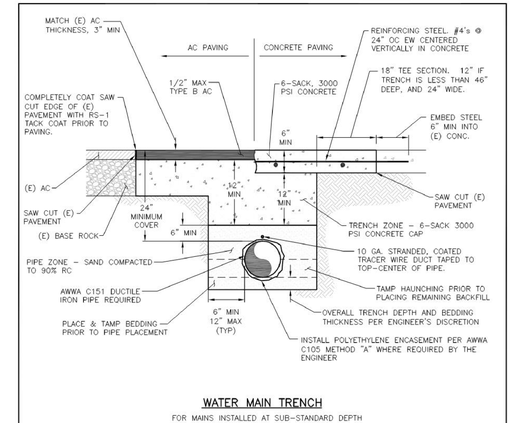


STANDARD WATER MAIN TRENCH

NOTES
1. IF ANY PORTION OF (E) PAVEMENT WITHIN SAWCUT LIMITS IS CONCRETE AT THE SURFACE, ENTIRE TRENCH SHALL BE RE-PAVED WITH CONCRETE AS SHOWN.
2. WHERE WATER MAIN INSTALLATION CANNOT MEET MINIMUM COVER REQUIREMENTS, THE ENGINEER MAY APPROVE ALTERNATE INSTALLATION PER DETAIL 16.
3. REFER TO SCWD TECHNICAL SPECIFICATIONS FOR COMPACTION TESTING REQUIREMENTS.
4. FOR SERVICE LATERALS, REFER TO DETAIL 14.

WATER DEPARTMENT
CITY OF SANTA CRUZ, CALIFORNIA
DETAIL 15
STANDARD WATER MAIN TRENCH
NOT TO SCALE
APPROVED: RCE 37391

76



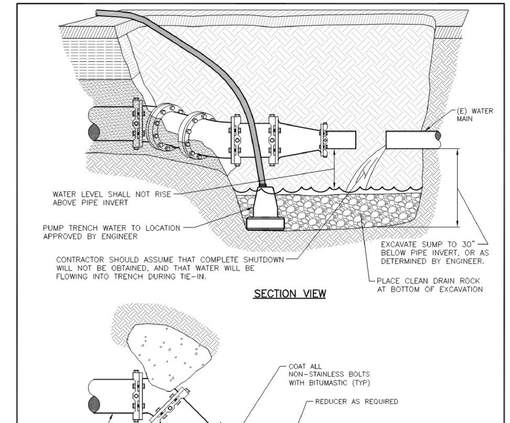
WATER MAIN TRENCH

FOR MAINS INSTALLED AT SUB-STANDARD DEPTH

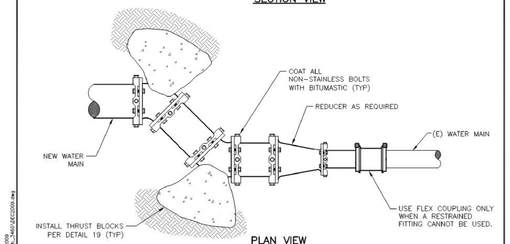
NOTES
1. USE OF THIS DETAIL REQUIRES PRIOR APPROVAL OF THE ENGINEER. REFER TO DETAIL 15 FOR STANDARD TRENCH.
2. IF ANY PORTION OF (E) PAVEMENT WITHIN SAWCUT LIMITS IS CONCRETE AT THE SURFACE, ENTIRE TRENCH SHALL BE RE-PAVED WITH CONCRETE AS SHOWN.
3. REFER TO SCWD TECHNICAL SPECIFICATIONS FOR COMPACTION TESTING REQUIREMENTS.
4. FOR SERVICE LATERALS REFER TO DETAIL 14.

WATER DEPARTMENT
CITY OF SANTA CRUZ, CALIFORNIA
DETAIL 16
SUB-STANDARD WATER MAIN TRENCH
NOT TO SCALE
APPROVED: RCE 37391

77



SECTION VIEW

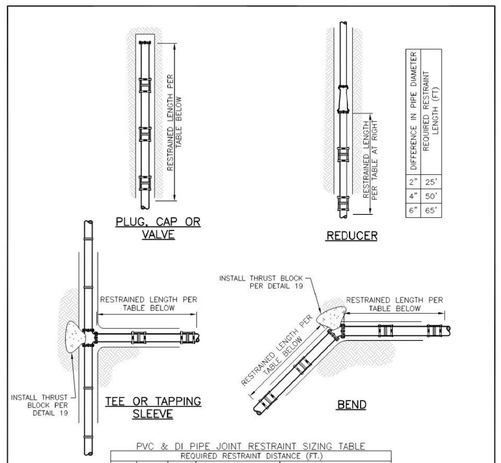


PLAN VIEW

NOTES
1. CONTRACTOR SHALL VERIFY (E) MAIN DIAMETER PRIOR TO SCHEDULING SYSTEM SHUT DOWN.
2. ELBOWS SHARPER THAN 45° ARE NOT ALLOWED.
3. PIPE AND FITTING SIZES & MATERIAL SHALL BE SPECIFIED BY ENGINEER.
4. JOINT RESTRAINTS AND THRUST BLOCKING PER DETAILS 19 AND 20 ARE REQUIRED.
5. TEMPORARY THRUST BLOCKING MAY BE REQUIRED WHILE CONCRETE CURES.

WATER DEPARTMENT
CITY OF SANTA CRUZ, CALIFORNIA
DETAIL 17
SYSTEM CONNECTION (TIE IN)
NOT TO SCALE
APPROVED: RCE 37391

78



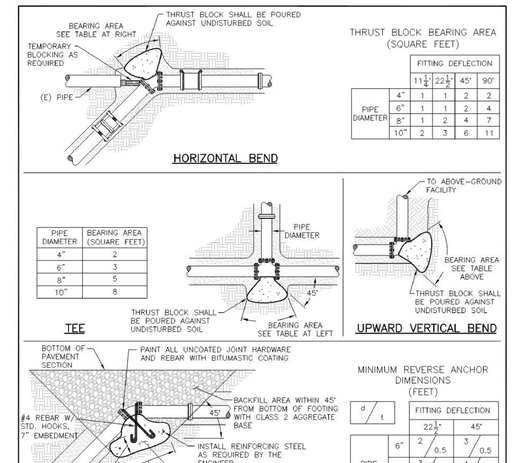
PVC & DI PIPE JOINT RESTRAINT SIZING TABLE
REQUIRED RESTRAINT DISTANCE (FT.)

PIPE DIA.	TEE BRANCH	PLUG, CAP, OR VALVE	VERTICAL BEND 11 1/4°	VERTICAL BEND 22 1/2°	VERTICAL BEND 45°	HORIZONTAL BEND 45°	HORIZONTAL BEND 90°
4	20	35	5	10	15	5	10	15
6	20	45	5	10	20	5	5	10	20
8	20	60	10	15	25	5	10	15	30
10	20	75	10	15	30	5	10	15	35

NOTES
1. ALL UNCOATED JOINT RESTRAINT AND FITTING HARDWARE SHALL BE COATED WITH BITUMASTIC.
2. THRUST BLOCKING PER DETAIL 19 IS REQUIRED.
3. RESTRAINED LENGTHS FOR PIPES LARGER THAN 10 INCHES IN DIAMETER SHALL BE DESIGNED BY THE ENGINEER.
4. SERVICE LATERALS SHALL BE FULLY RESTRAINED.

WATER DEPARTMENT
CITY OF SANTA CRUZ, CALIFORNIA
DETAIL 18
JOINT RESTRAINT INSTALLATION
NOT TO SCALE
APPROVED: RCE 37391

79



THRUST BLOCK BEARING AREA (SQUARE FEET)

PIPE DIAMETER	FITTING DEFLECTION 11 1/4°	22 1/2°	45°	90°
4"	1	1	2	2
6"	1	1	2	4
8"	1	2	4	7
10"	2	3	6	11

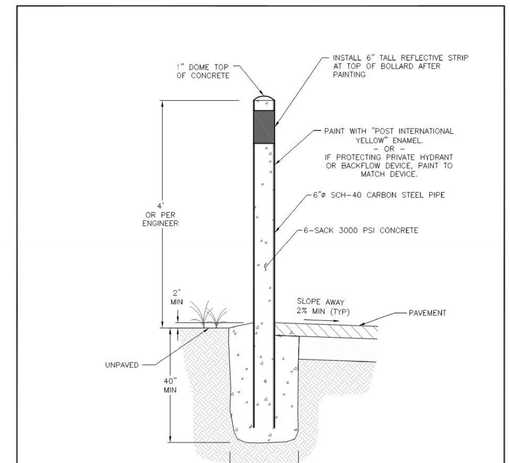
MINIMUM REVERSE ANCHOR DIMENSIONS (FEET)

PIPE DIAMETER	FITTING DEFLECTION 22 1/2° d / t	45° d / t
6"	2 / 0.5	3 / 0.5
8"	3 / 0.5	4 / 0.8
10"	3 / 0.5	5.5 / 2

NOTES
1. CONCRETE THRUST BLOCKS SHALL BE INSTALLED WHEN INDICATED BY THE CONTRACT DOCUMENTS OR AT THE DISCRETION OF THE ENGINEER.
2. THRUST BLOCKING IS REQUIRED WHERE IT IS UNKNOWN IF PIPE IS RESTRAINED, SUCH AS AT A CONNECTION TO EXISTING PIPE.
3. ALL CONCRETE SHALL BE 3000 PSI MINIMUM 28 DAYS COMPRESSIVE STRENGTH.
4. FOR PIPELINES LARGER THAN 10" IN DIAMETER, PIPELINES INSTALLED AT DEPTHS LESS THAN 36 INCHES, OR IN POOR SOILS, THRUST BLOCK DESIGN SHALL BE APPROVED BY THE ENGINEER ON A CASE BY CASE BASIS.

WATER DEPARTMENT
CITY OF SANTA CRUZ, CALIFORNIA
DETAIL 19
THRUST BLOCK INSTALLATION
NOT TO SCALE
APPROVED: RCE 37391

80



WATER DEPARTMENT
CITY OF SANTA CRUZ, CALIFORNIA
DETAIL 20
TRAFFIC BOLLARD INSTALLATION
NOT TO SCALE
APPROVED: RCE 37391

81

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED JP
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER MICHAEL E. DUCKER No. 63626 CIVIL STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12.09:39:41-07'00'

carollo

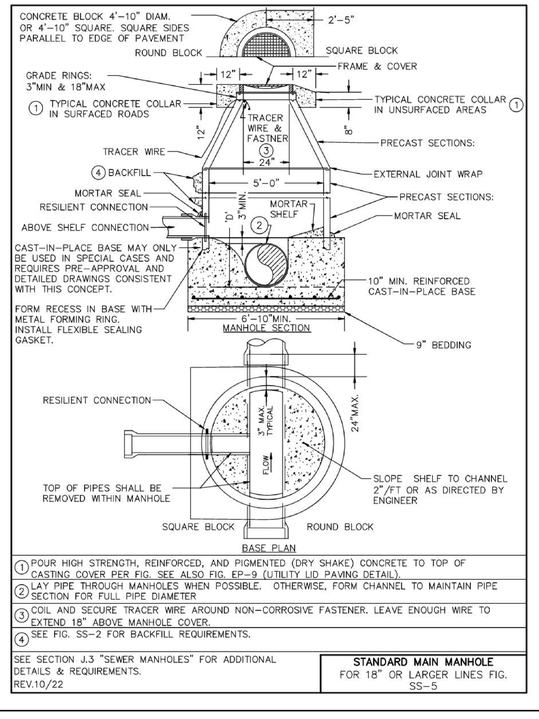
CITY OF SANTA CRUZ

CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
TYPICAL DETAILS
CITY WATER DEPARTMENT STANDARD DETAILS 2

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00TC02
SHEET NO. 50 OF 71

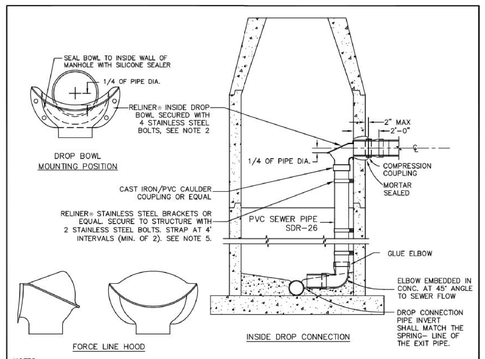
PROJECT NO. 202431-100000 FILE NAME: 20243100TC02.dgn



1. POUR HIGH STRENGTH, REINFORCED, AND PIGMENTED (DRY SHAKE) CONCRETE TO TOP OF CASTING COVER PER FIG. SEE ALSO FIG. EP-9 (UTILITY LID PAVING DETAIL).
2. LAY PIPE THROUGH MANHOLES WHEN POSSIBLE. OTHERWISE, FORM CHANNEL TO MAINTAIN PIPE SECTION FOR FULL PIPE DIAMETER
3. COIL AND SECURE TRACER WIRE AROUND NON-CORROSIVE FASTENER. LEAVE ENOUGH WIRE TO EXTEND 18" ABOVE MANHOLE COVER.
4. SEE FIG. SS-2 FOR BACKFILL REQUIREMENTS.

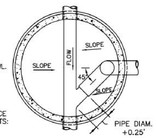
SEE SECTION J.3 "SEWER MANHOLES" FOR ADDITIONAL DETAILS & REQUIREMENTS.
REV.10/22

STANDARD MAIN MANHOLE
FOR 18" OR LARGER LINES FIG. SS-5



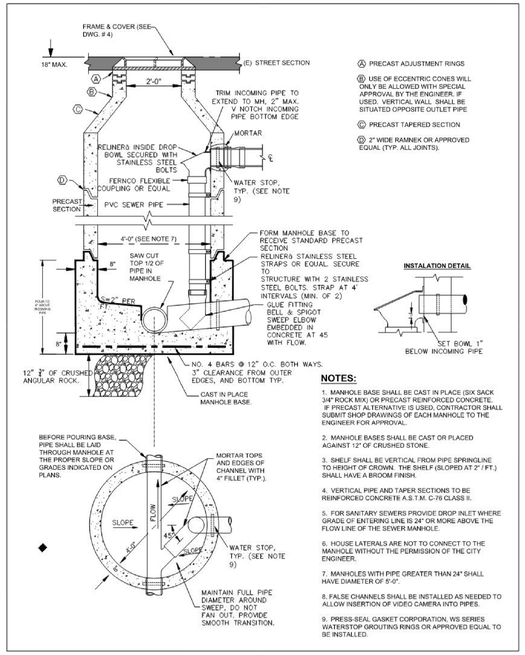
NOTES:
1. DROP MANHOLE CONNECTION WILL ONLY BE ALLOWED WITH PRIOR DISTRICT APPROVAL.
2. ALL INSIDE DROP CONNECTIONS FOR SERVICES AND COLLECTOR SEWERS SHALL USE THE DROP BOWL AS PRODUCED BY:
   RELINER-DURAN, INC.
   53 MT. ARCHER RD,
   LYME, CT 06371
   (800)508-6001 FAX: (877)434-3197, OR APPROVED EQUAL.
3. DROP BOWL MODEL "A-4" SHALL BE USED FOR ALL LINES UP THROUGH 6" INLETS. DROP BOWL MODEL "A-6" SHALL BE USED FOR ALL 8" INLETS. DROP BOWLS MODEL "B-8" SHALL BE USED FOR ALL 10" INLETS. DROP BOWLS ON LINES LARGER THAN 10" SHALL BE AS DIRECTED BY THE DISTRICT ENGINEER.
4. THE FORCE LINE HOOD SHALL BE ATTACHED ON MODELS "A-4" & "A-6" WHEN THE INCOMING LINE IS FROM A FORCE MAIN, OR THE SLOPE IS 3% OR GREATER, OR WHEN EXCESSIVE VELOCITY RESULTS IN SPILLING OUT OF BOWL.
5. SECURE DROP PIPE TO MANHOLE WALL WITH RELINER-DURAN, INC STAINLESS STEEL ADJUSTABLE CLAMPING BRACKETS OR APPROVED EQUAL.
6. ATTACH THE DROP BOWL & EACH CLAMPING BRACKET TO THE MANHOLE WALL WITH STAINLESS STEEL 3/8" X 3-3/4" RAMSET/RED HEAD BOLTS HELD INPLACE WITH 2 STAGE EPOXY PASTE. EPOXY SHALL MEET THE FOLLOWING REQUIREMENTS:
   A. EPOXY PASTE SHALL BE A TWO COMPONENT, 100% SOLIDS, SIKADUR 31 HI-MOD GEL BY SIKA CORPORATION (PHONE (800)/933-7452), OR APPROVED EQUAL.
   B. THE EPOXY PASTE SHALL DEVELOP A MINIMUM COMPRESSIVE STRENGTH OF 16,000 PSI IN 28 DAYS WHEN TESTED IN ACCORDANCE WITH ASTM D695 AT 73°F.
   C. THE EPOXY PASTE SHALL DEVELOP A MINIMUM TENSILE STRENGTH OF 3,300 PSI IN 7 DAYS WHEN TESTED IN ACCORDANCE WITH ASTM D638 AT 73°F.
   D. THE EPOXY PASTE SHALL DEVELOP A MINIMUM BOND STRENGTH OF 2,200 PSI IN 2 DAYS WHEN TESTED IN ACCORDANCE WITH ASTM C882 (HARDENED CONCRETE TO HARDENED CONCRETE).
   E. MANUFACTURER'S INSTRUCTIONS SHALL BE PRINTED ON EACH CONTAINER IN WHICH THE MATERIALS ARE PACKAGED.

REV. 10/21



INSIDE DROP — PLAN

INSIDE DROP MANHOLE CONNECTION
FIG. SS-6



Ⓐ PRECAST ADJUSTMENT RINGS

Ⓑ USE OF ECCENTRIC CONES WILL ONLY BE ALLOWED WITH SPECIAL APPROVAL BY THE ENGINEER, IF USED, VERTICAL WALL SHALL BE SITUATED OPPOSITE OUTLET PIPE

Ⓒ PRECAST TAPERED SECTION

Ⓓ 2" WIDE RAMNEK OR APPROVED EQUAL (TYP. ALL JOINTS).

INSTALATION DETAIL

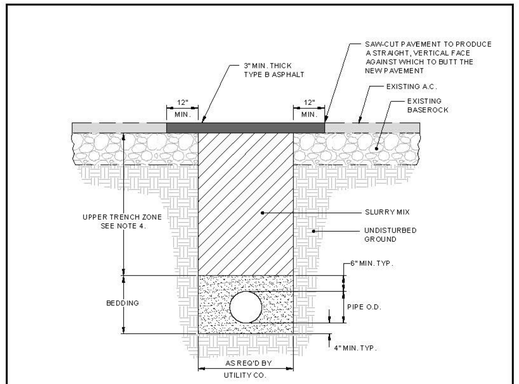
NOTES:
1. MANHOLE BASE SHALL BE CAST IN PLACE (SIX SACK 3/4" ROCK MIX) OR PRECAST REINFORCED CONCRETE. IF PRECAST ALTERNATIVE IS USED, CONTRACTOR SHALL SUBMIT SHOP DRAWINGS OF EACH MANHOLE TO THE ENGINEER FOR APPROVAL.
2. MANHOLE BASES SHALL BE CAST OR PLACED AGAINST 12" OF CRUSHED STONE.
3. SHELF SHALL BE VERTICAL FROM PIPE SPRINGLINE TO HEIGHT OF CROWN. THE SHELF (SLOPED AT 2" / FT.) SHALL HAVE A BROOM FINISH.
4. VERTICAL PIPE AND TAPER SECTIONS TO BE REINFORCED CONCRETE A.S.T.M. C-76 CLASS II.
5. FOR SANITARY SEWERS PROVIDE DROP INLET WHERE GRADE OF ENTERING LINE IS 24" OR MORE ABOVE THE FLOW LINE OF THE SEWER MANHOLE.
6. HOUSE LATERALS ARE NOT TO CONNECT TO THE MANHOLE WITHOUT THE PERMISSION OF THE CITY ENGINEER.
7. MANHOLES WITH PIPE GREATER THAN 24" SHALL HAVE DIAMETER OF 8'-0".
8. FALSE CHANNELS SHALL BE INSTALLED AS NEEDED TO ALLOW INSERTION OF VIDEO CAMERA INTO PIPES.
9. PRESS-SEAL GASKET CORPORATION. WS SERIES WATERSTOP GROUTING RINGS OR APPROVED EQUAL TO BE INSTALLED.

CITY OF SANTA CRUZ
PUBLIC WORKS DEPARTMENT
ENGINEERING DIVISION

STANDARD MANHOLE

CITY ENGINEER: _____

DATE: FEBRUARY 2011
SCALE: NONE
DWG NO. 3 OF 20



NOTES:
1. BACKFILL MIX TO PAVEMENT GRADE AND BRIDGE W/METAL PLATE UNTIL SLURRY MIX CAN SUPPORT VEHICULAR TRAFFIC. ASPHALT CONCRETE PATCH TO MATCH EXISTING THICKNESS. 3" MINIMUM (TYPE B). DO NOT MOVE SLURRY ONCE PLACED.
2. SLURRY MIX SPECIFICATIONS: PER CUBIC YARD
   1-SACK PORTLAND CEMENT
   12 GALLONS WATER
   2600 LBS. 3/8" AGGREGATE
   900 LBS. SAND
3. REFER TO UTILITY AGENCY REQUIREMENTS
4. FOR LESS THAN 18" COVER, BACKFILL WITH 4-SACK 2500 PSI CONCRETE CAP FOR LESS THAN 24" COVER, BACKFILL WITH 2-SACK SLURRY FOR MORE THAN 48" COVER BACKFILL WITH CLASS 2 AGG. BASE

NOT TO SCALE
DRAWN BY: BAW
CHECKED BY: JFR

CITY OF CAPITOLA INCORPORATED 1949

STANDARD DRAWINGS FOR
TRENCH BACKFILL SECTION

STEVEN JESBERG, PUBLIC WORKS DIRECTOR

DRAWN: 1/15
REV:
DRAWING No. CAP - 001

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED JP
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER MICHAEL E. DUCKER No. 63626 CIVIL STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:40:24 -07'00'

carollo®

CITY OF SANTA CRUZ

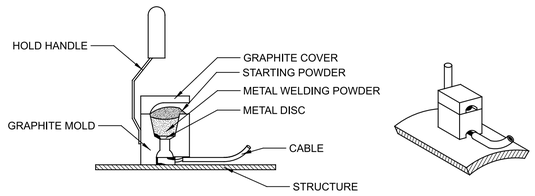
CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
TYPICAL DETAILS
CITY OF SANTA CRUZ, CITY OF CAPITOLA, AND COUNTY OF SANTA CRUZ STANDARD DETAILS 1

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00TC03
SHEET NO. 51 OF 71

PROJECT NO. 202431-100000 FILE NAME: 20243100TC03.dgn

Plot Date: 10-SEP-2025 10:17:40 AM
User: svcPW
Model: Layout1 ColorTable: gshade.ctb DesignScript: Carollo_Std_Pen_v0905.pen PlotScale: 1:1
LAST SAVED BY: cbonafoux



STEP 1. GRIND STRUCTURE CONNECTION AREA (3' X 3') TO BARE SHINY METAL AND CLEAN.

STEP 2. STRIP INSULATION FROM WIRE. ATTACH SLEEVE.

STEP 3. HOLD MOLD FIRMLY WITH OPENING AWAY FROM OPERATOR AND IGNITE WITH FLINT GUN.

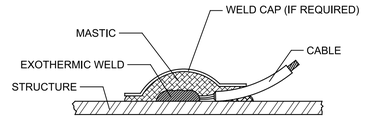
STEP 4. REMOVE SLAG FROM CONNECTION AND PEEN WELD FOR SOUNDNESS.

STEP 5A. FOR CONNECTION TO METALLICE STRUCTURES COVER CONNECTION WITH THERMITE WELD CAP. MAKE CERTAIN ALL COPPER IS COVERED. COAT WELD AREA WITH MASTIC COATING COMPOUNT.

STEP 5B. FOR CONNECTIONS TO MORTAR COATED STEEL, COVER CONNECTION WITH MASTIC COATING COMPOUND BEFORE REPAIRING MORTAR COATING.

NOTE: PROCEDURE IS TO BE USED AS A GENERAL GUIDE ONLY. CONSULT MANUFACTURER'S LITERATURE FOR SPECIFIC INSTALLATION INSTRUCTIONS.

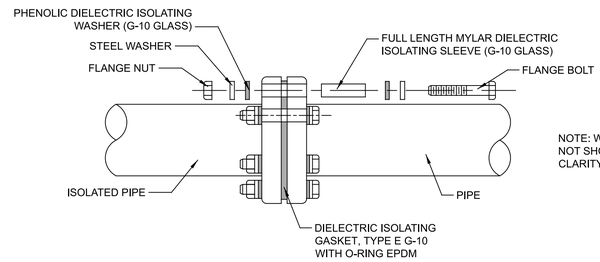
CP101 TYP S — CONNECTION - CABLE TO STRUCTURE EXOTHERMIC WELDING PROCEDURE



NOTES:

1. REFER TO CP101 FOR EXOTHERMICAL WELDING PROCEDURE.
2. CABLE SIZE MAY REQUIRE COPPER SLEEVE. SEE MANUFACTURER'S INSTRUCTIONS.

CP102 TYP S — CONNECTION - CABLE TO STRUCTURE METALLURGICAL EXOTHERMIC WELD



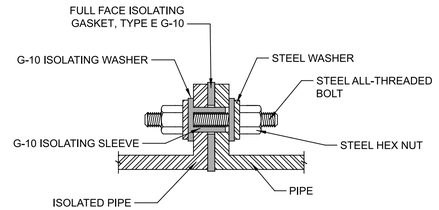
TOP VIEW ISOLATION JOINT FLANGE KIT

NOTES:

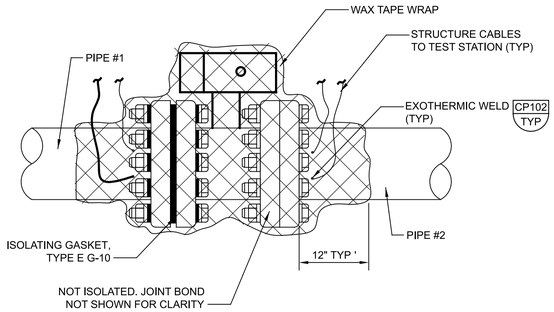
1. TYPICAL FOR NON-WELDED PIPING OR WELDED PIPING WITH MECHANICAL COUPLINGS.
2. FULL LENGTH ISOLATING SLEEVES REQUIRED FOR ALL THRU-FLANGE BOLTS OR STUDS.
3. ISOLATION IS TO BE TESTED PRIOR TO BURIAL AND TESTED AFTER BURIAL TO INSURE ISOLATION.
4. BURIED ISOLATION FLANGES ARE TO BE WRAPPED WITH WAX TAPE. DAMAGE COATINGS REPAIRED PER SPECIFICATION.
5. ALL ISOLATION FLANGES REQUIRE AN IJFK TEST STATION PER SPECIFICATION.
6. FOR NOMINAL PIPE DIAMETERS UP TO 36", PROVIDE ONE ISOLATING AND ONE STEEL WASHER ON EITHER SIDE OF FLANGE BOLT. FOR PIPE DIAMETERS GREATER THAN 36", ISOLATING WASHERS SHALL BE INSTALLED SANDWICHED BETWEEN A PAIR OF MATCHING STEEL WASHERS AT BOTH SIDES OF FLANGE BOLT.

CP175 TYP S — ISOLATION JOINT FLANGE KIT DETAILS

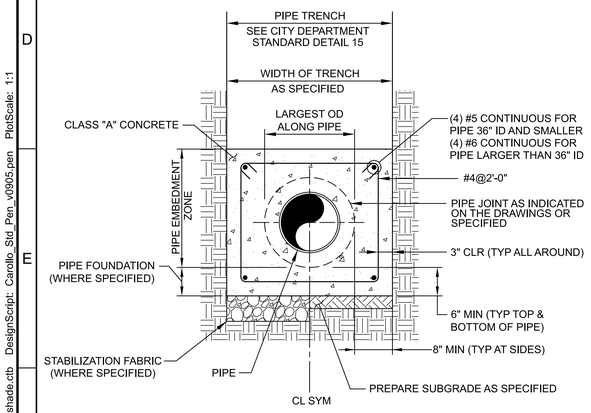
NOTE: WAX TAPE WRAP NOT SHOWN FOR CLARITY.



SIDE VIEW ISOLATION JOINT FLANGE KIT



BUTTERFLY VALVE

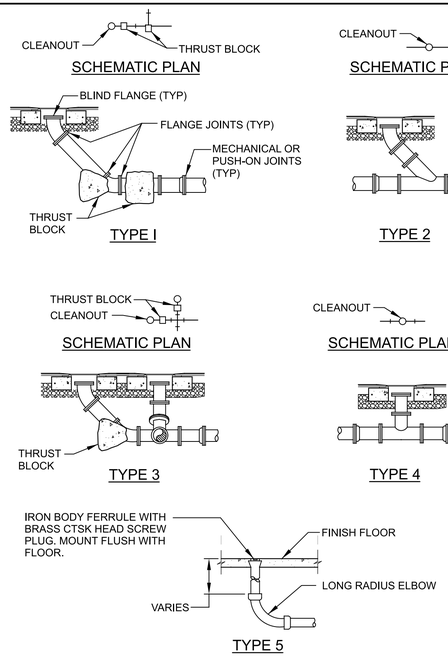


SECTION

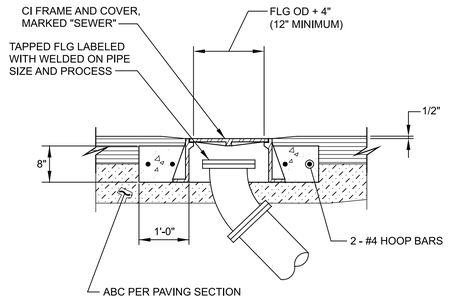
NOTE:

1. PIPE MATERIAL AND TYPE OF PIPE JOINTS OR COUPLERS AS INDICATED ON THE DRAWINGS.

CY119 TYP S — PIPE ENCASEMENT - CONCRETE



CY411 TYP S — CLEANOUTS



TERMINATION IN PAVEMENT ALL TYPES FOR 4"Ø TO 12"Ø

NOTES:

1. ALL THRUST BLOCKS SHALL BE PLACED PER TYPICAL DETAIL CY131.
2. CONCRETE RING SHALL BE PLACED AFTER PAVEMENT PLACEMENT.
3. ALL FLANGES SHALL BE TAPPED TO ALLOW THE INSTALLATION OF BLIND FLANGES WITH BOLTS.
4. CLEANOUT PIPE SHALL BE SAME SIZE AS LINE PIPE.
5. FOR CLEANOUTS IN YARD AREA, PLACE 12" SQUARE BY 4" THICK CONCRETE PAD.

CY411 TYP S — CLEANOUTS

5/1/2025

SHEET 1 OF 2 12/29/2020

SHEET 2 OF 2 12/29/2020

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED LL
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER MICHAEL E. DUCKER No. 63626 CIVIL STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:40:42 -07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

TYPICAL DETAILS

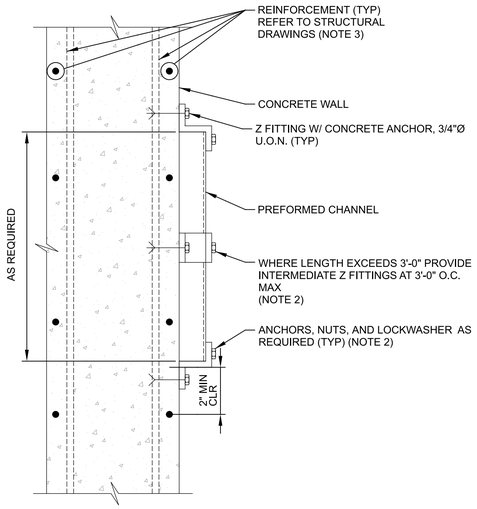
CIVIL 1

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00TC04
SHEET NO. 52 OF 71

PROJECT NO. 202431-100000 FILE NAME: 20243100TC04.dgn

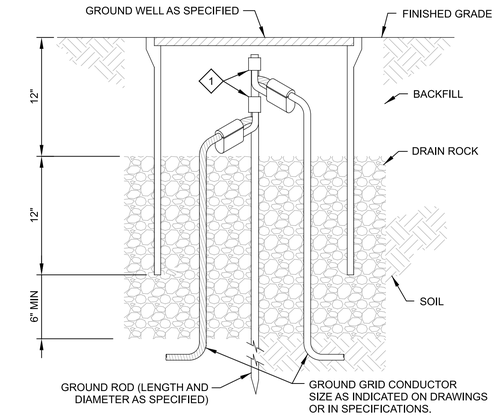
Plot Date: 10-SEP-2025 10:19:24 AM
User: svcPW
Model: Layout1 ColorTable: gshade.ctb DesignScript: Carollo_Std_Pen_v0905.pen PlotScale: 1:1
LAST SAVED BY: hvo



GENERAL NOTES:

1. THIS DETAIL TYPICAL FOR BOTH VERTICAL AND HORIZONTAL MOUNTING.
2. SUPPORTS TO BE SPACED IN ACCORDANCE WITH NEC REQUIREMENTS. CONCRETE ANCHORS SHALL BE PER THE SPECIFICATIONS.
3. REFER TO CIVIL DRAWINGS AND STRUCTURAL DETAILS FOR ORIENTATION OF REINFORCEMENT AND BARS.

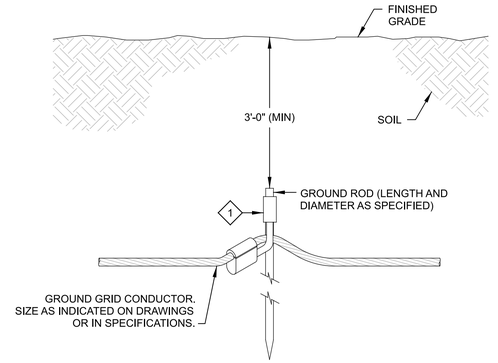
EA070 TYP S — PREFORMED CHANNEL ATTACHMENT TO CONCRETE WALL



KEY NOTES:

1. GROUND ROD TO GROUND GRID CROSS CONNECTOR. SIZE FOR ROD AND CABLE PER CONNECTOR MANUFACTURERS GUIDELINES.

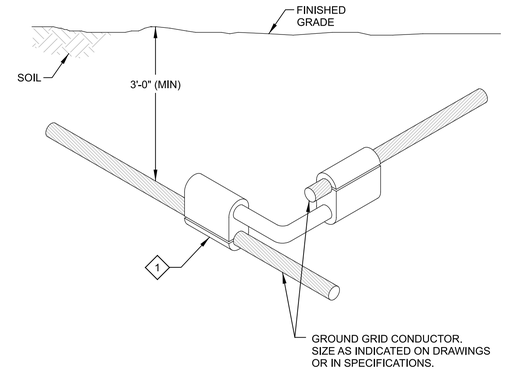
EG001 TYP S S — GROUND ROD AND GROUNDWELL COMPRESSION CONNECTION



KEY NOTES:

1. GROUND ROD TO GROUND GRID CROSS CONNECTOR. SIZE FOR ROD AND CABLE PER CONNECTOR MANUFACTURERS GUIDELINES.

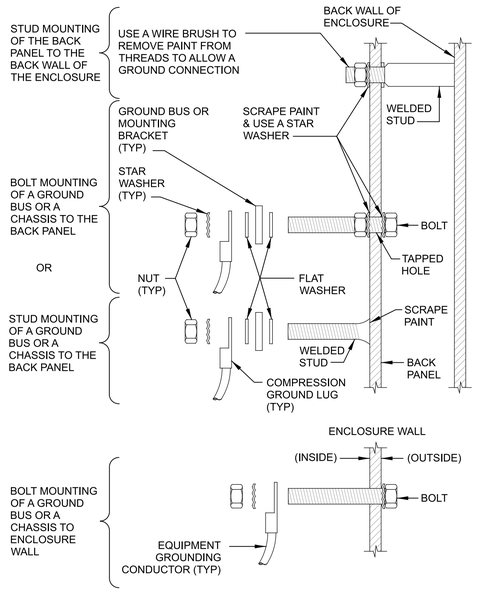
EG002 TYP S — GROUND ROD COMPRESSION CONNECTION



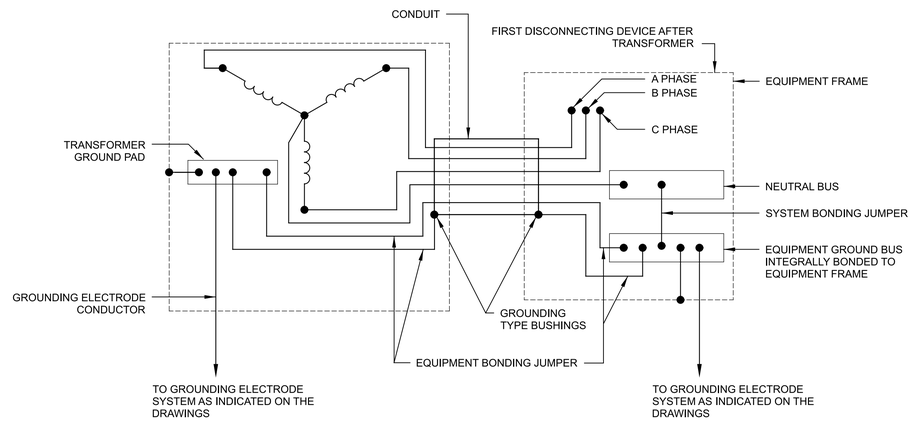
KEY NOTES:

1. GROUND GRID CROSS CONNECTOR. SIZE FOR CABLE PER CONNECTOR MANUFACTURERS GUIDELINES.

EG101 TYP — COPPER GROUNDING CABLE CONNECTION COMPRESSION CONNECTION



EG205 TYP S — ENCLOSURE GROUNDING DETAILS



EG511 TYP S — TRANSFORMER (NON-UTILITY) 3-PHASE, 4-WIRE SECONDARY POWER GROUNDING DETAIL

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED KW
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER ERIK M. BAHNEMAN No. E19683 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Erik M. Bahneman
Contact Info: Carollo Engineers, Inc.
Date: 2025-09-12 13:01:12 -07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

TYPICAL DETAILS

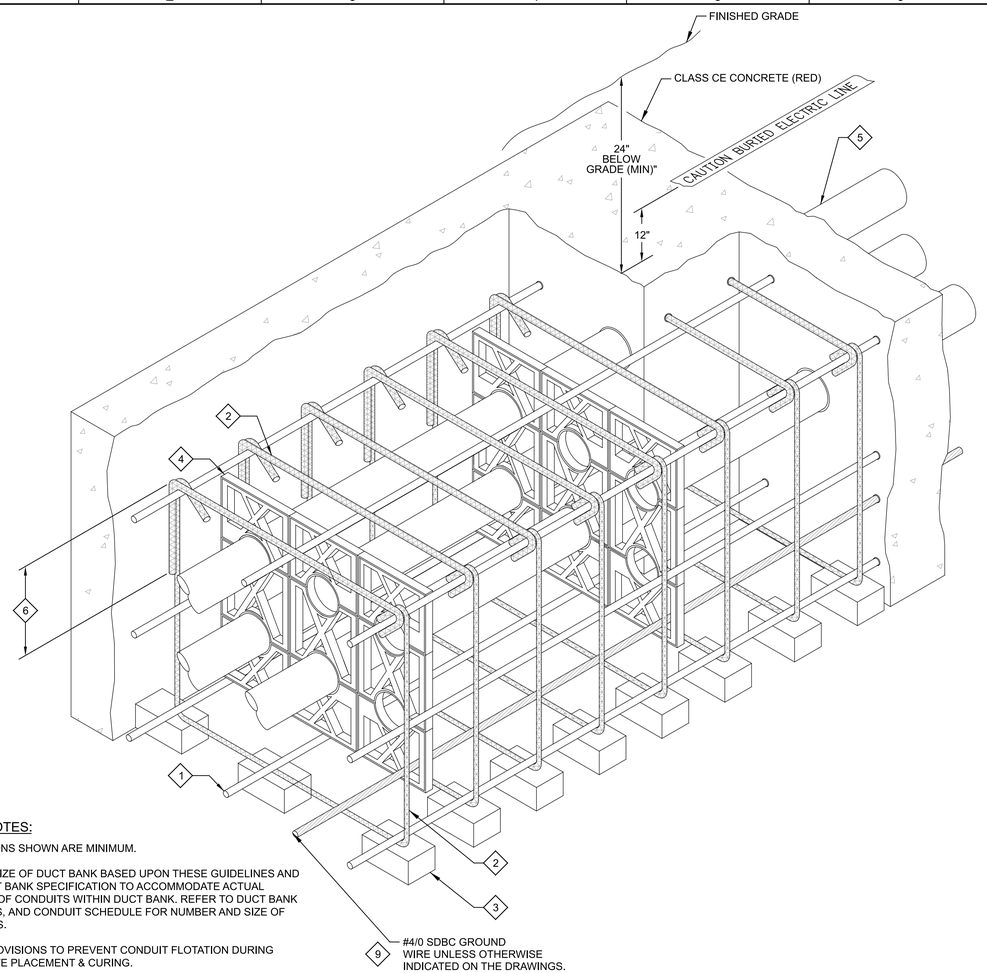
ELECTRICAL 1

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00TE01
SHEET NO. 53 OF 71

PROJECT NO. 202431-100000 FILE NAME: 20243100TE01.dgn

Plot Date: 10-SEP-2025 10:17:42 AM
User: svcPW
PlotScale: 1:1
DesignScript: Carollo_Std_Pen_v0905.pen
ColorTable: gshade.ctb
Model: Layout1
LAST SAVED BY: cbonafoux



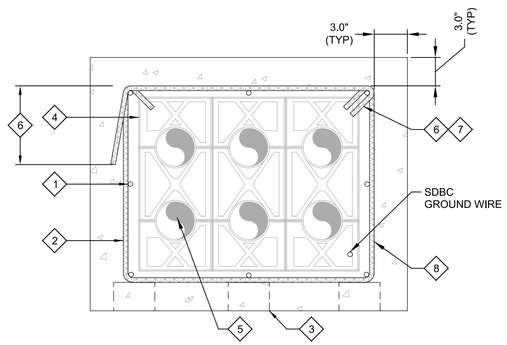
GENERAL NOTES:

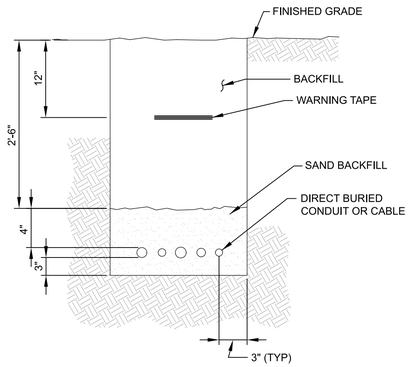
1. DIMENSIONS SHOWN ARE MINIMUM.
2. ADJUST SIZE OF DUCT BANK BASED UPON THESE GUIDELINES AND THE DUCT BANK SPECIFICATION TO ACCOMMODATE ACTUAL NUMBER OF CONDUITS WITHIN DUCT BANK. REFER TO DUCT BANK SECTIONS, AND CONDUIT SCHEDULE FOR NUMBER AND SIZE OF CONDUITS.
3. MAKE PROVISIONS TO PREVENT CONDUIT FLOTATION DURING CONCRETE PLACEMENT & CURING.

KEY NOTES:

1. #4 REINFORCING STEEL 12" MAXIMUM ON CENTER AROUND ENTIRE PERIMETER OF DUCT BANK.
2. #4 REINFORCING STEEL TIES MAXIMUM 24" ON CENTER ALONG LENGTH OF DUCT BANK.
3. MINIMUM OF TWO PRECAST CONCRETE BAR SUPPORTS PLACED UNDER A TIE AT EACH PVC CONDUIT SPACER ALONG LENGTH OF DUCT BANK. PROVIDE PRECAST BAR SUPPORTS AT INTERVALS OF 24" TO REDUCE DEFLECTION.
4. PVC CONDUIT SPACERS ON 8'-0" CENTERS (MAXIMUM). LOCATE 12" FROM TIES.
5. REFER TO DUCT BANK SECTIONS AND SPECIFICATIONS FOR CONDUIT REQUIREMENTS.
6. 1'-4" OR 135 DEGREE HOOK FOR SHALLOW DUCT BANKS SHALLOWER THAN 21"
7. CONTRACTOR'S OPTION TO PROVIDE 1'-4" LAP LENGTH EACH SIDE OF HORIZONTAL TIE.
8. LOWER PORTION OF TIES COULD BE U-BARS IF UPPER PORTIONS PROVIDES 1'-4" VERTICAL LEGS EACH SIDE.
9. BOND THE DUCT BANK GROUND WIRE TO THE GROUNDING SYSTEM AT BOTH ENDS OF THE DUCT BANK.

EM001 TYP S REINFORCED CONCRETE DUCT BANK

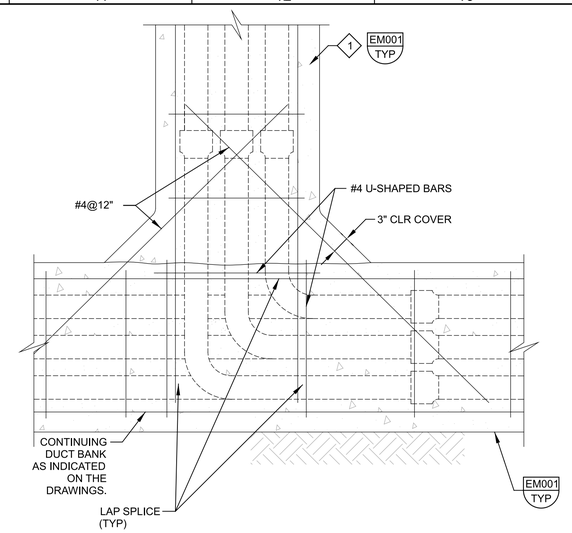




GENERAL NOTES:

1. ALL DIMENSIONS ARE MINIMUM UNLESS OTHERWISE INDICATED ON THE DRAWINGS.
2. REFER TO THE SPECIFICATIONS FOR TRENCH BACKFILL REQUIREMENTS.

EM015 TYP S DIRECT BURIED CONDUIT OR CABLE



GENERAL NOTES:

1. REFER TO THE SPECIFICATIONS FOR MATERIAL REQUIREMENTS.

KEY NOTES:

1. ADJUST DUCT SPACING TO FIT OPENING IN THE SLAB AND EQUIPMENT ABOVE.

EM020 TYP S DUCT BANK RISER

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED KW
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER ERIK M. BAHNEMAN No. E19683 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Erik M. Bahneman
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.10 13:15:17 -07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

TYPICAL DETAILS

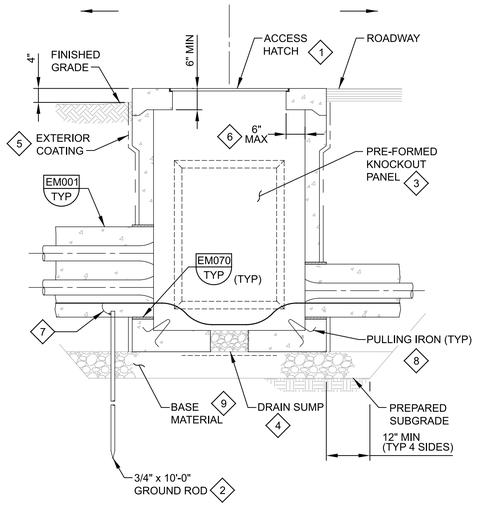
ELECTRICAL 2

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00TE02
SHEET NO. 54 OF 71

Plot Date: 10-SEP-2025 10:17:57 AM
User: svcPW
PlotScale: 1:1
DesignScript: Carollo_Std_Pen_v0905.pen
ColorTable: gshade.ctb
Model: Layout1
LAST SAVED BY: obonafaux

PROJECT NO. 202431-100000 FILE NAME: 20243100TE02.dgn



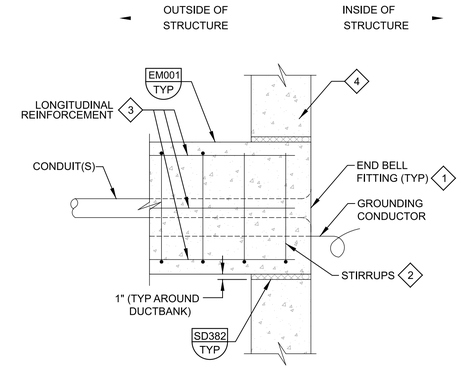
EM056 TYP S — ELECTRICAL HANDHOLE
PRECAST CONCRETE W/HATCH

GENERAL NOTES:

1. PROVIDE MINIMUM INTERIOR DIMENSIONS AS SHOWN IN THE ELECTRICAL HANDHOLE AND MANHOLE SCHEDULE.
2. BOND ALL METALLIC ITEMS INSIDE HANDHOLE TO GROUND ROD USING #4 AWG BARE COPPER CABLE.
3. SEE DRAWINGS FOR ORIENTATION, NUMBER, AND SIZE OF DUCT BANKS AT EACH HANDHOLE.

KEY NOTES:

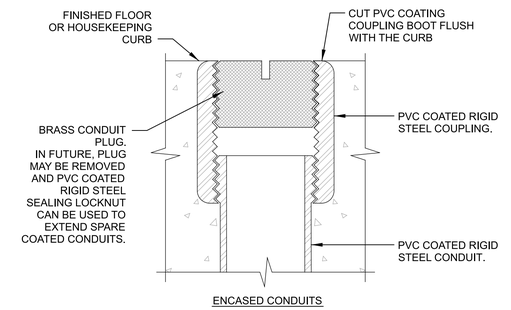
1. SEE THE MANHOLE AND HANDHOLE SCHEDULE FOR REQUIRED LOAD RATING OF HATCH.
2. BOND DUCT BANK GROUND CABLE TO GROUND ROD. REFER TO THE SPECIFICATIONS FOR CONNECTION REQUIREMENTS.
3. INSTALL DUCT BANKS ONLY THROUGH CAST-IN OPENINGS OR PREFORMED KNOCKOUT PANELS. PROVIDE KNOCKOUTS ON EACH WALL AROUND HANDHOLE.
4. PROVIDE MINIMUM 4 INCH DIAMETER, GRAVEL FILLED PENETRATION THROUGH FLOOR OF HANDHOLE. SET SUMP OPENING OVER MINIMUM 18" SQUARE FILTER FABRIC TO ISOLATE GRAVEL FROM BASE MATERIAL BELOW.
5. COAT EXTERIOR WALLS BELOW GRADE WITH BITUMINOUS DAMP PROOFING.
6. MAXIMUM TOP SLAB OVERHANG IS TYPICAL AROUND 4 SIDES OF HANDHOLE.
7. GROUNDING CABLE CONNECTION. REFER TO THE SPECIFICATIONS FOR CONNECTION REQUIREMENTS.
8. PROVIDE ONE PULLING IRON ON EACH WALL OF HANDHOLE.
9. BASE MATERIAL: PROVIDE MIN 12" COMPACTED AGGREGATE BASE COURSE.



KEY NOTES:

1. PROVIDE GROUNDING FITTING FOR METALLIC CONDUITS ENTERING MANHOLE. BOND GROUNDING FITTING TO DUCTBANK GROUNDING CONDUCTOR.
2. FOR FIRST 12'-0" FROM INSIDE FACE OF STRUCTURE, STIRRUP SPACING IN INCHES = (H-4)/2 WHERE H = CONCRETE ENCASEMENT HEIGHT IN INCHES.
3. ADDITIONAL #4 x 12'-0" @ 12" ON ALL FOUR FACES OF ENCASEMENT. ALTERNATE WITH TYPICAL REINFORCEMENT FOR 6" SPACING.
4. PROVIDE ADDITIONAL REINFORCEMENT AROUND OPENING AS REQUIRED. FOR CAST-IN-PLACE STRUCTURES, PROVIDE REINFORCEMENT PER SC012 TYP

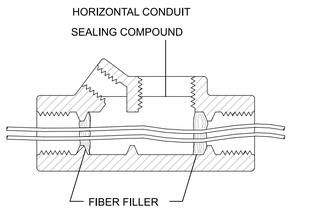
EM070 TYP S — ENCASED CONDUITS AT MANHOLES OR
STRUCTURES - W/O WATERSTOP

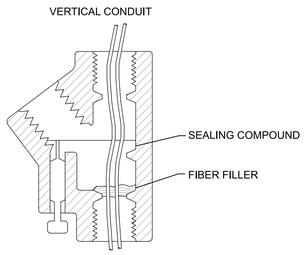


GENERAL NOTES:

1. PROVIDE 2" MIN CLEAR BETWEEN ADJACENT CONDUITS

EM105 TYP S — SPARE CONDUIT DETAIL





EM108 TYP — CONDUIT SEAL
DAMMING AND POURING DETAIL

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED KW
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER — ERIK M. BAHNEMAN — No. E19683 — ELECTRICAL — STATE OF CALIFORNIA

Digitally signed by Erik M. Bahneman
Contact Info: Carollo Engineers, Inc.
Date: 2025-09-12 13:13:17 -07'00'

carollo®

CITY OF SANTA CRUZ

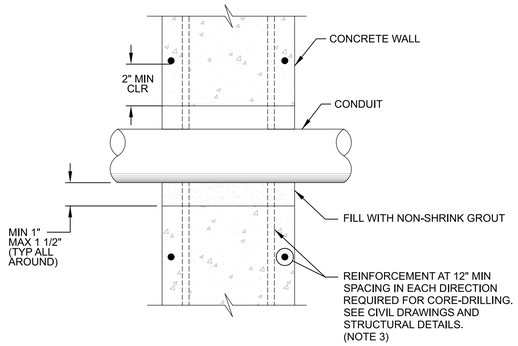
CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
TYPICAL DETAILS
ELECTRICAL 3

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00TE03
SHEET NO. 55 OF 71

Plot Date: 10-SEP-2025 11:22:11 AM
User: svcPW
PlotScale: 1:1
DesignScript: Carollo_Std_Pen_v0905.pen
ColorTable: gshade.ctb
Model: Layout1
LAST SAVED BY: cbonafoux

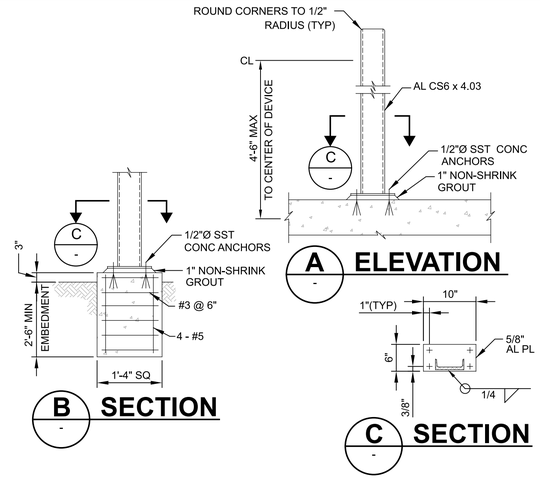
PROJECT NO. 202431-100000 FILE NAME: 20243100TE03.dgn



GENERAL NOTES:

1. PROVIDE NON-DESTRUCTIVE TESTING TO DETERMINE LOCATIONS OF REINFORCEMENT. MAINTAIN MIN 2" CLEAR BETWEEN CORE DRILLED OPENING AND REINFORCEMENT.
2. APPLY EPOXY CEMENT BONDING AGENT OR ROUGHEN CONCRETE SURFACE PRIOR TO GROUTING.
3. PROVIDE CAST-IN SLEEVE FOR PENETRATIONS IN WALLS WITH REINFORCEMENT SPACING LESS THAN 2" IN EACH DIRECTION. REFER TO CIVIL DRAWINGS AND STRUCTURAL DETAILS.

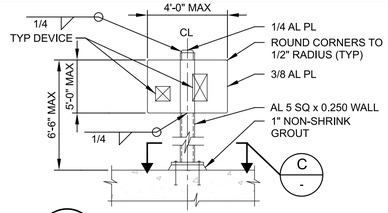
EM163 TYP S CORE DRILLED PENETRATION CONCRETE WALL

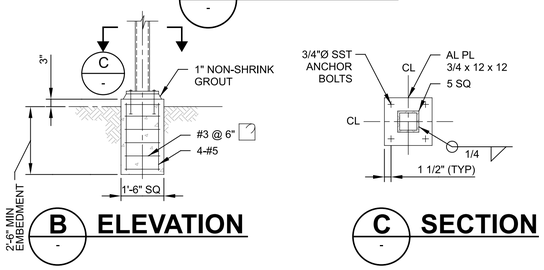


GENERAL NOTES:

1. WHERE SEPARATE FOUNDATION IS REQUIRED, SEE SECTION B.
2. COAT ALUMINUM SURFACES IN CONTACT WITH CONCRETE PER SPECIFICATIONS.
3. USE STAINLESS STEEL FASTENERS FOR MOUNTING DEVICES.
4. WEIGHT OF DEVICE(S) SHALL NOT EXCEED 100 POUNDS.

EM201 TYP S DEVICE SUPPORT AND MOUNTING





GENERAL NOTES:

1. USE ELEVATION B WHERE A SEPARATE FOUNDATION IS REQUIRED.
2. COAT ALUMINUM SURFACES IN CONTACT W/ CONCRETE PER SPECIFICATIONS.
3. USE STAINLESS STEEL FASTENERS FOR MOUNTING DEVICES.
4. WEIGHT OF DEVICE(S) SHALL NOT EXCEED 300 POUNDS.

EM202 TYP S DEVICE SUPPORT AND MOUNTING

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED KW
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER ERIK M. BAHNEMAN No. E19683 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Erik M. Bahneman
Contact Info: Carollo Engineers, Inc.
Date: 2025-09-12 13:01:10 -07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

TYPICAL DETAILS

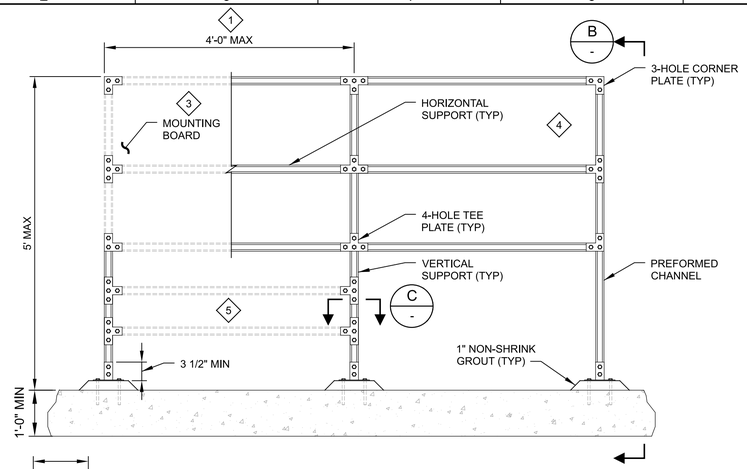
ELECTRICAL 4

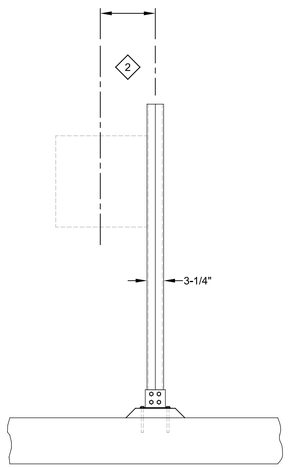
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00TE04
SHEET NO. 56 OF 71

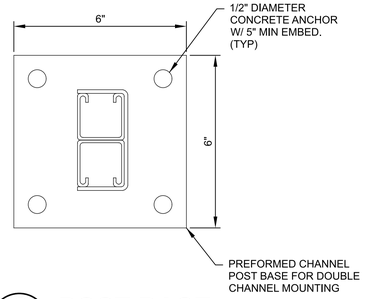
PROJECT NO. 202431-100000 FILE NAME: 20243100TE04.dgn

Plot Date: 10-SEP-2025 10:17:36 AM
User: svcPW
PlotScale: 1:1
DesignScript: Carollo_Std_Pen_v0905.pen
ColorTable: gshade.ctb
Model: Layout1
LAST SAVED BY: cbonafoux





B SECTION



C POST BASE

GENERAL NOTES:

1. AS SHOWN, THE MOUNTING STAND IS SUITABLE FOR THE FOLLOWING DESIGN CRITERIA.
   - STAINLESS STEEL OR HOT-DIPPED GALVANIZED PREFORMED CHANNEL
   - BASIC WIND SPEED (3 SECOND GUST. 33 FEET ABOVE GROUND) : 120 MPH
   - WIND EXPOSURE CATEGORY: C
   - NON -SPECIAL WIND REGIONS
   - SEISMIC DESIGN CATEGORY: A THROUGH D
   - RISK CATEGORY: III AND IV
   - MAXIMUM EQUIPMENT LOAD OF 100 LBS PER VERTICAL SUPPORT

   SUBMIT DESIGN CALCULATIONS FOR EACH INSTALLATION THAT EXCEEDS THE SPECIFIED DESIGN CRITERIA OR DIMENSIONAL LIMITATIONS IN THIS DETAIL. REFER TO THE SPECIFICATIONS FOR DESIGN CALCULATION SUBMITTAL REQUIREMENTS.
2. THE TOTAL SURFACE AREA OF ALL EQUIPMENT AND MOUNTING BOARDS SHALL NOT EXCEED 12 SQUARE FEET PER VERTICAL SUPPORT.
3. REFER TO THE SPECIFICATIONS FOR MATERIAL REQUIREMENTS.
4. WHERE CONCRETE ANCHORS COME IN CONTACT WITH DISSIMILAR METALS, ISOLATE DISSIMILAR METALS AS SPECIFIED IN THE SPECIFICATIONS.
5. VERTICAL SUPPORTS SHALL CONSIST OF PREFORMED DOUBLE CHANNELS. HORIZONTAL SUPPORTS SHALL CONSIST OF PREFORMED SINGLE CHANNELS.

KEY NOTES:

1. FOR MOUNTING STANDS WIDER THAN 4 FEET PROVIDE EQUALLY SPACED VERTICAL SUPPORTS AT 4 FOOT MAXIMUM SPACING.
2. MAXIMUM OFFSET TO THE CENTERLINE OF EQUIPMENT OR ENCLOSURES IS 1'-6".
3. PROVIDE A MOUNTING BOARD FOR INSTRUMENTS AND DEVICES WEIGHING LESS THAN 20 POUNDS THAT CANNOT BE MOUNTED DIRECTLY TO PREFORMED CHANNEL. EQUIPMENT ANCHORAGE TO THE MOUNTING BOARD SHALL BE DESIGNED BY THE CONTRACTOR.
4. PROVIDE ADDITIONAL PREFORMED CHANNEL SUPPORTS FOR ENCLOSURES THAT CAN BE MOUNTED DIRECTLY TO THE PREFORMED CHANNEL.
5. OPTIONAL HORIZONTAL SUPPORTS AND AVAILABLE SPACE FOR JUNCTION BOXES.

EM211 TYP S OUTDOOR EQUIPMENT MOUNTING STAND

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED KW
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER ERIK M. BARNEMAN No. E19683 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Erik M. Barneman
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 13:15:17 -07'00'

carollo

CITY OF SANTA CRUZ

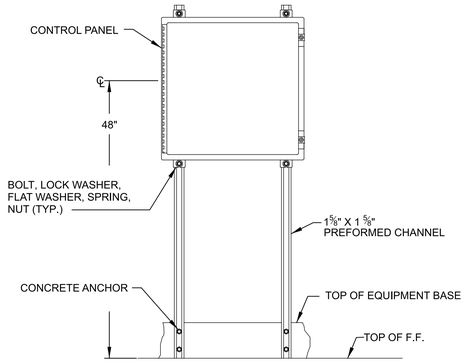
CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
TYPICAL DETAILS
ELECTRICAL 5

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

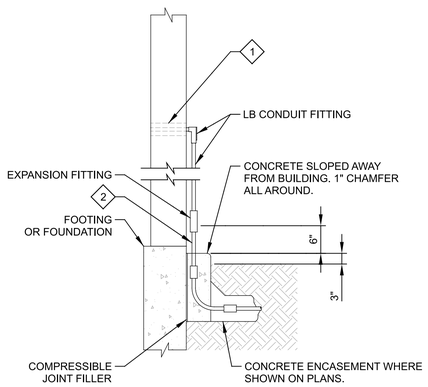
JOB NO. 202431
DRAWING NO. 00TE05
SHEET NO. 57 OF 71

PROJECT NO. 202431-100000 FILE NAME: 20243100TE05.dgn

LAST SAVED BY: obonafoux PlotScale: 1:1 DesignScript: Carollo_Std_Pen_v0905.pen ColorTable: gshade.ctb Model: Layout1 User: svcPW Plot Date: 10-SEP-2025 10:18:21 AM



EM217 TYP S CONTROL PANEL MOUNTING DETAIL



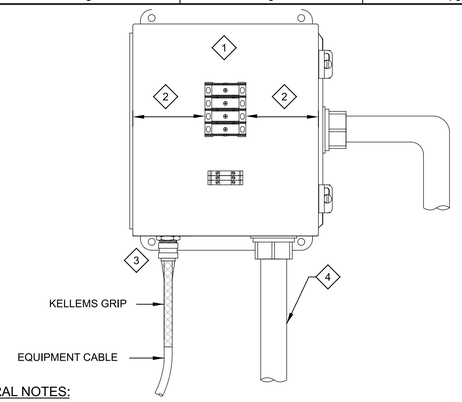
GENERAL NOTES:

1. REFER TO THE SPECIFICATIONS FOR MATERIAL REQUIREMENTS.

KEY NOTES:

1. USE THE WALL PENETRATION DETAIL SUITABLE FOR THE WALL CONSTRUCTION.
2. DO NOT ATTACH THE CONDUIT TO THE BUILDING BEFORE THE EXPANSION FITTING.

EM219 TYP S DUCT BANK RISER ADJACENT TO BUILDING



GENERAL NOTES:

1. REFER TO THE SPECIFICATIONS FOR ENCLOSURE AND MATERIAL REQUIREMENTS.
2. PROVIDE A BACK PANEL AND DIN RAIL FOR MOUNTING THE POWER AND CONTROL BLOCKS.
3. DO NOT MAKE CONDUIT CONNECTIONS TO THE TOP OF NEMA 4X ENCLOSURES.

KEY NOTES:

1. LISTED POWER TERMINAL BLOCKS WITH SAFETY COVER.
2. PROVIDE CLEARANCE IN ACCORDANCE WITH THE NEC.
3. THE EQUIPMENT CABLE MAY BE ROUTED IN CONDUIT FROM THE WET WELL. REFER TO THE DRAWINGS.
4. PROVIDE CONDUIT SEALS ON THE BUILDING WIRE SIDE OF THE JUNCTION BOX AS REQUIRED.

EM315 TYP S SUBMERSIBLE EQUIPMENT CABLE CONNECTION DETAIL

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED KW
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER ERIK M. BAHNEMAN No. E19683 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Erik M. Bahneman
Contact Info: Carollo Engineers, Inc.
Date: 2025-09-12 13:13:16 -07'00'

carollo®

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

TYPICAL DETAILS

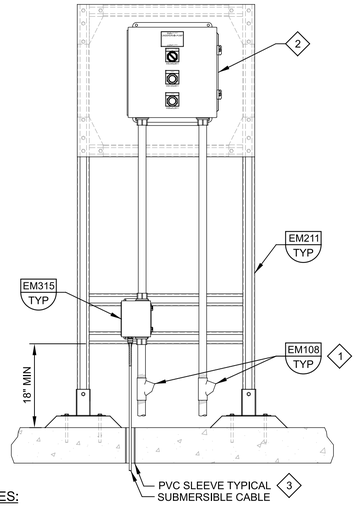
ELECTRICAL 6

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00TE06
SHEET NO. 58 OF 71

PROJECT NO. 202431-100000 FILE NAME: 20243100TE06.dgn

Plot Date: 10-SEP-2025 10:16:45 AM
User: svcPW
Model: Layout1 ColorTable: gshade.ctb DesignScript: Carollo_Std_Pen_v0905.pen PlotScale: 1:1
LAST SAVED BY: cbonafoux



GENERAL NOTES:

1. REFER TO THE SPECIFICATIONS FOR MATERIAL AND ENCLOSURE REQUIREMENTS.

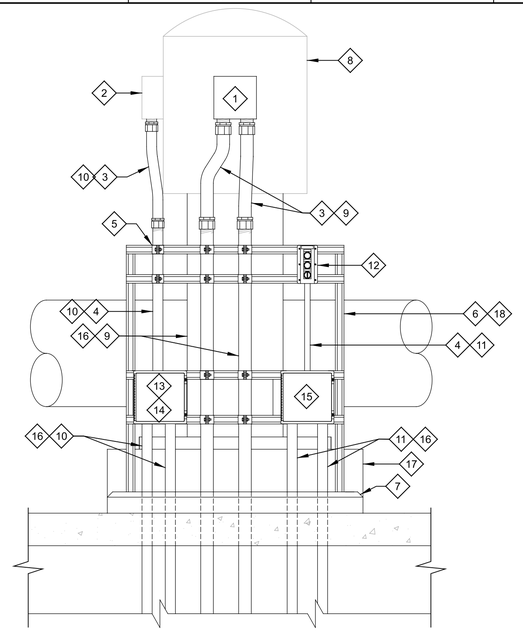
KEY NOTES:

1. CONDUIT SEALS WHERE REQUIRED FOR THE AREA CLASSIFICATION. REFER TO THE SPECIFICATIONS
2. LOCATE CONTROL PANEL OUTSIDE HAZARDOUS AREA. REFER TO THE SPECIFICATIONS.
3. MINIMUM CONDUIT SIZE SHALL BE 1". INCREASE CONDUIT SIZE AS REQUIRED TO MEET THE MINIMUM FILL REQUIREMENTS OF THE NEC.

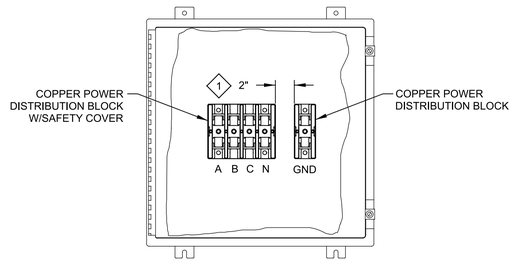
EM320 TYP S — SUBMERSIBLE EQUIPMENT CONTROL PANEL INSTALLATION

KEY NOTES:

1. MOTOR JUNCTION BOX POWER
2. MOTOR JUNCTION BOX SIGNAL - RTD
3. LIQUIDTIGHT FLEXIBLE CONDUIT, SIZE AS PER PLANS
4. GRC, SIZE AS PER PLANS
5. CONDUIT CLAMP
6. GALVANIZED PREFORMED CHANNEL
7. CONCRETE PAD
8. MOTOR HOUSING
9. POWER CONDUIT
10. SIGNAL - RTD CONDUIT
11. CONTROL CONDUIT
12. MOTOR CONTROL STATION
13. SIGNAL - RTD J-BOX NEMA 4
14. SIGNAL - RTD J-BOX MAY BE ELIMINATED IF ONLY ONE CONDUIT PRESENT.
15. CONTROL J-BOX NEMA 4
16. PCS CONDUIT SIZE AS PER PLANS
17. PUMP CAN
18. FASTEN PREFORMED CHANNEL INTO PUMP CONCRETE CURB WITH LAG BOLTS ANCHORS.



EM370 TYP S — LOCAL CONTROL STATION AND CONDUIT TERMINATION AT MOTOR



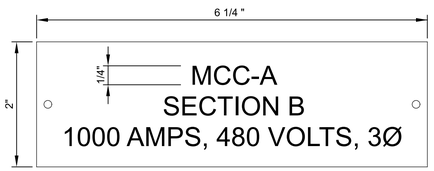
GENERAL NOTES:

1. CONTRACTOR TO SIZE BOX AND POWER BLOCKS SPACING TO CONFORM TO NEC AND MANUFACTURER REQUIREMENTS.
2. REFER TO THE SPECIFICATIONS FOR ENCLOSURE MATERIAL AND NEMA TYPE REQUIREMENTS.

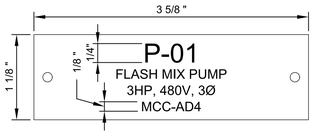
KEY NOTES:

1. INSTALL CIRCUIT BREAKERS OR FUSES AS REQUIRED TO MEET THE AVAILABLE FAULT CURRENT REQUIREMENTS

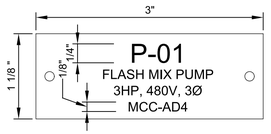
EM480 TYP S — TYPICAL POWER J-BOX DETAIL



OVERALL ELECTRICAL EQUIPMENT



STARTER OR CIRCUIT BREAKER COMPARTMENT



DISCONNECT, LOCAL CONTROL PANEL

GENERAL NOTES:

1. REFER TO THE SPECIFICATIONS FOR MATERIALS AND COLOR SCHEMES.
2. NAMEPLATE DIMENSIONS ARE APPROXIMATE.

EN001 TYP S — TYPICAL ELECTRICAL EQUIPMENT NAMEPLATES

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED KW
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER — ERIK M. BARNEMAN — No. E19683 — ELECTRICAL — STATE OF CALIFORNIA

Digitally signed by Erik M. Barneman
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 13:13:37 -07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

TYPICAL DETAILS

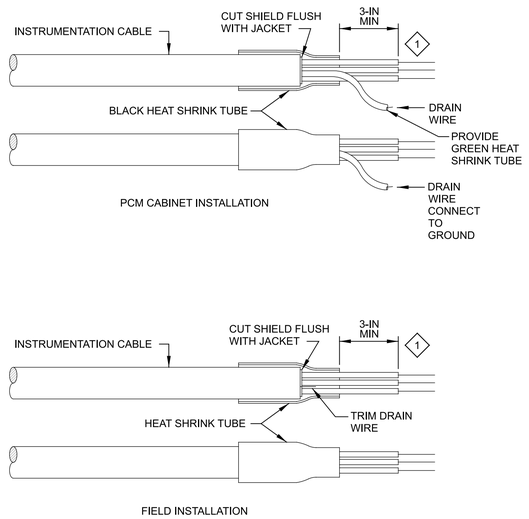
ELECTRICAL 7

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00TE07
SHEET NO. 59 OF 71

LAST SAVED BY: cbonafoux
Model: Layout1 ColorTable: gshade.ctb DesignScript: Carollo_Std_Pen_v0905.pen PlotScale: 1:1
Plot Date: 10-SEP-2025 10:18:01 AM
User: svcPW

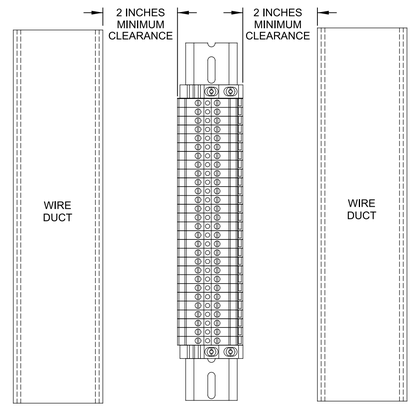
PROJECT NO. 202431-100000 FILE NAME: 20243100TE07.dgn



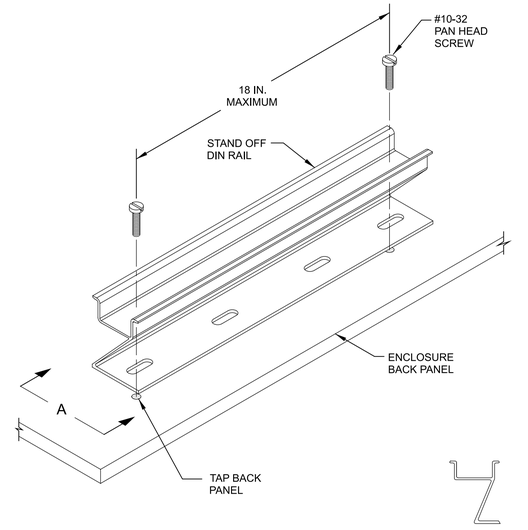
KEY NOTES:

1. SIMILAR FOR 2-CONDUCTOR SHIELDED CABLE.

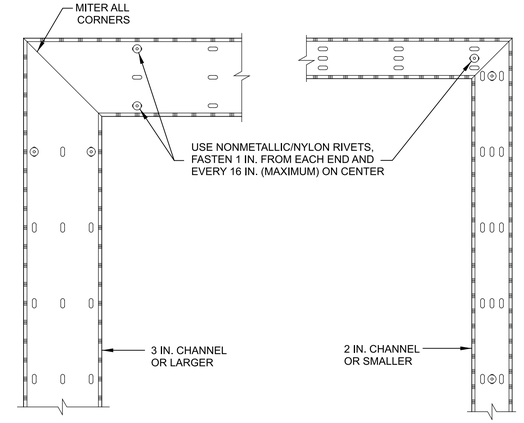
NE101 TYP S TERMINATION DETAILS INSTRUMENTATION SHIELDED CABLE



NE102 TYP S TERMINAL BLOCK CLEARANCE



NE104 TYP S RAISED DIN RAIL MOUNTING



NE105 TYP S PANEL WIRING DUCT MOUNTING

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED CS
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER DANIEL ROBINSON No. 20405 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Daniel S. Robinson
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:47:05-07'00'

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

TYPICAL DETAILS

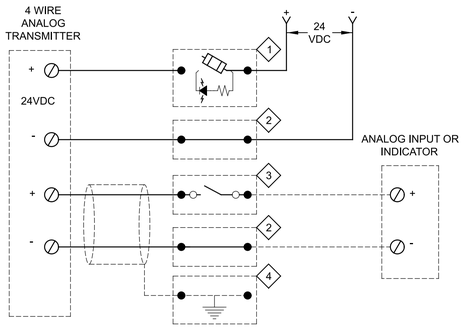
INSTRUMENTATION 1

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00TN01
SHEET NO. 60 OF 71

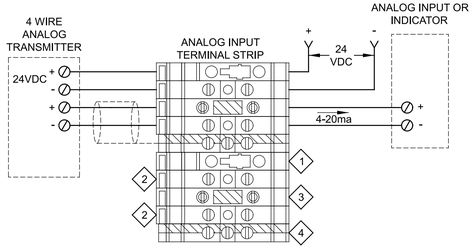
Plot Date: 10-SEP-2025 10:18:49 AM
User: svcPW
Model: Layout1 ColorTable: gshade.ctb DesignScript: Carollo_Std_Pen_v0905.pen PlotScale: 1:1
LAST SAVED BY: CRollins

PROJECT NO. 202431-100000 FILE NAME: 20243100TN01.dgn



KEY NOTES:

1. FUSED TERMINAL/DISCONNECT BLOCK.
2. FEED THROUGH TERMINAL BLOCK.
3. TEST BLOCK WITH KNIFE DISCONNECT SWITCH.
4. GROUNDING TERMINAL BLOCK.

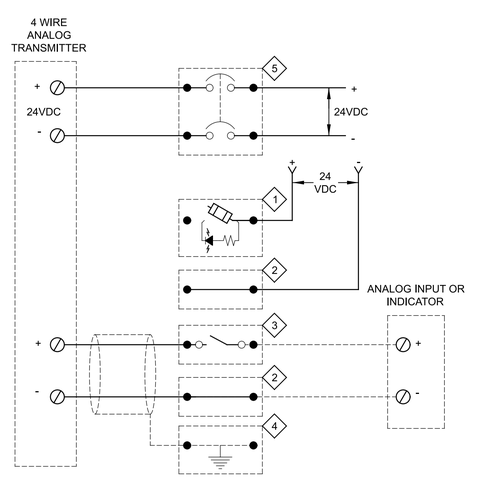


GENERAL NOTES:

1. GROUND SHIELD AT ANALOG TERMINAL STRIP INSIDE PCM PANEL.
2. (-)24VDC RETURNS OR COMMONS CAN'T BE PROTECTED OR HAVE A DISCONNECTING MEANS ON SYSTEMS WITH GROUNDED 24VDC POWER SUPPLIES.

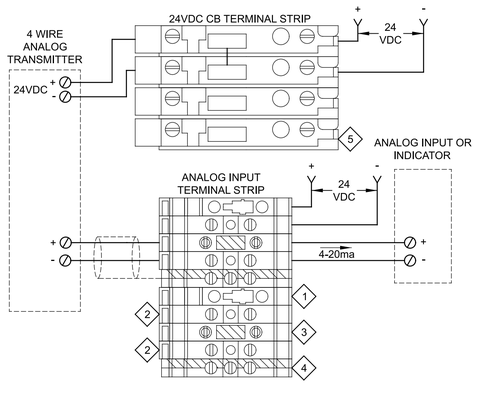
FOUR WIRE TRANSMITTER WITH (GROUNDED) 24VDC POWER SUPPLY SCHEMATIC

NE304 TYP S — ANALOG INPUT TERMINAL DETAILS



KEY NOTES:

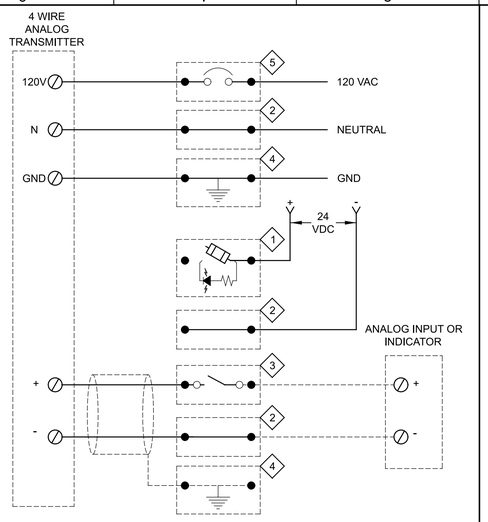
1. FUSED TERMINAL/DISCONNECT BLOCK.
2. FEED THROUGH TERMINAL BLOCK.
3. TEST BLOCK WITH KNIFE DISCONNECT SWITCH.
4. GROUNDING TERMINAL BLOCK.
5. 2-POLE 24VDC CIRCUIT BREAKER.



GENERAL NOTES:

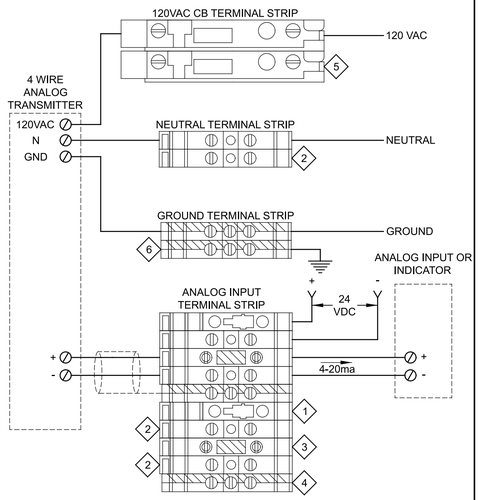
1. GROUND SHIELD AT ANALOG TERMINAL STRIP INSIDE PCM PANEL.
2. PROVIDE (-)24VDC RETURNS WITH PROTECTION ON ALL UN-GROUNDED 24VDC POWER SUPPLIES.

FOUR WIRE TRANSMITTER WITH (UN-GROUNDED) 24VDC POWER SUPPLY SCHEMATIC



KEY NOTES:

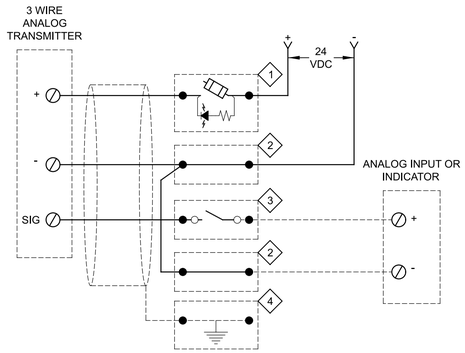
1. FUSED TERMINAL/DISCONNECT BLOCK.
2. FEED THROUGH TERMINAL BLOCK.
3. TEST BLOCK WITH KNIFE DISCONNECT SWITCH.
4. GROUNDING TERMINAL BLOCK.
5. 120VAC CIRCUIT BREAKER.



GENERAL NOTES:

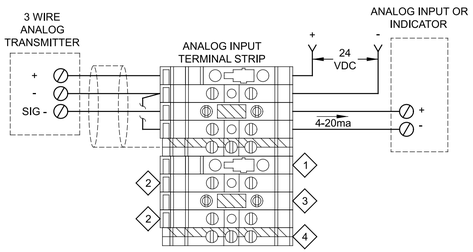
1. GROUND SHIELD AT ANALOG TERMINAL STRIP INSIDE PCM PANEL.
2. PROVIDE 120VAC CIRCUIT BREAKER FOR EACH INSTRUMENT.

FOUR WIRE (120VAC) TRANSMITTER SCHEMATIC



KEY NOTES:

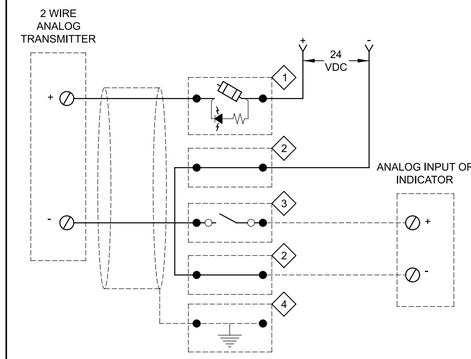
1. FUSED TERMINAL/DISCONNECT BLOCK.
2. FEED THROUGH TERMINAL BLOCK.
3. TEST BLOCK WITH KNIFE DISCONNECT SWITCH.
4. GROUNDING TERMINAL BLOCK.



GENERAL NOTES:

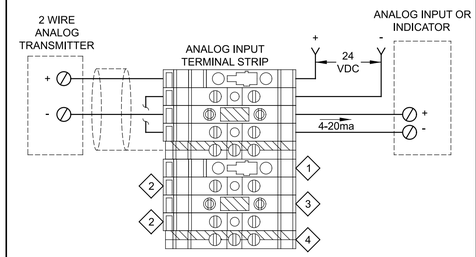
1. GROUND SHIELD AT ANALOG TERMINAL STRIP INSIDE PCM PANEL.

24VDC THREE WIRE ANALOG TRANSMITTER SCHEMATIC



KEY NOTES:

1. FUSED TERMINAL/DISCONNECT BLOCK.
2. FEED THROUGH TERMINAL BLOCK.
3. TEST BLOCK WITH KNIFE DISCONNECT SWITCH.
4. GROUNDING TERMINAL BLOCK.



GENERAL NOTES:

1. GROUND SHIELD AT ANALOG TERMINAL STRIP INSIDE PCM PANEL.

24VDC TWO WIRE TRANSMITTER SCHEMATIC

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED CS
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER — DANIEL ROBINSON — No. 20405 — ELECTRICAL — STATE OF CALIFORNIA

Digitally signed by Daniel S. Robinson
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:48:45-07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
TYPICAL DETAILS
INSTRUMENTATION 2

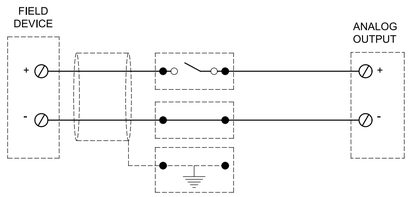
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

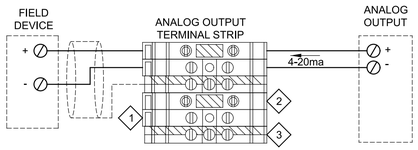
JOB NO. 202431
DRAWING NO. 00TN02
SHEET NO. 61 OF 71

PROJECT NO. 202431-100000 FILE NAME: 20243100TN02.dgn

Plot Date: 10-SEP-2025 10:20:04 AM
User: svcPW
PlotScale: 1:1
DesignScript: Carollo_Std_Pen_v0905.pen
ColorTable: gshade.ctb
Model: Layout1
LAST SAVED BY: CRollins

Plot Date: 10-SEP-2025 10:19:11 AM
User: svcPW
Model: Layout1 ColorTable: gshade.ctb DesignScript: Carollo_Std_Pen_v0905.pen PlotScale: 1:1
LAST SAVED BY: CRollins





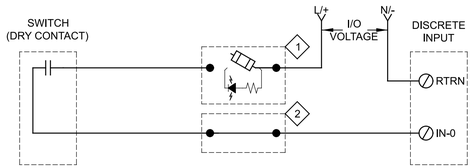
GENERAL NOTES:

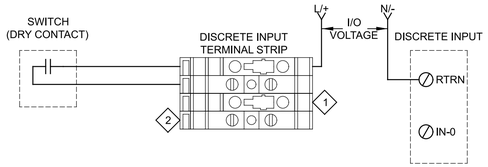
1. GROUND SHIELD AT ANALOG TERMINAL STRIP INSIDE PCM PANEL.

KEY NOTES:

1. FEED THROUGH TERMINAL BLOCK.
2. TEST BLOCK WITH KNIFE DISCONNECT SWITCH.
3. GROUNDING TERMINAL BLOCK.

NE305 TYP S — ANALOG OUTPUT TERMINAL DETAILS 24VDC ANALOG OUTPUT SCHEMATIC





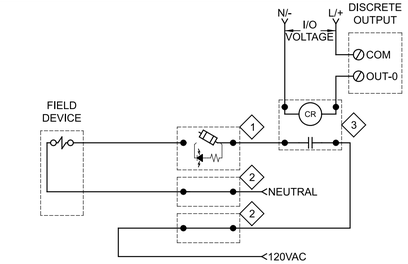
GENERAL NOTES:

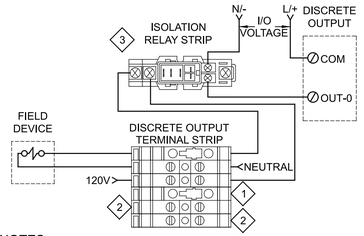
1. REFER TO SPECIFICATIONS FOR PLC DISCRETE I/O VOLTAGE.

KEY NOTES:

1. FUSED TERMINAL/DISCONNECT BLOCK.
2. FEED THROUGH TERMINAL BLOCK.

NE306 TYP S — DISCRETE INPUT TERMINAL DETAILS (DRY CONTACT) SCHEMATIC





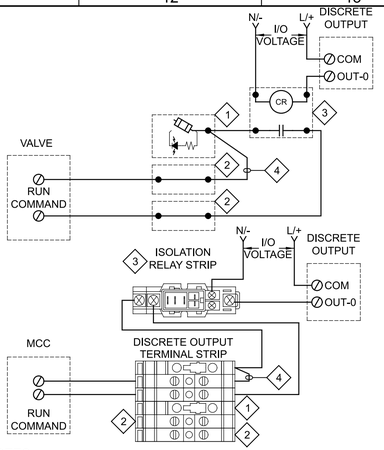
GENERAL NOTES:

1. REFER TO SPECIFICATIONS FOR PLC DISCRETE I/O VOLTAGE.

KEY NOTES:

1. FUSED TERMINAL/DISCONNECT BLOCK.
2. FEED THROUGH TERMINAL BLOCK.
3. ISOLATION RELAY.

NE307 TYP S — DISCRETE OUTPUT TERMINAL DETAILS (PANEL SOURCED) SCHEMATIC



GENERAL NOTES:

1. REFER TO SPECIFICATIONS FOR PLC DISCRETE I/O VOLTAGE.
2. USE MANUFACTURED SPADE OR PIN STYLE JUMPER. WIRE JUMPERS ARE NOT ACCEPTABLE.

KEY NOTES:

1. FUSED TERMINAL/DISCONNECT BLOCK.
2. FEED THROUGH TERMINAL BLOCK.
3. ISOLATION RELAY.
4. JUMPER.

NE308 TYP S — DISCRETE OUTPUT TERMINAL DETAILS (EXTERNALLY SOURCED) SCHEMATIC

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED CS
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER — DANIEL ROBINSON — No. 20405 — ELECTRICAL — STATE OF CALIFORNIA

Digitally signed by Daniel S. Robinson
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:47:41-07'00'

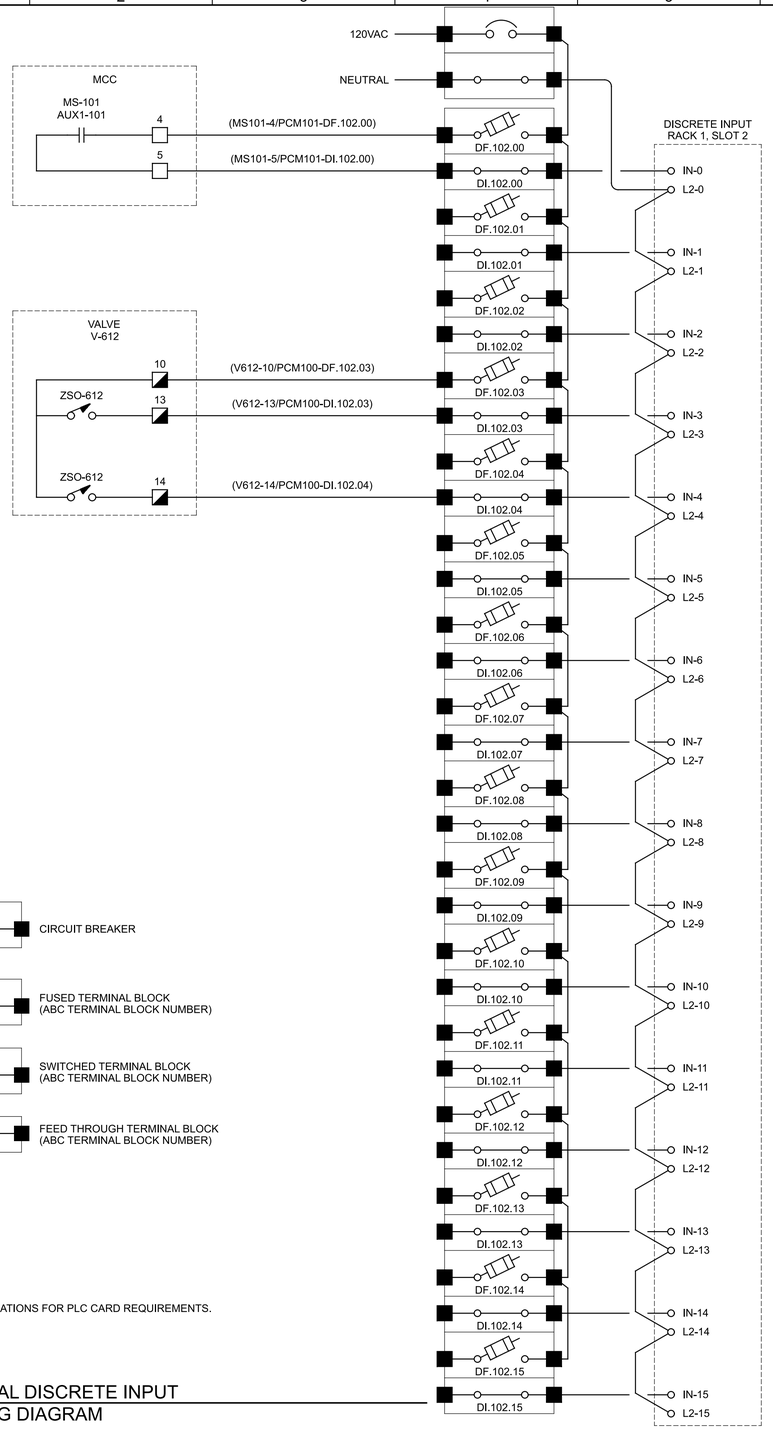
carollo®

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
TYPICAL DETAILS
INSTRUMENTATION 3

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

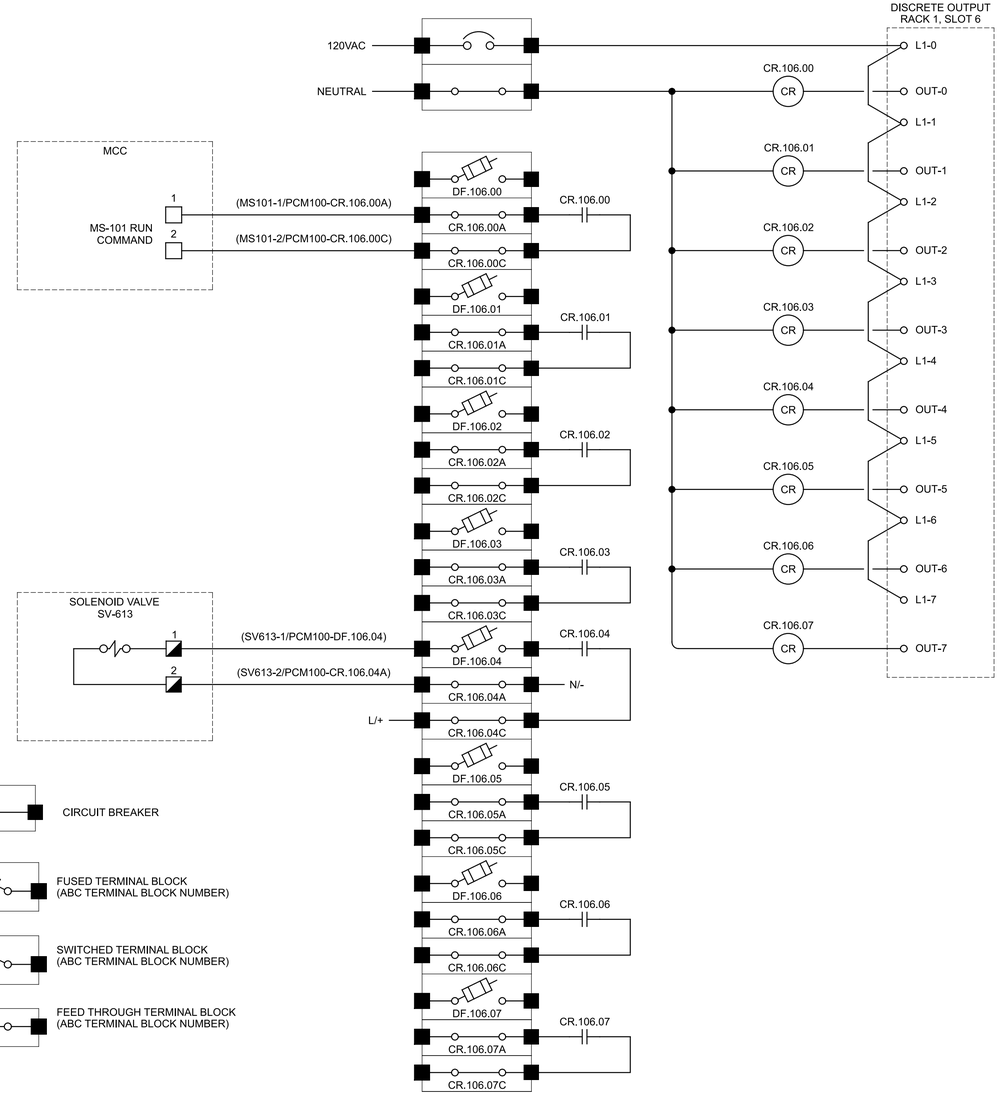
JOB NO. 202431
DRAWING NO. 00TN03
SHEET NO. 62 OF 71



GENERAL NOTES:

1. REFER TO SPECIFICATIONS FOR PLC CARD REQUIREMENTS.

NE310 TYP S TYPICAL DISCRETE INPUT WIRING DIAGRAM



GENERAL NOTES:

1. REFER TO SPECIFICATIONS FOR PLC CARD REQUIREMENTS.

NE311 TYP S TYPICAL DISCRETE OUTPUT WIRING DIAGRAM

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED CS
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER DANIEL ROBINSON No. 20405 ELECTRICAL STATE OF CALIFORNIA

Digitally signed by Daniel S. Robinson
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:46:49-07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

TYPICAL DETAILS

INSTRUMENTATION 4

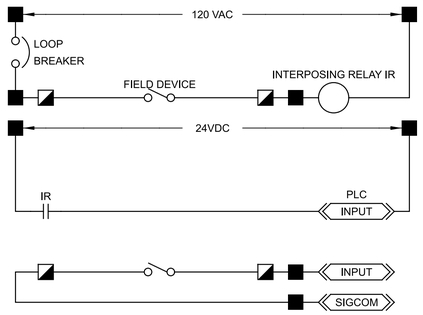
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00TN04
SHEET NO. 63 OF 71

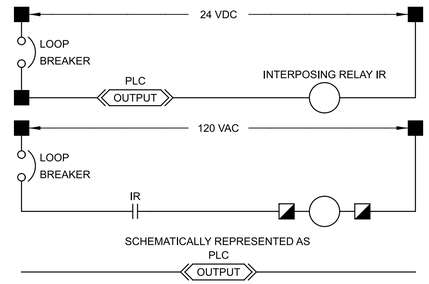
Plot Date: 10-SEP-2025 10:17:19 AM
User: svcPW
PlotScale: 1:1
DesignScript: Carollo_Std_Pen_v0905.pen
ColorTable: gshade.ctb
Model: Layout1
LAST SAVED BY: CRollins

PROJECT NO. 202431-100000 FILE NAME: 20243100TN04.dgn

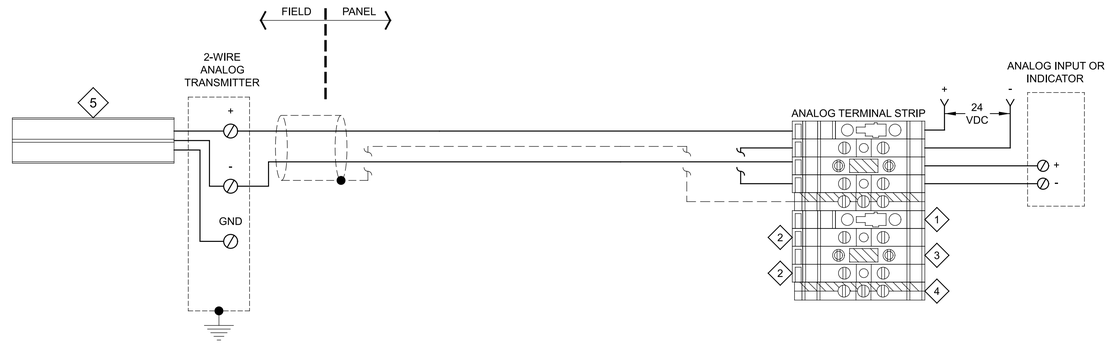
Plot Date: 10-SEP-2025 10:16:49 AM
User: svcPW
Model: Layout1 ColorTable: gshade.ctb DesignScript: Carollo_Std_Pen_v0905.pen PlotScale: 1:1
LAST SAVED BY: CYoung



NE314 TYP S — TYPICAL PLC 24VDC INPUT SCHEMATIC



NE315 TYP S — TYPICAL PLC 24VDC OUTPUT SCHEMATIC

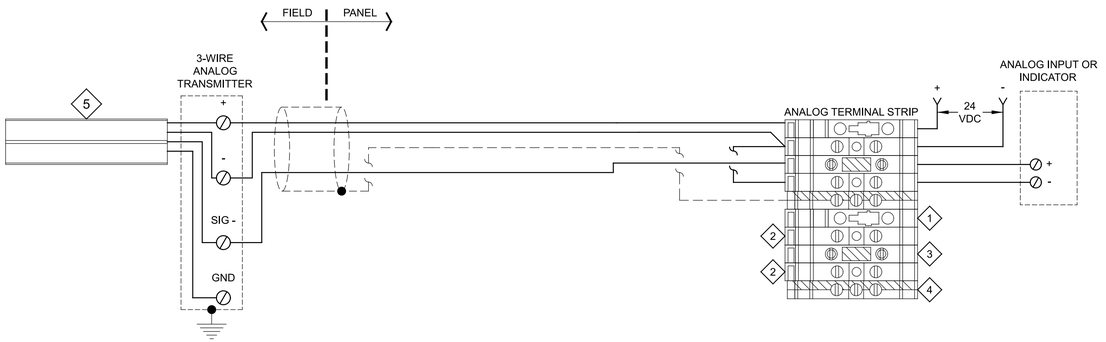


KEY NOTES:

1. FUSED TERMINAL/DISCONNECT BLOCK.
2. FEED THROUGH TERMINAL BLOCK.
3. TEST BLOCK WITH KNIFE DISCONNECT SWITCH.
4. GROUNDING TERMINAL BLOCK. BONDED TO EQUIPMENT GROUND VIA DIN RAIL MOUNTING FOOT.
5. FIELD DEVICE MOUNTED SURGE PROTECTIVE DEVICE. BONDED TO EQUIPMENT GROUND VIA FIELD DEVICE GROUND TERMINAL.

NE350 TYP R — TYPICAL SURGE PROTECTION WIRING 2-WIRE ANALOG TRANSMITTER

8/26/2025

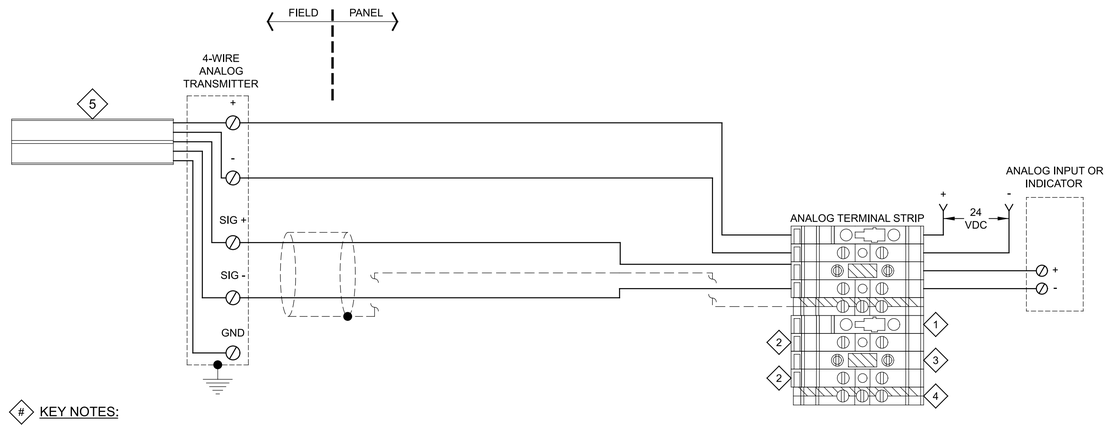


KEY NOTES:

1. FUSED TERMINAL/DISCONNECT BLOCK.
2. FEED THROUGH TERMINAL BLOCK.
3. TEST BLOCK WITH KNIFE DISCONNECT SWITCH.
4. GROUNDING TERMINAL BLOCK. BONDED TO EQUIPMENT GROUND VIA DIN RAIL MOUNTING FOOT.
5. FIELD DEVICE MOUNTED SURGE PROTECTIVE DEVICE. BONDED TO EQUIPMENT GROUND VIA FIELD DEVICE GROUND TERMINAL.

NE351 TYP R — TYPICAL SURGE PROTECTION WIRING 3-WIRE ANALOG TRANSMITTER

8/26/2025



KEY NOTES:

1. FUSED TERMINAL/DISCONNECT BLOCK.
2. FEED THROUGH TERMINAL BLOCK.
3. TEST BLOCK WITH KNIFE DISCONNECT SWITCH.
4. GROUNDING TERMINAL BLOCK. BONDED TO EQUIPMENT GROUND VIA DIN RAIL MOUNTING FOOT.
5. FIELD DEVICE MOUNTED SURGE PROTECTIVE DEVICE. BONDED TO EQUIPMENT GROUND VIA FIELD DEVICE GROUND TERMINAL.

NE352 TYP R — TYPICAL SURGE PROTECTION WIRING 4-WIRE ANALOG TRANSMITTER WITH GROUNDED 24VDC POWER SUPPLY

8/26/2025

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED CS
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER — DANIEL ROBINSON — No. 20405 — ELECTRICAL — STATE OF CALIFORNIA

Digitally signed by Daniel S. Robinson
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:46:32-07'00'

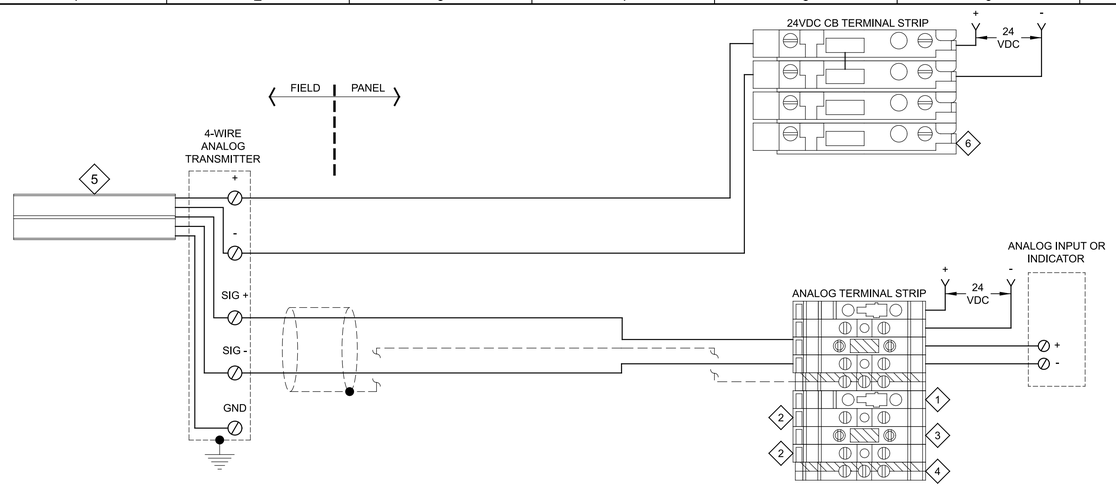
carollo®

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
TYPICAL DETAILS
INSTRUMENTATION 5

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00TN05
SHEET NO. 64 OF 71

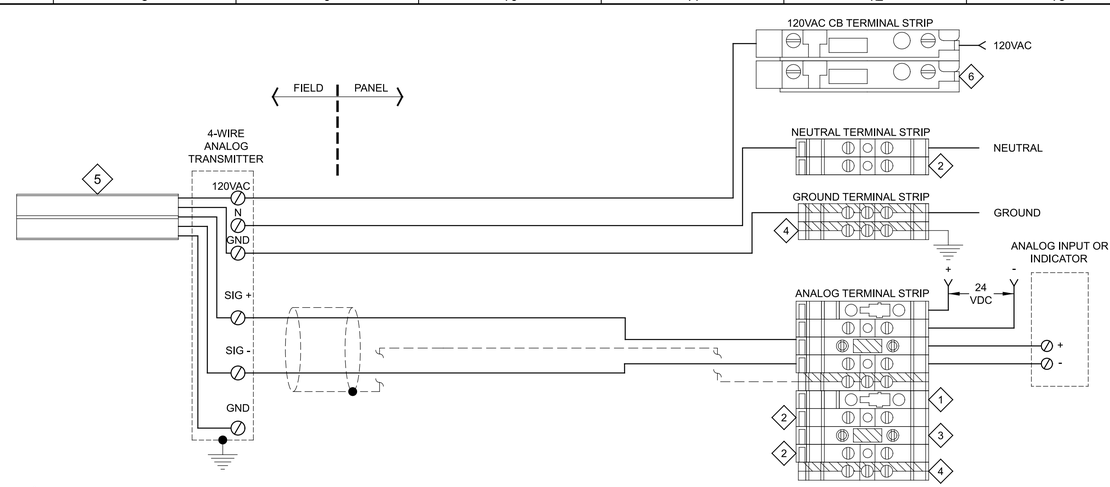


KEY NOTES:

1. FUSED TERMINAL/DISCONNECT BLOCK.
2. FEED THROUGH TERMINAL BLOCK.
3. TEST BLOCK WITH KNIFE DISCONNECT SWITCH.
4. GROUNDING TERMINAL BLOCK. BONDED TO EQUIPMENT GROUND VIA DIN RAIL MOUNTING FOOT.
5. FIELD DEVICE MOUNTED SURGE PROTECTIVE DEVICE. BONDED TO EQUIPMENT GROUND VIA FIELD DEVICE GROUND TERMINAL.
6. 2-POLE 24VDC CIRCUIT BREAKER.

NE353 TYP R — TYPICAL SURGE PROTECTION WIRING 4-WIRE ANALOG TRANSMITTER WITH UN-GROUNDED 24VDC POWER SUPPLY

8/26/2025

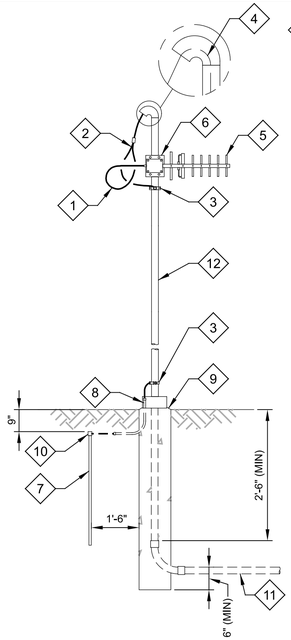


KEY NOTES:

1. FUSED TERMINAL/DISCONNECT BLOCK.
2. FEED THROUGH TERMINAL BLOCK.
3. TEST BLOCK WITH KNIFE DISCONNECT SWITCH.
4. GROUNDING TERMINAL BLOCK. BONDED TO EQUIPMENT GROUND VIA DIN RAIL MOUNTING FOOT.
6. FIELD DEVICE MOUNTED SURGE PROTECTIVE DEVICE. BONDED TO EQUIPMENT GROUND VIA FIELD DEVICE GROUND TERMINAL.
7. 120VAC CIRCUIT BREAKER.

NE354 TYP R — TYPICAL SURGE PROTECTION WIRING 4-WIRE ANALOG TRANSMITTER 120VAC POWER SUPPLY

8/26/2025



KEY NOTES:

1. COAXIAL CABLE GROUNDING KIT.
2. COAXIAL JUMPER CABLE WITH TYPE-N CONNECTORS. WEATHERPROOF CONNECTIONS USING WEATHERPROOF KIT.
3. MECHANICAL GROUNDING.
4. 2-1/2" WEATHERHEAD. CONNECT MAIN COAXIAL CABLE TO COAXIAL JUMPER CABLE INSIDE WEATHERHEAD WITH TYPE-N CONNECTORS. WEATHERPROOF CONNECTIONS USING CONNECTOR WEATHERPROOF KIT.
5. YAGI ANTENNA.
6. ADAPTER PLATE. SIZE AS REQUIRED. MOUNT TO MAST WITH U-BOLTS.
7. 5/8" X 8' SOLID COPPER GROUND ROD.
8. 3/4" PVC CONDUIT. 1#2G.
9. FOUNDATION PER DETAIL 5 ON DRAWING 08C03.
10. EXOTHERMIC GROUND CONNECTION.
11. TO CONTROL PANEL.
12. MONOPOLE MAST.

NM001 TYP J — YAGI ANTENNA

8/26/2025

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED CS
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER — DANIEL ROBINSON — No. 20405 — ELECTRICAL — STATE OF CALIFORNIA

Digitally signed by Daniel S. Robinson
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:52:49-07'00'

carollo®

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
TYPICAL DETAILS
INSTRUMENTATION 6

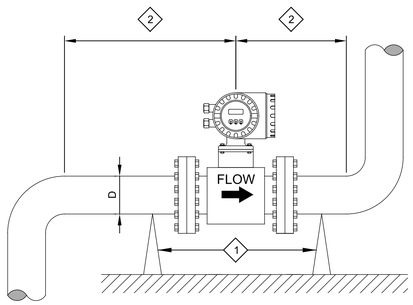
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00TN06
SHEET NO. 65 OF 71

Model: Layout1 ColorTable: gshade.ctb DesignScript: Carollo_Std_Pen_v0905.pen PlotScale: 1:1
Plot Date: 11-SEP-2025 10:10:40 AM User: svcPW
LAST SAVED BY: wchristgen

PROJECT NO. 202431-100000 FILE NAME: 20243100TN06.dgn

Plot Date: 11-SEP-2025 10:10:38 AM
User: svcPW
Model: Layout1 ColorTable: gshade.ctb DesignScript: Carollo_Std_Pen_v0905.pen PlotScale: 1:1
LAST SAVED BY: wchristgen



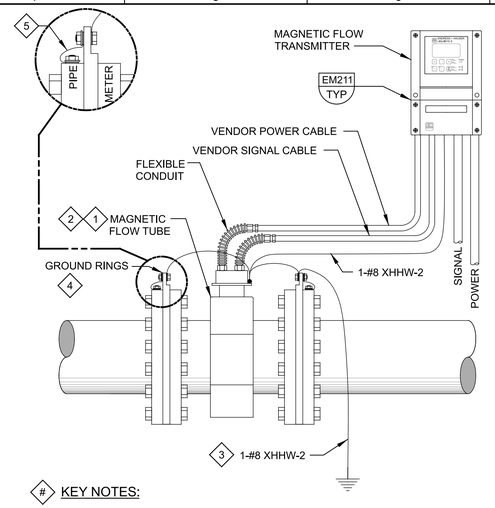
GENERAL NOTES:

1. FOLLOW MANUFACTURER'S RECOMMENDED MAXIMUM TORQUE SETTINGS. DO NOT OVER-TORQUE FLANGE BOLTS. OVERTIGHTENING THE FASTENERS WILL DEFORM SEALING FACES OR DAMAGE THE LINE.
2. ALWAYS TIGHTEN FLANGE BOLTS UNIFORMLY AND IN DIAGONALLY OPPOSITE SEQUENCE.
3. MOUNT METER SO THAT IT REMAINS FULLY FLOODED.
4. FOR METERS SPECIFIED WITH ZERO DIAMETER FEATURE, REFER TO THE MECHANICAL DRAWINGS FOR INSTALLATION.

KEY NOTES:

1. PIPE SUPPORTS BY MECHANICAL CONTRACTOR. NO SUPPORTS SHALL BE INSTALLED AT THE METER HOUSING.
2. INSTALL METER SUCH THAT THERE ARE NO PIPE BENDS FOR 5 PIPE DIAMETERS UPSTREAM AND 3 PIPE DIAMETERS DOWNSTREAM OF THE METER.

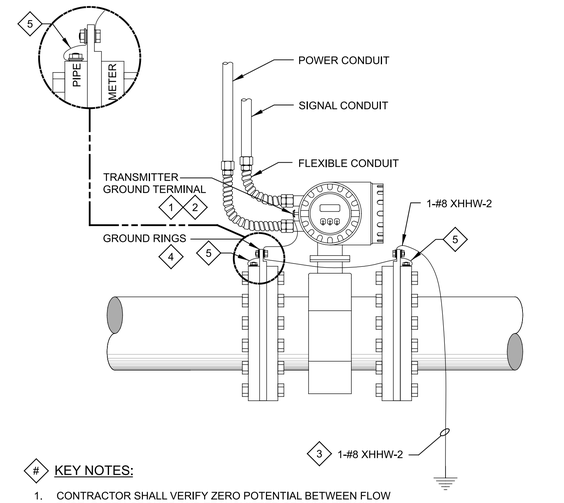
NF130 TYP S — MAGNETIC FLOWMETER MOUNTING DETAIL



KEY NOTES:

1. CONTRACTOR SHALL VERIFY ZERO POTENTIAL BETWEEN FLOW TUBE, EARTH GROUND AND TRANSMITTER GROUND TERMINAL.
2. CONNECT TRANSMITTER GROUND TERMINAL TO GROUND RINGS.
3. CONNECT METER BODY TO EARTH GROUND POTENTIAL.
4. EQUALIZE POTENTIAL VIA GROUND RINGS BETWEEN FLUID AND MAGMETER.
5. PROVIDE BONDING JUMPER ON CONDUCTIVE PIPES.

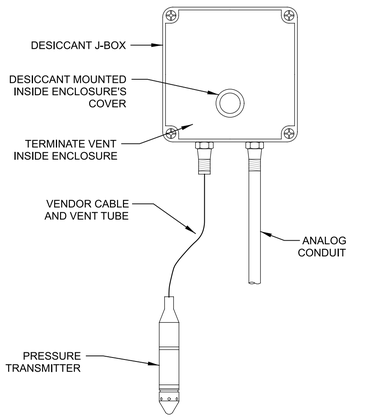
NF135 TYP S — REMOTE TRANSMITTER MAGNETIC FLOWMETER GROUNDING DETAIL



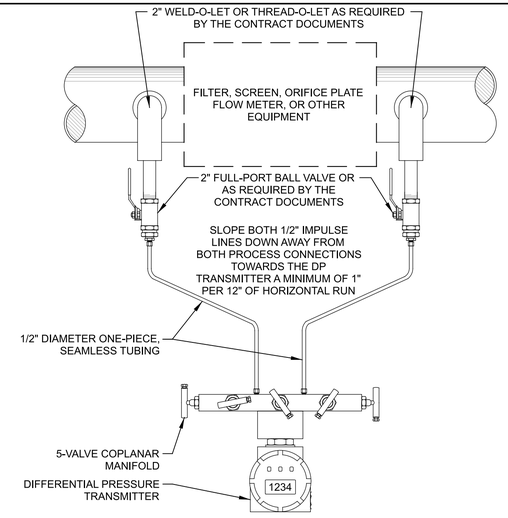
KEY NOTES:

1. CONTRACTOR SHALL VERIFY ZERO POTENTIAL BETWEEN FLOW TUBE, EARTH GROUND AND TRANSMITTER GROUND TERMINAL.
2. CONNECT TRANSMITTER GROUND TERMINAL TO GROUND RINGS.
3. CONNECT METER BODY TO EARTH GROUND POTENTIAL.
4. EQUALIZE POTENTIAL VIA GROUND RINGS BETWEEN FLUID AND MAGMETER.
5. PROVIDE BONDING JUMPER ON CONDUCTIVE PIPES.

NF136 TYP S — INTEGRAL MAGNETIC FLOWMETER GROUNDING DETAIL



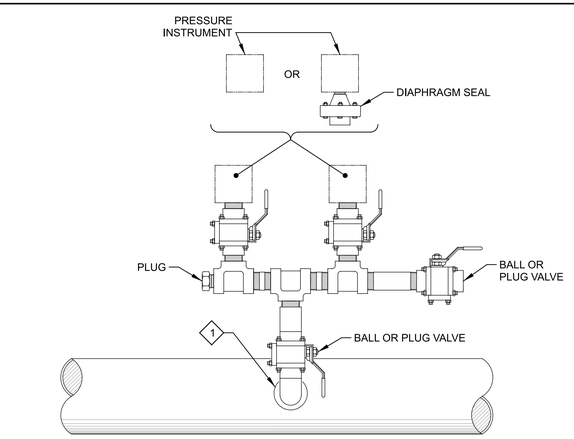
NL132 TYP S — DROP-IN PRESSURE TRANSMITTER DESICCANT J-BOX DETAIL



GENERAL NOTES:

1. INSTALL TRANSMITTER USING MANUFACTURER PROVIDED PIPE MOUNTING BRACKET ATTACHED TO AN APPROVED STRUCTURE.
2. SUPPORT 1/2" TUBING EVERY 48" MAXIMUM OR AS NEEDED.

NP189 TYP S — DIFFERENTIAL PRESSURE TRANSMITTER LIQUID OR STEAM APPLICATION



GENERAL NOTES:

1. USE THE INSTRUMENT DATA SHEETS AND INSTRUMENTATION SPECIFICATIONS TO IDENTIFY REQUIREMENTS FOR DIAPHRAGM SEALS.
2. PROVIDE INSTRUMENT ASSEMBLY WITH 1" VALVES AND PIPING, OR AS APPROVED BY ENGINEER. USE STAINLESS STEEL OR AS REQUIRED FOR COMPATIBILITY WITH WITH PROCESS FLUID. PROVIDE FITTINGS FOR INSTRUMENT CONNECTIONS AS REQUIRED.
3. REFER TO MECHANICAL DRAWINGS FOR INSTRUMENT LOCATION AND PROCESS PIPE ORIENTATION.

KEY NOTES:

1. PROVIDE SIDE-TAP PROCESS CONNECTION. THREADED TAP OR SADDLE CONNECTION FOR DUCTILE IRON PIPE. WELD-O-LET OR THREAD-O-LET FOR WELDED PIPE. TEE OR REDUCING TEE FOR NON-METALLIC PIPE AND PIPES 1" OR SMALLER.

NP501 TYP S — MULTIPLE PRESSURE INSTRUMENTS MOUNTING DETAIL

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED CS
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER — DANIEL ROBINSON — No. 20405 — ELECTRICAL — STATE OF CALIFORNIA

Digitally signed by Daniel S. Robinson
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:45:37-07'00'

carollo®

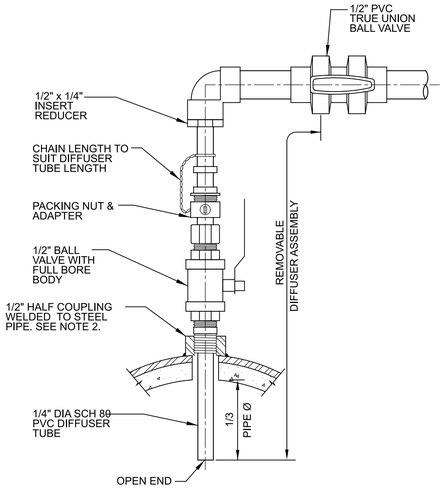
CITY OF SANTA CRUZ

CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
TYPICAL DETAILS
INSTRUMENTATION 7

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00TN07
SHEET NO. 66 OF 71

Plot Date: 10-SEP-2025 11:21:23 AM
User: svcPW
PlotScale: 1:1
DesignScript: Carollo_Std_Pen_v0905.pen
ColorTable: gshade.ctb
Model: Layout1
LAST SAVED BY: hvo

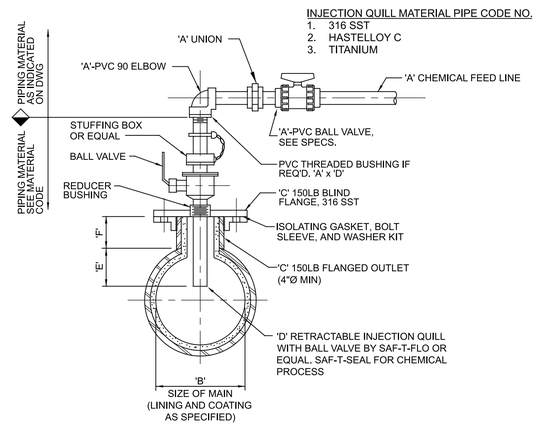


NOTES:

1. DIFFUSER AND DIFFUSER MATERIALS AS SPECIFIED IN SECTION 40_05_06.01.
2. USE SERVICE SADDLE FOR PIPE CONNECTION FOR DUCTILE IRON PIPE.

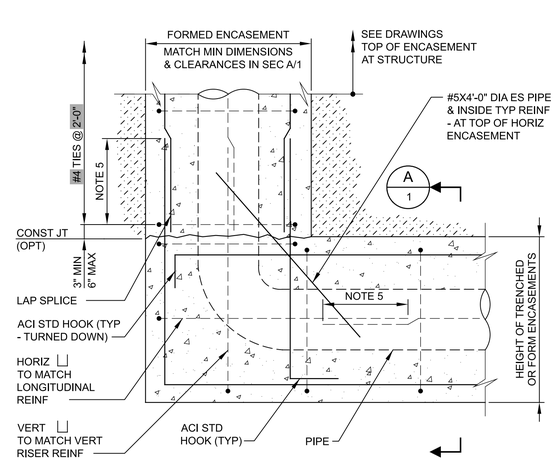
MC777 TYP — DIFFUSER - "STAB TUBE" AT WELDOLET

12/01/22



MC781 TYP — CHEMICAL DIFFUSER - STAB TUBE AT TEE WITH BALL VALVE

8/7/23

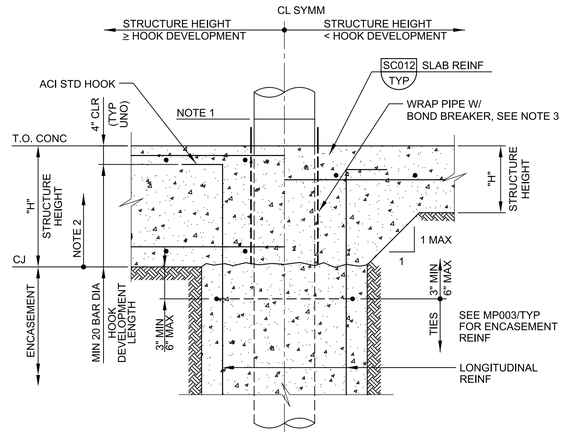


B — VERTICAL RISER BELOW STRUCTURE

MP003 TYP S — CONCRETE ENCASEMENT - BELOW STRUCTURE

SHEET 2 OF 2

08/03/2023

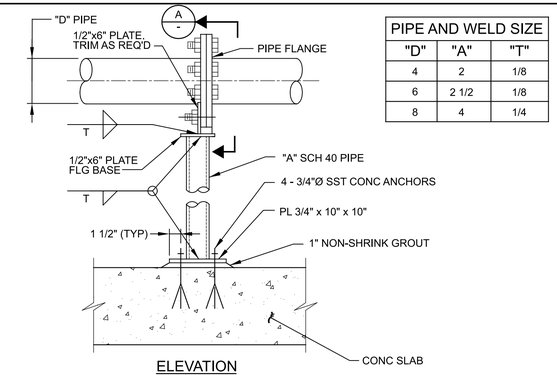


NOTES:

1. SEE MECHANICAL DRAWINGS FOR PIPE JOINT AND COUPLER.
2. COAT PIPE ABOVE VERTICAL ENCASEMENT BEFORE PLACING CONCRETE.
3. WRAP PIPE TO 2" ABOVE FINAL TOP OF CONCRETE WITH 2 LAYERS 6 MIL POLYETHYLENE SHEETING. CUT SHEETING TO TOP OF CONCRETE AFTER PLACEMENT AND CURING.

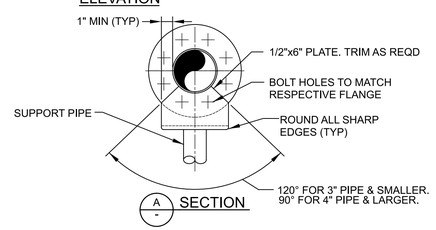
MP005 TYP S — PIPE ENCASEMENT - CONNECTION AT SLAB CONSTRUCTION JOINT, TIED

09/01/23



PIPE AND WELD SIZE		
"D"	"A"	"T"
4	2	1/8
6	2 1/2	1/8
8	4	1/4

ELEVATION



A - SECTION

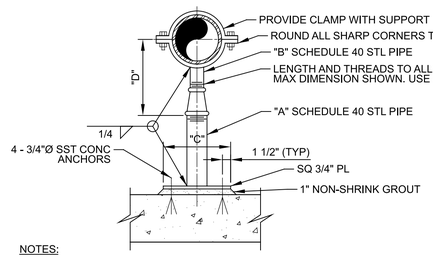
NOTE:

1. IF SUPPORT IS SUBMERGED OR LOCATED BELOW THE TOP OF WALL IN WATER BEARING STRUCTURE, ALL MATERIAL FOR SUPPORT SHALL BE STAINLESS STEEL. IN ALL OTHER AREAS, ALL MATERIAL FOR SUPPORT SHALL BE HOT-DIP GALVANIZED STEEL UNLESS OTHERWISE INDICATED ON DRAWINGS. HOT-DIP GALVANIZE AFTER FABRICATION.

MP032 TYP NS — PIPE SUPPORT - POST ON CONCRETE: FIXED HEIGHT STEEL W/ TOP CONNECTION TO PIPE FLANGE

05/31/23

ADJUSTABLE PIPE SADDLE SUPPORT SCHEDULE (INCHES)					
SIZE OF SUPPORTED PIPE **	PIPE SIZE "A"	PIPE SIZE "B"	"C"	"D"	
				MINIMUM	MAXIMUM
2 1/2 *	2 1/2	1 1/2	12	8	13
3	2 1/2	1 1/2	12	8 1/2	13 1/2
3 1/2	2 1/2	1 1/2	12	8 1/2	13 1/2
4	3	2 1/2	12	9 1/2	14
6	3	2 1/2	12	10 1/2	15 1/2
8	3	2 1/2	12	11 1/2	16 1/2
10	3	2 1/2	12	13 1/2	18 1/2
12	3	2 1/2	12	15	19 1/2
14	4	3	12	16 1/2	20 1/2
16	4	3	12	17 1/2	22 1/2
18	6	3 1/2	14	19 1/2	24
20	6	3 1/2	14	21	25 1/2
24	6	4	14	23 1/2	28 1/2
30	6	4	14	27	31 1/2
32	6	4	14	28 1/2	32 1/2
36	6	4	14	30 1/2	34 1/2

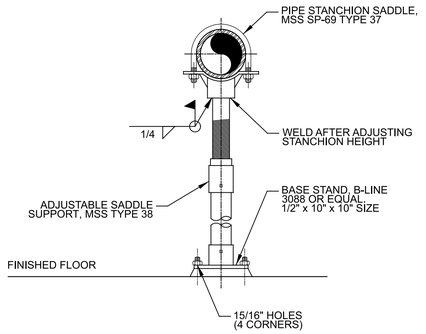


NOTES:

1. REFER TO THE SPECIFICATIONS FOR MATERIAL REQUIREMENTS.
2. * = USE 2 1/2" SUPPORTS FOR PIPES LESS THEN 2 1/2"Ø.
3. ** = NOMINAL PIPE SIZE.

MP034 TYP NS — PIPE SUPPORT - POST ON CONCRETE: ADJUSTABLE HEIGHT STEEL W/ TOP SADDLE

10/12/23



MP035 TYP S — PIPE SUPPORT - POST ON CONCRETE: ADJUSTABLE HEIGHT STEEL W/ U-BOLT

01/25/24

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED LL
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER MICHAEL E. DUCKER No. 63626 CIVIL STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:36:54-07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

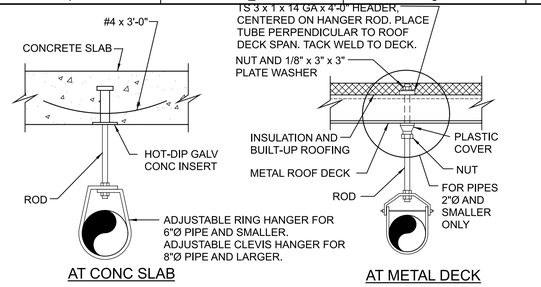
TYPICAL DETAILS

MECHANICAL 1

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00TM01
SHEET NO. 67 OF 71

Plot Date: 10-SEP-2025 10:16:49 AM
User: svcPW
Model: Layout1 ColorTable: gshade.ctb DesignScript: Carollo_Std_Pen_v0905.pen PlotScale: 1:1
LAST SAVED BY: OBarranco

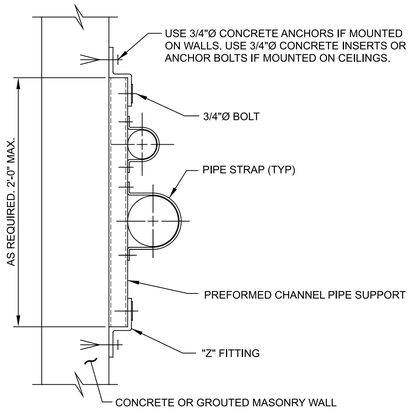


PIPE HANGER RODS AND SUPPORT SPACING		
PIPE DIA (INCHES)	ROD DIA (INCHES)	MAX SUPPORT SPACING
2 AND LESS	3/8	5 FEET
2 1/2 TO 3 1/2	1/2	10 FEET
4 TO 5	5/8	10 FEET
6	3/4	10 FEET
8	7/8	10 FEET
10	7/8	10 FEET
12	7/8	10 FEET

NOTES:

1. ISOLATE ALL COPPER PIPE FROM SUPPORT WITH PVC TAPE.
2. REFER TO THE SPECIFICATIONS FOR MATERIAL REQUIREMENTS.
3. PROVIDE ADDITIONAL HANGER AT EACH SIDE OF ALL VALVES 4 INCHES AND LARGER.

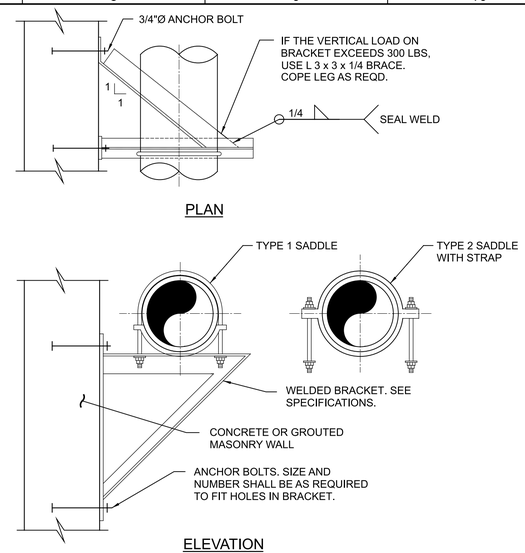
MP132 TYP N — PIPE SUPPORT - OVERHEAD ROD W/ ADJUSTABLE RING OR CLEVIS — 09/18/23



NOTES:

1. REFER TO THE SPECIFICATIONS FOR MATERIAL REQUIREMENTS.
2. SPACE PREFORMED CHANNEL PIPE SUPPORTS AT MAXIMUM 5'-0" O.C.

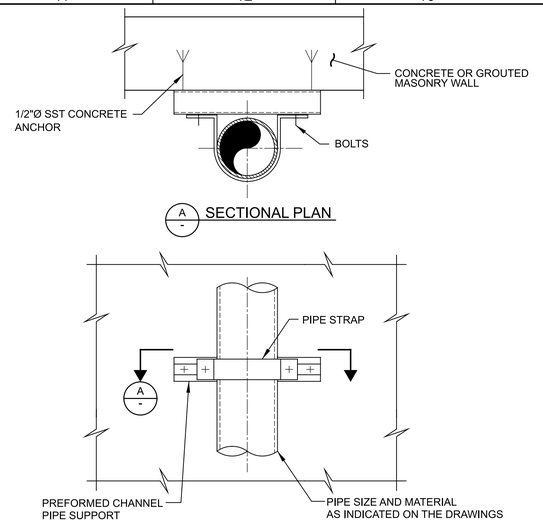
MP218 TYP N — PIPE SUPPORT - WALL - PREFORMED CHANNEL W/ PIPE CLIPS — 10/05/23



NOTES:

1. MAXIMUM ALLOWABLE VERTICAL LOAD IS THE SMALLER OF 1500 POUNDS AND THE MANUFACTURERS MAXIMUM ALLOWABLE BRACKET LOAD.
2. REFER TO THE SPECIFICATIONS FOR MATERIAL REQUIREMENTS.
3. ISOLATE ALL COPPER PIPE WITH PVC TAPE.

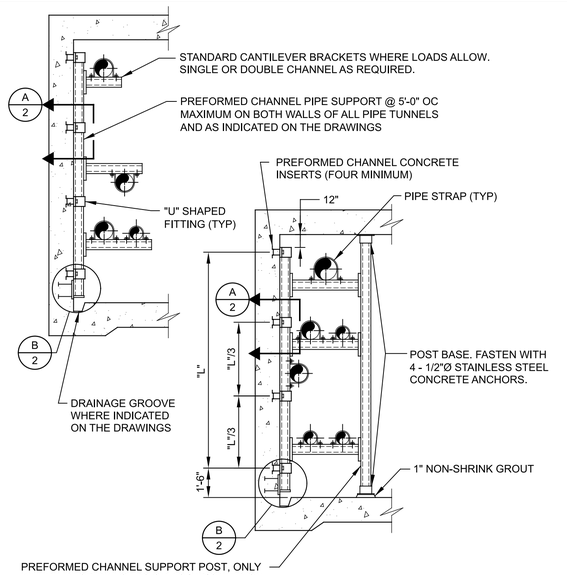
MP222 TYP N — PIPE SUPPORT - WALL - PREFORMED BRACKET W/ SADDLE ABOVE — 10/12/23



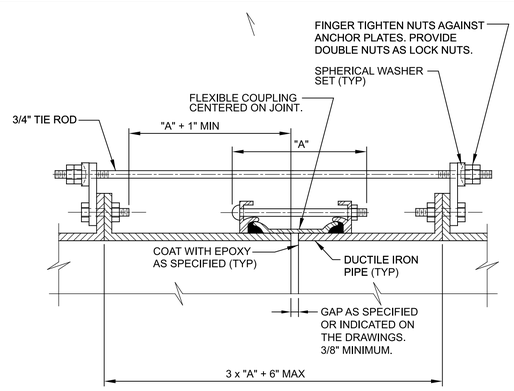
NOTE:

1. IF SUPPORT IS SUBMERGED OR LOCATED BELOW THE TOP OF WALL IN WATER BEARING STRUCTURE, ALL MATERIAL SHALL BE STAINLESS STEEL. IN ALL OTHER AREAS, THE MATERIALS SHALL BE HOT-DIP GALVANIZED STEEL UNLESS OTHERWISE INDICATED ON THE DRAWINGS. HOT-DIP GALVANIZE AFTER FABRICATION.

MP253 TYP — PIPE SUPPORT - PREFORMED CHANNEL: SURFACE MOUNTED — 08/08/23

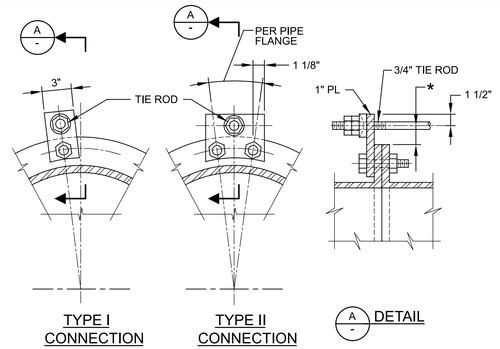


MP272 TYP N — PIPE RACK -"F" TYPE - PREFORMED CHANNELS — SHEET 1 OF 2 — 12/01/22



ROD SCHEDULE		
PIPE THRUST. SEE NOTE 2.	TYPE OF CONNECTION	NO. OF RODS
0-6,000#	I	2
6,001 - 12,000#	II	2
12,001 - 18,000#	II	3
18,001 - 24,000#	II	4
24,001 - 30,000#	II	5

MP310 TYP N — PIPE JOINT - DIP - FLEXIBLE COUPLING - RESTRAINED — SHEET 1 OF 2 — 9/05/23



NOTES:

1. ALL EXPOSED FLEXIBLE COUPLINGS SHALL HAVE TIE RODS UNLESS SPECIFICALLY INDICATED OTHERWISE ON THE DRAWINGS.
2. PIPE THRUST SHALL BE BASED ON TEST PRESSURE.
3. PIPE THRUST = 0.7854 x D^2 x TEST PRESSURE, WHERE "D" IS PIPE OD.
4. MINIMUM TIE ROD YIELD = 48,000 PSI.
5. FOR THRUSTS GREATER THAN 30,000 POUNDS, ADD ONE 3/4 INCH DIAMETER TIE ROD FOR EVERY 6,000 POUNDS INCREASE IN THRUST.
6. ALL ROD CONNECTIONS SHALL BE TYPE II FOR THRUSTS GREATER THAN 30,000 POUNDS.
7. GRIND ALL CORNERS SMOOTH.
8. * = AS REQUIRED TO CLEAR FLEXIBLE COUPLING. 3/4" MINIMUM AND 1 1/2" MAXIMUM.

MP310 TYP N — PIPE JOINT - DIP - FLEXIBLE COUPLING - RESTRAINED — SHEET 2 OF 2 — 09/05/23

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED LL
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER MICHAEL E. DUCKER No. 63626 CIVIL STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:39:37 -07'00'

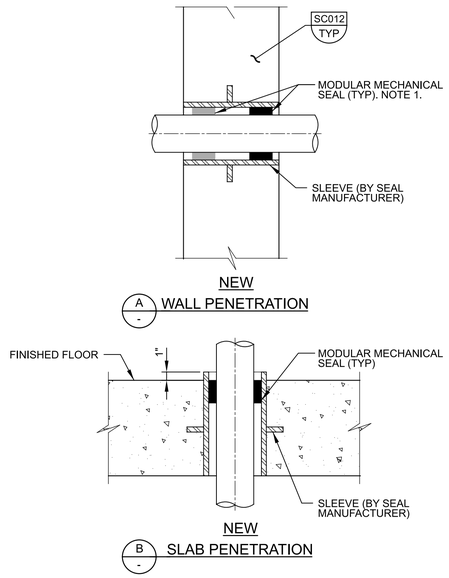
carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY
TYPICAL DETAILS
MECHANICAL 2

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00TM02
SHEET NO. 68 OF 71

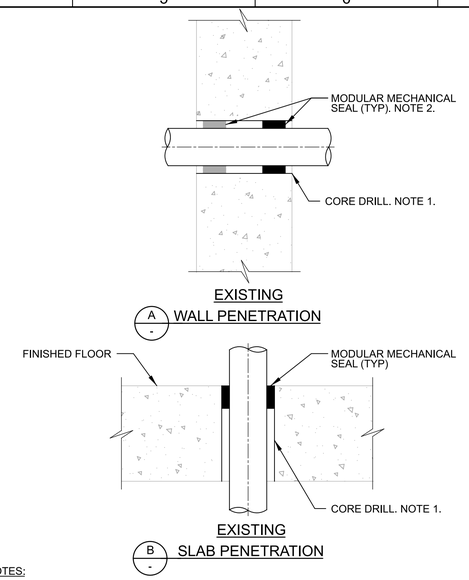


NOTES:

1. WALLS THICKER THAN 12" INSTALL MODULAR MECHANICAL SEAL AT BOTH ENDS OF WALL SLEEVE.

MP544 TYP — WALL PENETRATION - CAST-IN SLEEVE W/ BARRIER SEALS

NS — SHEET 1 OF 2 — 09/06/23

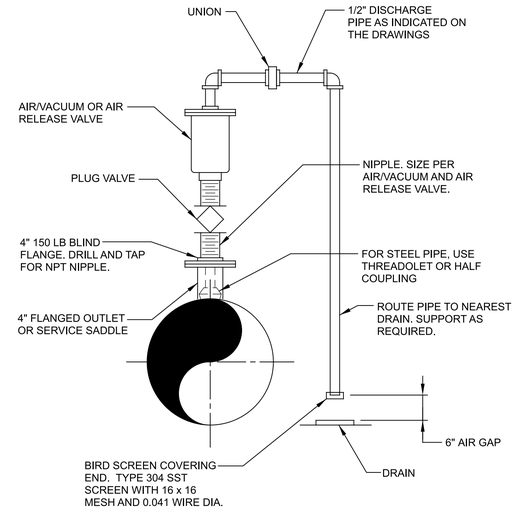


NOTES:

1. CORE DRILL DIAMETER, PROCEDURES, AND POST -DRILLING SURFACE PREPARATION PER MODULAR MECHANICAL SEAL MANUFACTURER'S RECOMMENDATIONS FOR SPECIFIC PIPE OD.
2. WALLS 12" OR THICKER INSTALL MODULAR MECHANICAL SEAL AT BOTH ENDS OF PENETRATION.

MP544 TYP — WALL PENETRATION - CAST-IN SLEEVE W/ BARRIER SEALS

NS — SHEET 2 OF 2 — 09/06/23

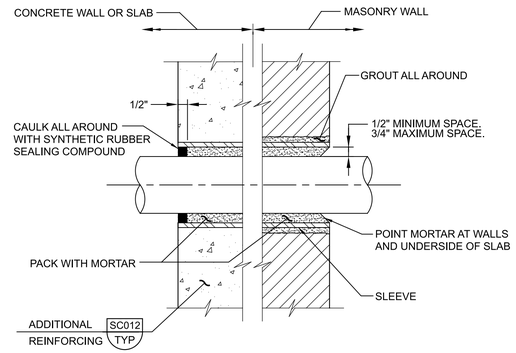


NOTES:

1. VALVE SIZE SHALL BE AS INDICATED ON THE DRAWINGS.
2. SERVICE TAP AND PLUG VALVE SHALL MATCH VALVE INLET SIZE.

MP898 TYP — PIPING - VALVE - VACUUM AND AIR RELEASE: 3" AND SMALLER VALVE

12/01/22



NOTES:

1. 6"Ø DIAMETER SLEEVES AND SMALLER SHALL BE SCHEDULE 40 STEEL PIPE OR SCHEDULE 80 PVC PIPE.
2. SLEEVES LARGER THAN 6"Ø SHALL BE 1/4" THICK STEEL PIPE.
3. STEEL SLEEVE SHALL BE HOT-DIP GALVANIZED AFTER FABRICATION.
4. SLEEVES FOR ELECTRICAL CONDUIT SHALL BE SCHEDULE 80 PVC.

P302 TYP — SLEEVE INSTALLATION THROUGH DRY WALLS AND FLOOR SLABS

NS — 08/01/05

VALVE SCHEDULE AND MODES OF OPERATION

VALVE DESCRIPTION	EQUIPMENT TAG	ACTUATOR	VALVE TYPE	MAINTENANCE (OFF)	EXTRACTION (RECOVERY)	INJECTION (RECHARGE)	TRICKLE FLOW (STORAGE)	BACKFLUSH TO RECLAIM TANK	BACKFLUSH TO STORM DRAIN	LINE FLUSH TO STORM DRAIN
WELLHEAD FLOW CONTROL VALVES										
EXTRACTION TO WTP	BFV-9905020	MOV	OPEN/CLOSE	CLOSED	OPEN	CLOSED	CLOSED	OPEN	CLOSED	CLOSED
INJECTION	BFV-9905110	MOV	OPEN/CLOSE	CLOSED	CLOSED	OPEN	CLOSED	CLOSED	CLOSED	OPEN
DOWNHOLE CONTROL VALVE	DHCV-9905130	PNEUMATIC	MODULATING	CLOSED	CLOSED	OPEN (MOD)	CLOSED	CLOSED	CLOSED	CLOSED
FLUSH TO STORM DRAIN	BFV-9905030	MOV	OPEN/CLOSE	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	OPEN	OPEN
DISTRIBUTION ISOLATION	GV-9905110	MANUAL	MANUAL	-	-	-	-	-	-	-
WELL ISOLATION	GV-9905010	MANUAL	MANUAL	CLOSED	OPEN	OPEN	OPEN	OPEN	OPEN	CLOSED
TRICKLE FLOW	-	MANUAL	MANUAL	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED

NOTES:

(1) NOT ALL ALL EXISTING VALVES ARE SHOWING IN THIS TABLE. VALVES SHOWN IN THIS TABLE ARE SHOWN FOR USE IN PRIMARY OPERATIONAL MODES.

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED LL
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER — MICHAEL E. DUCKER — No. 63626 — CIVIL — STATE OF CALIFORNIA

Digitally signed by Michael E. Ducker
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.12 09:38:23-07'00'

carollo

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

TYPICAL DETAILS

MECHANICAL 3

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00TM03
SHEET NO. 69 OF 71

PROJECT NO. 202431-100000 FILE NAME: 20243100TM03.dgn

Plot Date: 10-SEP-2025 10:19:43 AM
User: svcPW
Model: Layout1 ColorTable: gshade.ctb DesignScript: Carollo_Std_Pen_v0905.pen PlotScale: 1:1
LAST SAVED BY: hvo

1. SEE DIVISION 03 SPECIFICATION FOR REQUIREMENTS FOR CONCRETE CONSTRUCTION.
2. UNLESS OTHERWISE INDICATED ON THE DRAWINGS, MINIMUM REINFORCEMENT OF CONCRETE WALLS OR SLABS SHALL BE AS FOLLOWS. CONTACT ENGINEER FOR LOCATIONS INSIDE CONCRETE.
   10" THICK OR LESS: .....#5 @ 12" EACH WAY.
   MORE THAN 10" THICK: .....#5 @ 12" EACH WAY, EACH FACE.
3. WALL REINFORCEMENT AT CORNERS OR JUNCTIONS OF WALLS SHALL BE CONTINUOUS, LAP SPLICED, OR TERMINATED IN AN ACI STANDARD 90 DEGREE HOOK. SEE DETAIL SC310/TYP.
4. UNLESS OTHERWISE INDICATED ON THE DRAWINGS, DOWELS BETWEEN ADJACENT CONCRETE PLACEMENTS SHALL BE THE SAME SIZE AND SPACING AS THE REINFORCEMENT WHICH IS SPLICED TO THE DOWELS.
5. SLAB, BEAM AND COLUMN REINFORCING BARS SHALL HAVE A MINIMUM EXTENSION OR ANCHORAGE INTO SUPPORTS IN ACCORDANCE WITH ACI 318 AND ACI 350.
6. PROVIDE STIRRUP SUPPORT BARS SHALL BE TO SECURE TOP BARS AGAINST DISPLACEMENT AS REQUIRED.
7. UNLESS OTHERWISE INDICATED ON THE DRAWINGS, CONCRETE COVER OVER #11 AND SMALLER REINFORCING BARS SHALL BE AS FOLLOWS:
   A. SLABS AND JOISTS:
      FORMED CONCRETE SURFACES AND UNFORMED TOP SURFACES FOR DRY CONDITIONS
      #7 BARS AND SMALLER.....1"
      #8 BARS AND LARGER.....1 1/2"
      FORMED CONCRETE SURFACES AND UNFORMED TOP SURFACES EXPOSED TO WEATHER, IN CONTACT WITH SOIL OR FLUIDS, OR LOCATED OVER FLUIDS.....2"
   B. BEAMS AND COLUMNS:
      FORMED CONCRETE SURFACES FOR DRY CONDITIONS:
      STIRRUPS, SPIRALS, AND TIES.....1 1/2"
      PRINCIPAL REINFORCEMENT.....2"
      FORMED CONCRETE SURFACES EXPOSED TO WEATHER, IN CONTACT WITH SOIL OR FLUIDS, OR IN BEAMS LOCATED OVER FLUIDS:
      STIRRUPS AND TIES.....2"
      PRINCIPAL REINFORCEMENT.....2 1/2"
   C. WALLS:
      FORMED CONCRETE SURFACES FOR DRY CONDITIONS:
      #7 BARS AND SMALLER.....1"
      #8 BARS AND LARGER.....1 1/2"
      FORMED CONCRETE SURFACES EXPOSED TO WEATHER, OR IN CONTACT WITH SOIL OR FLUIDS.....2"

SC001 TYP S — REINFORCED CONCRETE - NOTES

D. FOOTINGS AND SLABS ON GRADE:
   FORMED VERTICAL CONCRETE SURFACES.....2"
   AT UNFORMED CONCRETE SURFACES CAST AGAINST SOIL, ROCK, OR CONCRETE WORK MATS.....3"
   TOP SURFACE OF FOOTINGS AND SLABS.....SAME AS SLABS
8. WATERSTOPS:
   A. PROVIDE WATERSTOPS AT JOINTS IN SLABS AND WALLS OF LIQUID-CONTAINING STRUCTURES, AND PORTIONS OF STRUCTURES BELOW THE DESIGN GROUNDWATER LEVEL. MAKE WATERSTOPS CONTINUOUS THROUGH STRUCTURE, SPLICING WATERSTOPS IN SLABS WITH WATERSTOPS IN WALLS.
   B. END WATERSTOPS 3" BELOW TOP OF WALLS. WHERE TOP OF WALL IS COVERED BY A SLAB WITHOUT WATERSTOPS, CONTINUE WATERSTOP TO WALL/SLAB JOINT. WHERE TOP OF WALL IS COVERED BY A SLAB WITH WATERSTOPS, MAKE WATERSTOPS CONTINUOUS, SPLICING WATERSTOPS IN WALLS WITH WATERSTOPS IN SLAB.
9. CURE CONCRETE IN ACCORDANCE WITH THE CONTRACT DOCUMENTS. WHERE WATER CURING IS SPECIFIED, MEMBRANE CURING IS NOT ALLOWED.
   A. THE CONTRACTOR IS WARNED THAT WATER CURING IS DIFFICULT AT TIMES DUE TO WIND AND DRY CONDITIONS. STUDY SPECIFICATION REQUIREMENTS AND FURNISH ADEQUATE SYSTEMS TO PROVIDE WATER CURING WHERE REQUIRED.
   B. KEEP WATER CURED SURFACES VISIBLY MOIST AT ALL TIMES. FLOOD TOPS OF WALLS NOT LESS THEN 3 TIMES DAILY.
10. DO NOT PLACE BACKFILL AGAINST WALLS UNTIL:
   A. WALLS HAVE BEEN CAST TO FULL HEIGHT OF STRUCTURE AND CONCRETE HAS REACHED THE MINIMUM SPECIFIED COMPRESSIVE STRENGTH (f'c).
   B. CONNECTING SLABS AND BEAMS HAVE BEEN CAST AND CONCRETE IN THOSE ELEMENTS HAS REACHED THE MINIMUM SPECIFIED COMPRESSIVE STRENGTH (f'c).
11. LAP SPLICES:
   A. SEE TABLE 1 OF THIS DETAIL FOR LAP SPLICE LENGTHS.
   B. WHEN MULTIPLE BARS ARE SPLICED AT THE SAME SECTION, THE "CLEAR BAR SPACING" IS DEFINED AS THE MINIMUM CLEAR DISTANCE BETWEEN THE BARS OUTSIDE THE SPLICE LENGTH MINUS ONE BAR DIAMETER.
   C. UNLESS OTHERWISE INDICATED ON THE DRAWINGS, BARS AT A LAP SPLICE SHALL BE IN CONTACT WITH EACH OTHER.
   D. "TOP BARS" ARE HORIZONTAL REINFORCEMENT AT LOCATIONS WHERE MORE THAN 12 INCHES OF FRESH CONCRETE IS CAST IN THE MEMBER BELOW THE BAR.
12. FORM EXPOSED CONCRETE CORNERS AND EDGES WITH 3/4" CHAMFER UNLESS OTHERWISE INDICATED ON THE DRAWINGS.

SC001 TYP S — REINFORCED CONCRETE - NOTES

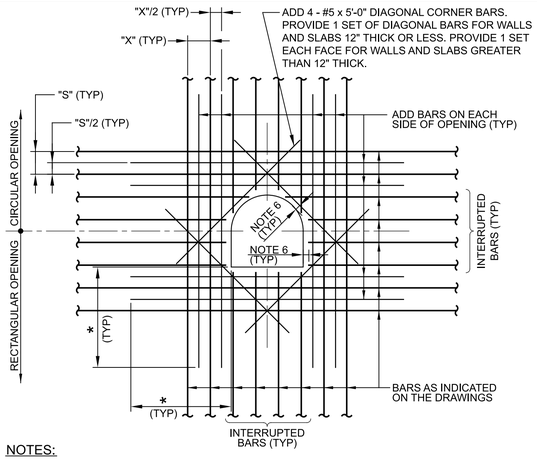
TABLE 1: REINFORCING BAR LAP SPLICES: f'c = 4000 PSI, Fy = 60,000 PSI

BAR SIZE	MINIMUM COVER (BAR DIA)	MINIMUM CLEAR BAR SPACING (BAR DIA)	LAP SPLICE LENGTH (INCHES)	
			TOP BARS	OTHER BARS
#4	MORE THAN 1	MORE THAN 2	32 *	25 *
	MORE THAN 2	MORE THAN 4	20	16
#5	MORE THAN 1	MORE THAN 2	40 *	31 *
	MORE THAN 2	MORE THAN 4	26	20
#6	MORE THAN 1	MORE THAN 2	48 *	37 *
	MORE THAN 2	MORE THAN 4	30	24
#7	MORE THAN 1	MORE THAN 2	70 *	54 *
	MORE THAN 2	MORE THAN 4	43	33
#8	MORE THAN 1	MORE THAN 2	81 *	62 *
	MORE THAN 2	MORE THAN 4	50	38
#9	MORE THAN 1	MORE THAN 2	90 *	70 *
	MORE THAN 2	MORE THAN 4	56	42
#10	MORE THAN 1	MORE THAN 2	104 *	81 *
	MORE THAN 2	MORE THAN 4	62	48
#11	MORE THAN 1	MORE THAN 2	114 *	88 *
	MORE THAN 2	MORE THAN 4	69	54

REINFORCING BAR LAP SPLICE TABLE NOTES:

1. TABULATED SPLICE LENGTHS ARE APPLICABLE ONLY WHEN BOTH REQUIREMENTS FOR MINIMUM COVER AND FOR MINIMUM CLEAR BAR SPACING ARE SATISFIED.
2. * = IF THE CLEAR BAR SPACING IS LESS THAN OR EQUAL TO TWO BAR DIAMETERS, OR THE COVER IS LESS THAN OR EQUAL TO ONE BAR DIAMETER, THE LAP SPLICE LENGTH SHALL BE INCREASED BY 50 PERCENT.

SC001 TYP S — REINFORCED CONCRETE - NOTES

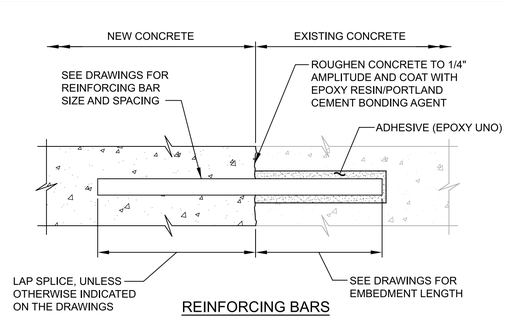


NOTES:

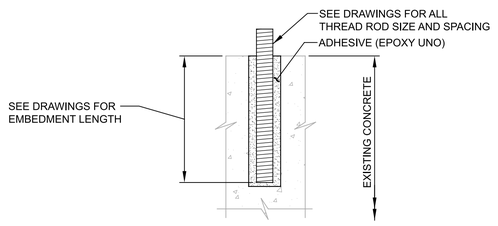
1. AREA OF ADD BARS AT EACH EDGE OF OPENING IN EACH DIRECTION SHALL BE EQUAL TO OR GREATER THAN 1/2 THE CROSS SECTIONAL AREA OF THE INTERRUPTED BARS.
2. PROVIDE STANDARD ACI HOOKS ON BARS IF STRAIGHT EXTENSION PAST THE OPENING, CANNOT BE ACHIEVED.
3. PLACE ADD BARS IN SAME PLANES AS INTERRUPTED REINFORCING.
4. PLACE #5 DIAGONAL BARS ON INSIDE OF INTERRUPTED REINFORCING.
5. * DIMENSION EQUALS OPENING DIMENSION MEASURED PERPENDICULAR TO ADD BARS PLUS LAP SPLICE LENGTH.
6. 2" CLEAR TO CONCRETE OPENINGS OR OUTSIDE FACE OF PIPES AND PIPE SLEEVES. DO NOT OVERCUT REINFORCEMENT FOR EASIER PLACEMENT OF WEEP RINGS AND FLANGES.
7. ADD BARS ARE NOT REQUIRED AT SIDES OF OPENINGS PARALLEL TO AND WITHIN 6" OF A WALL OR BEAM.

SC012 TYP S, N — CONCRETE - REINFORCEMENT - ADDITIONAL REINF AT OPENINGS - SLABS AND WALLS

12/18/2023



REINFORCING BARS



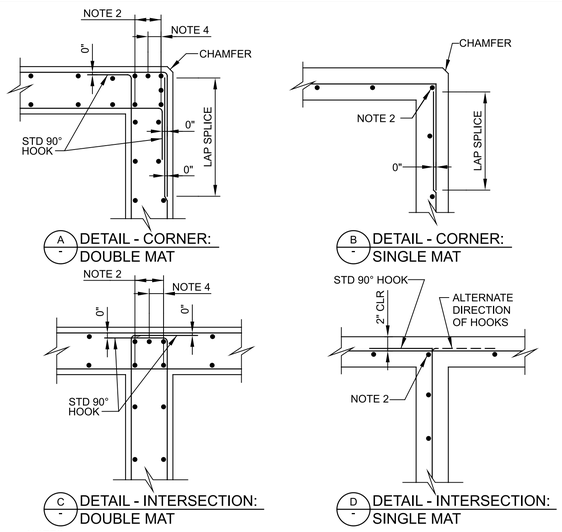
ALL-THREAD RODS

NOTE:

1. INSTALLATION OF REINFORCING BARS AND ALL THREAD RODS AS INDICATED IN THE SPECIFICATIONS.

SC040 TYP N — CONCRETE REINFORCEMENT - ADHESVE-BONDED BARS AND ALL-THREAD RODS

12/18/2023



NOTES:

1. BAR SIZE, SPACING, AND ORIENTATION OF BAR LAYERS SHALL BE AS INDICATED ON THE DRAWINGS.
2. AT INTERSECTION, MAKE BAR SIZE THE LARGER OF BAR SIZES IN CONNECTING WALLS. PLACE BARS IN SAME LAYERS AS AT CONNECTING WALLS (TYP).
3. BAR TAILS: 12 BAR DIAMETERS PLUS 12".
4. EXTERIOR VERTICAL BARS SHALL BE PROVIDED AT A SPACING THAT DOES NOT EXCEED THE SPACING SPECIFIED ON THE DRAWINGS REGARDLESS OF THE WALL THICKNESS.

SC310 TYP N — CONCRETE - REINFORCEMENT - WALL CORNERS AND INTERSECTIONS

12/18/2023

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED AE
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER — ROMAN EZADDIN — No. 53219 — CIVIL — STATE OF CALIFORNIA

Digitally signed by Azman Ezaddin
Contact Info: Carollo Engineers, Inc.
Date: 2025.08.11 14:28:43-07'00'

carollo®

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

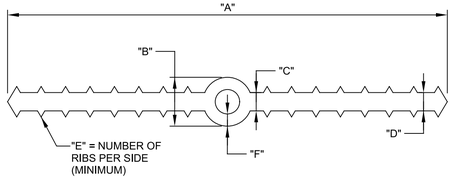
BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

TYPICAL DETAILS

STRUCTURAL 1

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00TS01
SHEET NO. 70 OF 71



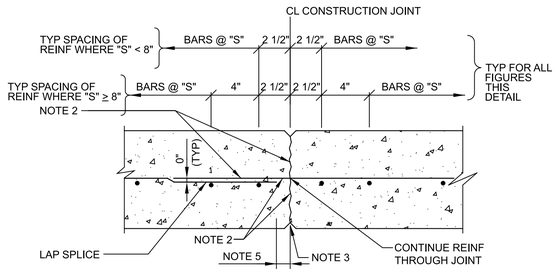
TYPE	"A"	"B"	"C"	"D"	"E"	"F"	APPLICATION
W/O CENTER BULB	6"	-	3/8"	3/8"	7	-	CONSTRUCTION AND CONTROL JOINTS
CENTER BULB	9"	1"	3/8"	3/8"	7	1/4"	EXPANSION JOINTS 1" AND NARROWER
CENTER BULB	9"	2"	3/8"	3/8"	7	1/4"	EXPANSION JOINTS WIDER THAN 1" AND TENSION/COMPRESSION RING BEAM AT DIGESTERS

NOTES:

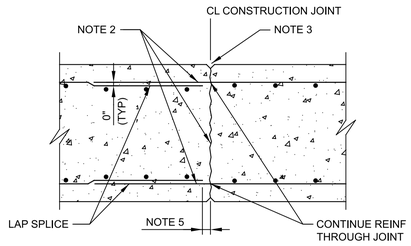
1. SEE SPECIFICATIONS FOR MATERIAL REQUIREMENTS.
2. DIMENSIONS ARE MINIMUM, UNLESS OTHERWISE NOTED.

SD004 TYP — CONCRETE JOINTS - PVC WATERSTOPS - SCHEDULE

12/18/2023



NON-WATER BEARING WALL OR SLAB
SINGLE LAYER REINFORCEMENT

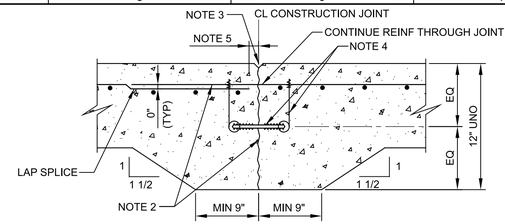


NON-WATER BEARING WALL OR SLAB
DOUBLE LAYER REINFORCEMENT

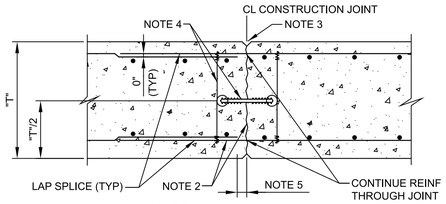
SD102 TYP N — CONCRETE JOINTS - CONSTRUCTION JOINT - WALL OR SLAB

SHEET 1 OF 2

12/18/2023



WATER BEARING SLAB LESS THAN 12" THICK



WATER BEARING SLAB OR WALL

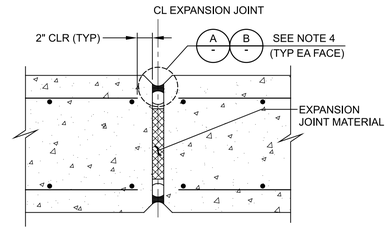
NOTES:

1. "S" EQUALS TYPICAL BAR SPACING INDICATED ON THE DRAWINGS.
   "T" EQUALS SLAB OR WALL THICKNESS.
2. WATER-BLAST EXPOSED JOINT FACE AND PROJECTING REINFORCEMENT BEFORE PLACING CONCRETE.
3. JOINT EDGES:
   A. FOR WALLS AND BOTTOM OF EXPOSED SLABS: FORM EDGES WITH 1/2" CHAMFER.
   B. FOR SLABS: EDGE TOP AND ENDS WITH 1/4" RADIUS.
4. 6" WATERSTOP CENTERED ON JOINT - SEE DETAIL SD004/TYP. PROVIDE WIRE TIES MAX 2'-0" OC. HOG RINGS MAY BE USED IN LIEU OF WIRE LOOPS. THOROUGHLY CLEAN WATERSTOP BEFORE PLACING CONCRETE IN SECOND POUR.
5. STOP REINFORCING 2" CLEAR OF JOINT.

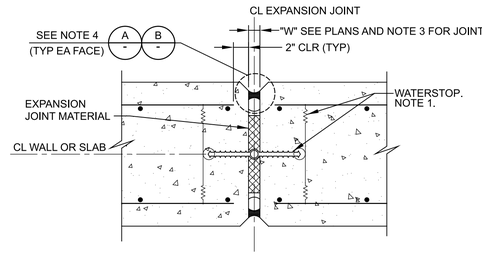
SD102 TYP N — CONCRETE JOINTS - CONSTRUCTION JOINT - WALL OR SLAB

SHEET 2 OF 2

12/18/2023



NON-WATER BEARING SLAB OR WALL



WATER BEARING SLAB OR WALL

SD382 TYP N — CONCRETE JOINTS - ISOLATION JOINT - WALL OR SLAB

12/18/2023

REV	DATE	BY	DESCRIPTION

DESIGNED CE
DRAWN CE
CHECKED AE
DATE SEPTEMBER 2025

REGISTERED PROFESSIONAL ENGINEER — AZMAN EZADDIN — No. 53219 — CIVIL — STATE OF CALIFORNIA

Digitally signed by Azman Ezaddin
Contact Info: Carollo Engineers, Inc.
Date: 2025.09.11 14:28:55-07'00'

carollo®

CITY OF SANTA CRUZ

CITY OF SANTA CRUZ

BELTZ 8 UPGRADES FOR AQUIFER STORAGE AND RECOVERY

TYPICAL DETAILS

STRUCTURAL 2

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 — 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 202431
DRAWING NO. 00TS02
SHEET NO. 71 OF 71

PROJECT NO. 202431-100000 FILE NAME: 20243100TS02.dgn

Plot Date: 10-SEP-2025 10:18:19 AM
User: svcPW
Model: Layout1 ColorTable: gshade.ctb DesignScript: Carollo_Std_Pen_v0905.pen PlotScale: 1:1
LAST SAVED BY: obonafoux