CITY OF MORRO BAY

WATER RECLAMATION FACILITY

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90% YARD PIPING SUBMITTAL SPECIFICATIONS

NOT FOR CONSTRUCTION

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Section 13 47 13

CATHODIC PROTECTION SYSTEM

PART 1 - GENERAL

1.1 THIS SECTION INCLUDES

A. The WORK of this Section includes providing a complete cathodic protection (CP) system for the Morro Bay Reclamation Facility pipeline as outlined in this Section and on the Drawings. The pipeline includes:

1. Approximately 500 feet of 78-inch dielectrically coated steel pipe

B. Electrical isolation of the structures from adjacent metallic structures, steel reinforced concrete structures, casings, structures of dissimilar metal or dissimilar coatings, conduits, and all other metallic components that may impact the operation of the CP system.

C. Electrical bonding of all non-insulated, non-welded pipe joints and mechanical joints.

D. Installation of galvanic anodes, test stations, other components associated with the CP system, and all other work described herein and on the Drawings.

E. Testing of CP system during installation.

F. Cleanup and restoration of work site.

G. Final System Checkout: Testing of CP system after installation and backfilling.

1.2 REQUIREMENTS

A. If the products installed as part of this Section are found to be defective or damaged or if the WORK of this Section is not in conformance with these Specifications, then the products and WORK shall be corrected.

B. Any retesting required due to inadequate installation or defective materials shall be performed at no additional cost to the owner.

C. The WORK also requires that one Supplier or Subcontractor accept responsibility for the WORK, as indicated, but without altering or modifying the DESIGN-BUILDER's responsibilities under the Contract Documents.

D. The WORK also requires coordination of assembly, installation, and testing between the pipeline contractor and any CP material supplier or subcontractor.

E. All electrical WORK shall be in accordance with NEC and local requirements.

1.3 RELATED SECTIONS

A. The WORK of the following Sections applies to the WORK of this Section. Other Sections of the Specifications, not referenced below, shall also apply to the extent required for proper performance of this WORK.

1. Site Safety and Regulatory Requirements

2. Excavation, Trenching, Backfilling, and Compacting

3. Piping

4. Cast-In-Place Concrete

5. Protective Coatings

1.4 REFERENCED SPECIFICATIONS, CODES AND STANDARDS

A. The WORK of this Section shall comply with the current editions of the codes and standards referenced in this specification, including the following:

1. AASHTO — American Association of State Highway and Transportation Officials

    a. H20 — Specification for Highway Bridges

2. ASTM — ASTM International

    a. A123 — Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

b. A615 Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

c. B3 Standard Specification for Soft or Annealed Copper Wire

d. B8 Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

e. B80 Standard Specification for Magnesium-Alloy Sand Castings

f. B187 Standard Specification for Copper, Bus Bar, Rod, and Shapes and General Purpose Rod, Bar, and Shapes

g. B843 Standard Specification for Magnesium Alloy Anodes for Cathodic Protection

h. C94 Standard Specification for Ready-Mixed Concrete

i. D1000 Standard Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications

j. D1248 Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable

k. D2220 Standard Specification for Poly(Vinyl Chloride) Insulation for Wire and Cable, 75°C Operation

l. D3005 Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape

m. D4388 Standard Specification for Nonmetallic Semi-Conducting and Electrically Insulating Rubber Tapes

n. D6386 Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting

o. G97 Standard Test Method for Laboratory Evaluation of Magnesium Sacrificial Anode Test Specimens for Underground Applications

3. AWWA American Water Works Association

a. C217 Petrolatum and Petroleum Wax Tape Coatings for the Exterior of Connections and Fittings for Steel Water Pipelines

4. NACE International, the Corrosion Society

a. RP0375 Field-Applied Underground Wax Coating Systems for Underground Pipelines: Application, Performance, and Quality Control

b. SP0169 Control of External Corrosion on Underground or Submerged Metallic Piping Systems

c. TM0497 Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems

5. NFPA National Fire Protection Association

a. NFPA 70 National Electric Code (NEC)

6. NEMA National Electrical Manufacturers Association

a. TC2 and Conduit Electrical Polyvinyl Chloride (PVC) Tubing

b. TC3 and Tubing PVC Fittings for Use with Rigid PVC Conduit

7. UL Underwriters Laboratories

a. 6 Rigid Metal Conduits

b. 467 Grounding and Bonding Equipment

c. 514B Fittings for Cable and Conduit

B. Whenever the Drawings or these Specifications require a higher degree of workmanship or better quality of material than indicated in the above codes and standards, these Drawings and Specifications shall prevail.

1.5 PERMITS AND JOB ACCESS

A. Prior to the start of construction, the DESIGN-BUILDER shall apply to the required authorities for permits required for installation of the CP system.

B. The DESIGN-BUILDER shall contact Underground Service Alert prior to commencing construction to locate existing utilities in the area of construction. Existing utilities include, but are not limited to, water lines, gas lines, telephone, street lights, sewer and storm drains, and overhead and underground electric utilities.

C. If traffic control is necessary, it shall satisfy the requirements of the governing locality.

1.6 QUALITY ASSURANCE

A. Installation of the CP equipment shall be performed by individuals having at least five years of experience in the installation of the CP equipment described herein.

B. All testing required to be performed by a “Corrosion Technician” shall be performed by a NACE certified Corrosion Technician under the supervision of a Corrosion Engineer. A Corrosion Technician is a NACE CP2 (CP Technician), CP3 (CP Technologist), or CP4 (CP Specialist). A Corrosion Engineer is a Registered Professional Corrosion Engineer or a NACE CP4 (CP Specialist).

1.7 SUBMITTALS

A. The following shall be submitted prior to any equipment installation.

1. Catalog cuts, bulletins, brochures, or data sheets for all materials specified herein.

2. Statement that the equipment and materials proposed meet the Specifications and the intent of the Specifications.

3. Statement of installation experience required.

4. Schedule, including the expected start date and planned completion date.

B. The following shall be submitted after completion of the WORK.

1. Wire connection testing.

2. Joint bond testing, before and after backfilling.

3. Final System Checkout Report.

4. Record Drawings shall be submitted to and approved by the Engineer of Record before the WORK is considered complete.

1.8 INTERFERENCE AND EXACT LOCATIONS

A. The locations of CP equipment, test stations, devices, outlets, and appurtenances, as indicated are approximate only. Exact locations shall be determined by the DESIGN-BUILDER in the field subject to the approval of the Engineer of Record.

B. The DESIGN-BUILDER shall field verify all data and final locations of work done under other Sections of the Specifications required for placing of the electrical work.

C. In case of interference with other work, foreign pipeline, or erroneous locations with respect to equipment or structures, the DESIGN-BUILDER shall furnish all labor and materials necessary to complete the WORK in an acceptable manner to the OWNER. Deviations from the Drawings and Specifications shall be submitted to the OWNER for approval.

PART 2 - PRODUCTS

2.1 GENERAL

A. All materials installed must be new. All equipment and materials supplied shall be similar to that which has been in satisfactory service for at least 5 years.

2.2 GALVANIC ANODES

A. High-potential magnesium anodes: Cast magnesium anodes shall conform to ASTM B843 Type M1C. Anodes shall have an open circuit potential of -1.70 volts or more electronegative and a current efficiency of at least 48% when tested in accordance with ASTM G97. Anodes shall have the following size, form, and shape. Anodes shall be manufactured by Farwest, Corrpro, Mesa, Matcor, or equivalent.

Ingot				Packaged		
Weight (lb)	Width (inch)	Height (inch)	Length (inch)	Weight (lb)	Diameter (inch)	Length (inch)
60	4 to 5	4	60	126 to	6 to 7	64

B. Galvanic anodes shall be pre-packaged in a cloth bag containing backfill of the following composition: 75% gypsum, 20% bentonite, and 5% sodium sulfate. The anodes shall be of the size indicated on the Drawings and placed where indicated on the Drawings.

C. Anode lead wire:

1. The wire attached to the anodes shall be of the size and type indicated on the Drawings. The anode lead wire shall conform to the specifications given for “Wires” in this specification.

2. Connection of wire to the anode shall have a pulling strength that exceeds the wire’s tensile strength.

3. Anode lead wires shall be of one continuous length, without splices, unless otherwise indicated on the Drawings, from the anode connection to the test station.

2.3 READY-MIXED CONCRETE

A. Ready-mixed concrete shall be in accordance with ASTM C94, permit requirements, and the Specification section for cast-in-place concrete.

2.4 REINFORCING STEEL

A. Reinforcing steel shall be in accordance with ASTM A615, permit requirements, and the Specification section for reinforcing steel.

2.5 FLUSH-MOUNTED TEST STATION

A. Flush-mounted test station boxes shall be traffic boxes rated to withstand AASHTO H20 traffic loading.

B. The traffic boxes shall be G05 Utility Boxes, as manufactured by Christy Concrete Products, Inc.; No. 3RT Utility Box, as manufactured by Brooks Products; or an approved equivalent.

C. Traffic box covers for test stations shall be cast iron with welded bead legend and labeled “CP TEST” or “ANODE,” as required.

2.6 TERMINAL BOARDS

A. Terminal boards shall be made of 1/4-inch thick phenolic plastic and sized as indicated on the Drawings.

B. Connection hardware shall be brass or bronze. All connections shall be double nutted bolts with serrated lock washers.

C. Copper bus bar shall be 1/8-inch thick and sized to fit. The copper bus bar shall be per ASTM B187 with 98% conductivity.

2.7 MECHANICAL LUGS

A. Mechanical lugs shall be brass or copper with a brass, copper, or stainless steel set screw. Tin plating on the lugs is optional. Aluminum lugs shall not be permitted. Zinc-plated steel set screws shall not be permitted. The lug shall be listed per UL 467, suitable for direct burial, and appropriately sized for the incoming wires. The lug shall be ILSCO Type XT-6DB, Burndy GKA8C, or an approved equivalent.

2.8 SHUNTS

A. Shunts shall be selected by the size indicated on the Drawings.

B. 0.01-ohm, 6-amp shunts shall be manganin wire type, as indicated. Shunts shall be Type RS, as manufactured by Holloway, or equivalent.

2.9 CONDUIT AND FITTINGS

A. The minimum conduit size shall be 1 inch unless otherwise indicated. Refer to NFPA 70 (NEC) for additional conduit size requirements.

B. Conduit and fittings placed below grade shall be Schedule 80 PVC in accordance with NEMA TC2 and NEMA TC3

C. Union couplings for conduit shall be Erickson or Appleton Type EC, 0-Z Gedney 3-piece Series 4, or equivalent.

2.10 CAUTION TAPE

A. The caution tape shall be an inert plastic film designed for prolonged underground use. The caution tape shall be a minimum of 3 inches wide and a minimum of 4 mils thick.

B. The caution tape shall be continuously printed over the entire length with the wording "CAUTION: CATHODIC PROTECTION CABLE BURIED BELOW."

C. The wording shall be printed using bold black letters. The color of the tape shall be red.

2.11 WIRES

A. Conductors shall consist of stranded copper of the gauge indicated on the Drawings. Wire sizes shall be based on American Wire Gauge (AWG). Copper wire shall be in conformance with ASTM B3 and ASTM B8.

B. Insulation Type and Colors: As shown on the Drawings.

1. High molecular weight polyethylene (HMWPE) wires shall be rated for 600 volts and shall conform to ASTM D1248, Type 1, Class C, Grade 5.

2.12 WIRE IDENTIFICATION TAGS

A. Wire identification tags shall be the wrap-around type with a high resistance to oils, solvents, and mild acids. Wrap-around markers shall fully encircle the wire with imprinted alpha-numeric characters for pipe identification. The letters and numbers height shall be 3/16 inch at minimum.

2.13 EXOTHERMIC WELDS

A. Exothermic welds shall be in accordance with the manufacturer’s recommendations. Exothermic welds shall be Cadweld manufactured by Erico, Thermoweld manufactured by Burndy, or an approved equivalent.

B. Prevent molten weld metal from leaking out of the mold, where necessary, by using Duxseal packing manufactured by Johns-Manville, Thermoweld packing material manufactured by Burndy, Cadweld T403 Mold Sealer manufactured by Erico, or an approved equivalent.

C. The shape and charge of the exothermic weld shall be chosen based on the following parameters:

1. Pipe material
2. Pipe size
3. Wire size and requirement for sleeves
4. Number of wires to be welded
5. Orientation of weld (vertical or horizontal)

2.14 EXOTHERMIC WELD COATING

A. After exothermic welding, repair coatings and linings in accordance with the coating and lining manufacturer's recommendation.

B. For bare steel, dielectrically coated steel, or ductile iron pipe, weld caps with integrated primer shall be used to cover the exothermic weld connecting the wire to the pipe. The weld cap shall be a 10-mil thick durable plastic sheet that has a dome filled with a moldable compound to assure complete encapsulation of the exothermic weld and a layer of elastomeric adhesive with integrated primer. The adhesive and primer shall be compatible with the pipe material and pipe coating material. Adhesion to steel shall be at least 10 lb/in per ASTM D1000. Weld cap with integrated primer shall be Handy Cap IP manufactured by Royston or equivalent for wire size up to 8 AWG and Handy Cap XL IP manufactured by Royston or equivalent for wire size up to 2 AWG.

2.15 PETROLATUM WAX TAPE

A. Petrolatum wax tape shall meet or exceed the requirements of AWWA C217 and shall consist of three parts: Surface primer, wax tape, and outer covering. All three parts shall be the product of a single manufacturer.

B. The primer shall be a blend of petrolatums, plasticizers, and corrosion inhibitors having a paste-like consistency. Primer shall be Wax-Tape Primer manufactured by Trenton, Denso Paste manufactured by Denso, or approved equivalent.

C. The wax tape shall be synthetic-fiber felt, 45 to 90 mils thick, saturated with a blend of micro- crystalline wax, petrolatums, plasticizers, and corrosion inhibitors that are capable of easy conformability over irregular surfaces. Wax tape shall be #1 Wax-Tape manufactured by Trenton, Denso Tape manufactured by Denso, or approved equivalent.

D. The outer covering shall be a plastic wrap consisting of one 150-gauge sheet or three 50- gauge sheets wound together as a single sheet, clear polyvinylidene chloride, shrink wrap that is flexible enough to conform to irregular surfaces. Outer wrapping shall be Poly-Ply by Trenton, Poly-Wrap by Denso, or approved equivalent.

PART 3 - EXECUTION

3.1 MATERIAL AND EQUIPMENT STORAGE

A. All materials and equipment to be used in construction shall be stored in such a manner to be protected from detrimental effects from the elements. If warehouse storage cannot be provided, materials and equipment shall be stacked well above ground level and protected from the elements with plastic sheeting or another method, as appropriate.

3.2 EXCAVATION AND BACKFILL

A. Buried wires shall have a minimum cover of 24 inches.

B. Caution tape shall be installed above buried wire. Caution tape shall be installed a minimum of 6 inches above underground wires and conduits.

C. Wire identification tags shall be placed on the wires prior to placing wire in conduit or backfilling.

3.3 SURFACE GROUND BED FOR GALVANIC ANODES

A. Prepackaged anodes shall be installed at the locations indicated on the Drawings.

B. Plastic or paper wrapping shall be removed from the anode prior to lowering the anode into the hole. Anodes shall not be suspended by the lead wires. Damage to the canvas bag, anode- to-wire connection, copper wire, or wire insulation before or during installation will require replacement of the entire anode assembly. Anodes shall be inspected and approved prior to backfilling.

C. Anodes shall be backfilled with native soil. Backfilling with native soil shall proceed in 6-inch lifts, compacting the soil around the anode during each lift, until the backfill has reached grade. Upon completion of compaction of backfill to the top of the anode, and prior to filling the hole and compacting the backfill to the surface, a

minimum of 10 gallons of fresh water shall be poured into the hole to saturate the prepackaged anode backfill and surrounding soil.

D. Anode lead wires shall be routed and terminated on the panel board as shown in the Drawings.

3.4 TEST STATIONS

A. Test stations shall be installed at the approximate locations shown on the Drawings. The DESIGN-BUILDER shall field verify all final locations, subject to acceptance by the Engineer of Record. Test stations shall be located within the pipeline easement. Test stations shall be located in areas not subject to vehicular traffic, such as sidewalks, unless otherwise approved.

B. For flush-mounted test stations, place the bottom of the test box on native soil. Do not place rock, gravel, sand, or debris in the box. Install 4,000 psi concrete collar with reinforcement after placement of the test box to finished grade. Provide sufficient sloping in the concrete pad or surrounding pavement to provide drainage away from the test box.

C. Connect wires to the terminal board as shown on the Drawings. Each wire shall be identified with a permanent wire identifier within 4 inches of the termination. After installation, all wire connections in the test station shall be tested by the Design-Builder to ensure they meet the requirements herein.

D. The DESIGN-BUILDER shall provide global positioning system (GPS) coordinates for each test station location with a minimum accuracy of 1 meter or 3 feet. The DESIGN-BUILDER shall provide the GPS coordinates of the test stations after installation.

3.5 WIRES

A. Buried wires shall be laid straight without kinks. Each wire run shall be continuous in length and free of joints or splices, unless otherwise indicated. Care shall be taken during installation to avoid punctures, cuts, or other damage to the wire insulation. Damage to insulation shall require replacement of the entire length of wire.

B. At least 12 inches of slack (coiled) shall be left for each wire at each flush-to-grade test station. Wire slack shall be sufficient to allow removal of wire extension for testing.

C. Wire shall not be bent into a radius of less than eight times the overall wire diameter.

D. The wire conduits must be of sufficient diameter to accommodate the wires. This shall be determined by the number and size of wires in accordance with the applicable codes and standards.

E. Conduit shall be installed to a minimum depth of 30 inches below grade.

F. Install caution tape a minimum of 6 inches above buried wire and conduits. Every 3 feet, double over the tape for a distance of 8 inches to increase the apparent flexibility of the tape.

3.6 WIRE IDENTIFICATION TAGS

A. All wires shall be coded with wire identification tags within 4 inches of the wire end indicating diameter and type of pipe.

B. Wire identification tags shall be placed on all wires prior to backfilling and installation of test stations.

3.7 EXOTHERMIC WELD CONNECTIONS

A. Exothermic weld connections shall be installed in the manner and at the locations indicated. Exothermic welds shall be spaced at least 6 inches apart from other exothermic welds, fittings, and circumferential welds.

Coating materials shall be removed from the surface over an area of sufficient size to make the connection and as indicated on the Drawings. The surface shall be cleaned to bare metal per SSPC SP11 prior to welding the conductor. The use of resin impregnated grinding wheels will not be allowed.

B. Only enough insulation shall be removed such that the copper conductor can be placed in the welding mold. If the wire conductor diameter is not the same as the opening in the mold, then a copper adapter sleeve shall be fitted over the conductor.

C. The DESIGN-BUILDER shall be responsible for testing all test lead and bond wire welds. The Engineer of Record, at his or her discretion, shall witness these tests. After the weld has cooled, all slag shall be removed and the metallurgical bond shall be tested for adherence by the DESIGN-BUILDER. A 22-ounce hammer shall be used for adherence testing by striking a blow to the weld. Care shall be taken to avoid hitting the wires. All defective welds shall be removed and replaced in a new location at least 6 inches away from the original weld location.

D. All exposed surfaces of the copper and steel shall be covered with insulating materials.

1. For dielectrically coated or polyethylene encased pipes, a plastic weld cap with integrated primer shall cover the exothermic weld and surrounding area. All surfaces must be clean, dry, and free of oil, dirt, loose particles, and all other foreign materials prior to application of the weld cap.

E. The DESIGN-BUILDER shall inspect both the interior and exterior of the pipe to confirm that all coatings and linings removed or damaged as a result of the welding have been repaired. The DESIGN-BUILDER shall furnish all materials, clean surfaces, and repair protective coatings and linings damaged as a result of the welding. Repair of any coating or lining damaged during welding shall be performed in accordance with coating or lining manufacturer's recommendations.

F. After backfilling pipe, all test lead pairs shall be tested for broken welds using a standard ohmmeter. The resistance shall not exceed 150% of the theoretical wire resistance, as determined from published wire data.

3.8 JOINT BONDS

A. Joint bonding shall be provided across flexible couplings and all non-welded joints to ensure electrical continuity, except where insulating joints have been installed to provide electrical isolation. Joint bonds shall be of the type, size, length, and number shown on the Drawings and installed as indicated.

B. Bonding wires shall allow at least 2 inches of movement in the pipe joint. The wire shall be attached by exothermic welding. At least 2 bond wires shall be provided between all discontinuous joints.

C. For ductile iron pipe, the DESIGN-BUILDER may, at his or her own expense, provide weld plates that are installed by the pipe manufacturer at the spigot end of the pipe. Provision of the weld plates does not relieve the DESIGN-BUILDER from responsibility for repair of damage to the coating or

lining as a result of exothermic welding of the pipe. Coating repairs shall be performed in accordance with coating manufacturer's recommendations.

3.9 PETROLATUM WAX TAPE

A. Petrolatum wax tape systems shall be applied on insulating joints and non-cathodically protected metallic appurtenances and fittings, regardless of whether they are bare or factory coated, as indicated in the Drawings. Extend the petrolatum wax tape coating system over any adjacent pipe coating by a minimum of 12-inches. Petrolatum wax tape systems shall be applied in accordance with NACE RP0375, AWWA C217, these Specifications, and the Manufacturer's recommendations.

B. Surfaces shall be cleaned of all dirt, grease, oil and other foreign materials immediately prior to coating. Loose rust, loose paint, and other foreign matter shall be removed in accordance with SSPC SP2 or SP3.

C. A prime coating shall be applied in a uniform coating over the entire surface to be wrapped. A liberal coating shall be applied to threads, cavities, shoulders, pits, and other irregularities.

D. Petrolatum wax tape shall be applied immediately after applying the primer using a 1-inch overlap. A spiral wrap shall be used and slight tension shall be applied to ensure that there are no air pockets or voids. For bolts, nuts, and other irregular shapes, cut strips of wax tape and apply them by gloved hand so that there are no voids or spaces under the tape. Apply a sufficient amount of tape to completely encapsulate all exposed steel surfaces. After applying the tape, the applicator shall firmly press and smooth out all lap seams and crevice areas. The tape shall be in tight intimate contact with all surfaces. The minimum wax tape thickness shall be 70 mils over smooth surfaces and 140 mils over sharp and irregular surfaces, or more as required to fill all voids.

E. Apply two layers of outer covering over the wax tape coating by tightly wrapping it around the pipe such that it adheres and conforms to the wax tape. Secure the outer covering to the pipe with adhesive tape.

3.10 WIRE CONNECTIONS

A. After installation, all wire connections shall be tested to ensure electrical continuity at the test station locations by the DESIGN-BUILDER to ensure that they meet the requirements and intent of the Contract Documents.

3.11 RESTORATION SERVICES

A. RESTORATION OF SOD: Restore unpaved surfaces disturbed during the installation of anodes and wires to their original elevation and condition. Preserve sod and topsoil carefully and replace after the backfilling is completed. Replace sod that is damaged using sod of quality equal to that removed. Where the surface is disturbed in a newly seeded area, re-seed the area with the same quality and formula of seed as that used in the original seeding.

B. RESTORATION OF PAVEMENT: Patch pavement, sidewalks, curbs, and gutters where existing surfaces are removed for construction.

3.12 CONTINUITY TESTING

A. Continuity testing of joint bonds shall be performed by the DESIGN-BUILDER's qualified corrosion technician as defined in this section after backfilling. The electrical continuity test may additionally be performed before backfilling at the DESIGN-BUILDER's option.

B. The pipe shall be tested for electrical continuity. Continuity shall be verified using the linear resistance method. The pipe should be tested in spans that are no less than 250 feet, unless the pipe is shorter than 250 feet, and no more than 1,000 feet, if test station locations are available. Each test span shall have two test leads connected to the pipe at each end. Existing test stations can be used. A direct current shall be applied through the pipe using two of four test leads. The potential across the test span shall be measured using the other two test leads. The current applied and voltage drop shall be recorded for a minimum of three different current levels.

C. The theoretical resistance of the pipe shall be calculated. It shall take into account the pipe wall thickness, material, and joint bonds.

D. The average measured resistance shall be compared to the theoretical resistance of the pipe and bond wires. If the measured resistance is greater than 125% of the theoretical resistance, then the joint bonds shall be considered deficient and shall be repaired and retested. If the measured resistance is less than 100% of the theoretical resistance, then the test and/or calculated theoretical resistance shall be considered deficient and the test span shall be retested and/or recalculated. If the piping forms a loop which allows current to flow both in and out of the test span, then consideration shall be made for current circulating through both the loop and the test span.

E. Alternative continuity testing methods can be submitted for consideration and approval.

3.13 FINAL SYSTEM CHECKOUT

A. Upon completion of the installation, the DESIGN-BUILDER shall provide testing of the completed system by a Corrosion Technician, and the data shall be reviewed by a Corrosion Engineer to ensure conformance with the Contract Documents and NACE SP0169.

B. The testing described herein shall be in addition to and not substitution for any required testing of individual items at the manufacturer's plant and during installation.

C. Testing shall be performed at all test leads of all test stations and locations of exposed pipe as soon as possible after installation of the CP system.

D. Testing shall include the following and shall be conducted in accordance with NACE TM0497:

1. Measure and record native pipe-to-soil and anode-to-soil potentials at all test locations. DESIGN-BUILDER shall submit data a minimum of 48 hours before energizing the cathodic protection system.

2. Confirm electrical continuity of the cathodically protected pipeline in accordance with this Section. DESIGN-BUILDER shall submit data a minimum of 48 hours before energizing the cathodic protection system.

3. Measure and record the “On” and “Instant Off” pipe-to-soil potentials at each location after the structure has been given adequate time to polarize.

4. Measure and record the current output of each anode when the CP system is initially activated and again after it has been given adequate time to polarize.

E. Test results shall be analyzed to determine compliance with NACE SP0169.

F. Test results shall be analyzed to determine if stray current interference is present. Stray current interference is defined as a ±50 mV shift in a pipeline’s pipe-to-soil potential that is caused by a foreign current source. Stray current interference shall be tested on the project pipeline and foreign pipelines that have a reasonable chance of being affected by stray currents.

G. The DESIGN-BUILDER shall provide a written report, prepared by the Corrosion Engineer, documenting the results of the testing and recommending corrective work, as required to comply with the Contract Documents. Any deficiencies of systems tested shall be repaired and re-tested at no additional cost to the OWNER.

End of Section

Section 31 23 11

EXCAVATION AND FILL FOR STRUCTURES

PART 1 - GENERAL

1-1. SCOPE. This section covers earthwork and shall include the necessary clearing, grubbing, and preparation of the site; removal and disposal of all debris; excavation; handling, storage, transportation, and disposal of all excavated material; all necessary temporary earth retention and other protection work; preparation of subgrades; pumping and dewatering as necessary; protection of adjacent property; backfilling; construction of fills and embankments; grading; and other appurtenant work.

1-2. GENERAL. With reference to the terms and conditions of the construction standards for excavations set forth in OSHA "Safety and Health Regulations for Construction", Chapter XVII of Title 29, CFR, Part 1926, Design-Builder shall employ a competent person and, when necessary based on the regulations, a licensed professional engineer in the state where the earthwork is located, to act upon all pertinent matters of the work of this section.

1-3. SUBMITTALS. Drawings, specifications, and data covering the proposed materials shall be submitted in accordance with the Submittals Procedures section.

1-3.01. Temporary Excavation Design Certificate. Before starting construction on the temporary excavation and in accordance with OSHA requirements enumerated above, the Design-Builder shall ensure that the temporary excavation design engineer shall complete the Temporary Excavation Design Certificate , Figure 1-31 23 11 and shall use the temporary excavation design. If required by the OSHA requirements enumerated above or to protect existing facilities, the Design-Builder is responsible for ensuring that a separate certificate shall be submitted for each unique design. Refer to paragraph in this specification titled, “Temporary Excavations”.

1-3.02. Filter Fabric Data. Complete descriptive and engineering data for the fabric shall be submitted in accordance with the Submittals Procedures section. Data submitted shall include:

A 12 inch square sample of fabric.

Manufacturer's descriptive product data.

Installation instructions.

1-3.03 Test Results for Review of Materials. Complete test results for tests performed on fill and backfill, and other material specified herein, by an independent commercial laboratory retained by the Design-Builder, as described in the paragraph titled, “Review of Materials”.

1-3.04 CLSM Mix Design. Mix design by an independent commercial laboratory retained by the Design-Builder

PART 2 - PRODUCTS

2-1. MATERIALS.

2-1.01. Filter Fabric. Filter fabric shall be provided in rolls wrapped with covering for protection from mud, dirt, dust, and debris.

2-1.01.01. Filter Fabric Type A. Filter fabric Type A shall be provided for installation at locations indicated on the Drawings and as specified herein. Filter fabric Type A shall be a non-woven fabric consisting of only continuous chains of polypropylene filaments or yarns of polyester formed into a stable network by needle punching. The fabric shall be inert to commonly encountered chemicals; shall be resistant to mildew, rot, ultraviolet light, insects, and rodents; and shall have the indicated properties:

Property	Test Method	Unit	Min Roll Value*
Grab Strength	ASTM D4632	lbs	160
Grab Elongation	ASTM D4632	percent	50
CBR Puncture Strength	ASTM D6241	lbs	410
Trapezoidal Tear	ASTM D4533	lbs	60
UV Resistance at 500 hours	ASTM D4355	% Strength Retained	70

*Minimum average roll value in weakest principal direction.

The apparent opening size (diameter) for the filter fabric Type A shall be no larger than the U.S. Standard Sieve Size 70 per ASTM D4751.

2-1.01.02. Filter Fabric Type B. Filter fabric Type B shall be provided for installation at locations indicated on the Drawings and as specified herein. Filter fabric Type B shall be a non-woven fabric consisting of only continuous chains of polypropylene filaments or yarns of polyester formed into a stable network by needle punching. The fabric shall be inert to commonly encountered chemicals; shall be resistant to mildew, rot, ultraviolet light, insects, and rodents, and shall have the indicated properties:

Property	Test Method	Unit	Min Roll Value*
Grab Strength	ASTM D4632	lbs	250
Grab Elongation	ASTM D4632	Percent	50
CBR Puncture Strength	ASTM D6241	lbs	700
Trapezoidal Tear	ASTM D4533	lbs	100
UV Resistance at 500 hours	ASTM D4355	% Strength Retained	100

*Minimum average roll value in weakest principal direction.

The apparent opening size (diameter) for the filter fabric Type B shall be no larger than the U.S. Standard Sieve Size 70 per ASTM D4751.

2-1.01.03. Filter Fabric Type C. Filter fabric Type C shall be provided for installation at locations indicated on the Drawings and as specified herein. Filter fabric Type C shall be a woven fabric, TenCate Mirafi RS380*i*, or equal.

2-1.02. Polyethylene Film. Polyethylene film beneath concrete slabs or slab base course material shall comply with requirements of ASTM D4397, 6 mil minimum thickness.

2-1.03. Fill and Embankment Materials. To the maximum extent available, excess suitable material obtained from structure and trench excavation shall be used for the construction of site fills and embankments. Additional material shall be provided from Design-Builder's offsite source.

All material placed in fills and embankments shall be free from rocks or stones larger than 6 inches in their greatest dimension, brush, stumps, logs, roots, debris, and other organic or deleterious materials. No rocks or stones shall be placed in the upper 18 inches of any fill or embankment. Rocks or stones within the allowable size limit may be incorporated in the remainder of fills and embankments, provided they are distributed so that they do not interfere with proper compaction.

2-1.04. Granular Fill. Granular fill material shall be crushed rock or gravel suitable for use as a free draining subbase beneath slabs and foundations. Granular fill shall be free from dust, clay, and trash; hard, durable, non-friable; and shall be graded 3/4 inch to No. 4 as defined in ASTM C33 for No. 67 coarse aggregate. Granular fill shall meet the quality requirements for ASTM C33 coarse aggregate. The edges of granular fill shall be confined, either by placing against an excavation face or other fill.

2-1.05. Structure Backfill. Structure backfill shall be defined as the material placed around and outside of structures. For structures constructed in open excavations, structure backfill shall extend to the temporary excavation slope so that the entire excavation outside the structure shall be filled with structure backfill. For structures constructed in supported excavations, the structure backfill shall completely fill the space between structure and temporary earth retention, or between structure and excavation face, if these specifications permit removal of the system. Structure backfill shall meet the requirements of the previous paragraph entitled "Fill and Embankment Materials", unless the Drawings indicate crushed rock or clean sand structure backfill is to be used.

2-1.05.01. Crushed Rock Structure Backfill. Crushed rock for structure backfill shall meet the following gradation requirements:

Size	Percent Passing
1/2 inch	100
3/8 inch	90 – 100
No. 4	30 – 60
No. 8	0 – 10
No. 200	0 - 5

2-1.05.02. Clean Sand Structure Backfill. Clean sand for structure backfill shall meet the following gradation requirements:

Size	Percent Passing
3/8 inch	100
No. 4	95 – 100
No. 8	75 – 90
No. 30	30 – 50
No. 100	2 – 10
No. 200	0 - 5

2-1.06. Select Fill. Select fill shall be defined as the material placed beneath the structure foundations and slabs below any granular material layer or lean concrete slab indicated on the Drawings. Select fill shall be used to replace any unsuitable material below the structure foundations and slabs and to raise the site grades below and within 5 feet horizontally(unless a different dimension is otherwise indicated on the Drawings or specified) of structural footprints and at locations indicated on the Drawings. Select fill shall meet the requirements of the previous paragraph entitled "Fill and Embankment Materials", unless the Drawings indicate crushed rock or clean sand select fill is to be used.

2-1.06.01. Crushed Rock Select Fill. Crushed rock for select fill shall meet the following gradation requirements:

Size	Percent Passing
1/2 inch	100
3/8 inch	90 – 100
No. 4	30 - 60
No. 8	0 - 10
No. 200	0 - 5

2-1.06.02. Clean Sand Select Fill. Clean sand for select fill shall meet the following gradation requirements:

Size	Percent Passing
3/8 inch	100
No. 4	95 – 100
No. 8	75 – 90
No. 30	30 – 50
No. 100	2 – 10
No. 200	0 - 5

2-1.07. Gravel Base Beneath Slabs. "Gravel Base Beneath Slabs" is defined as material to be placed directly beneath building floor slabs as shown on the Drawings. The material shall meet the quality requirements specified for ASTM C33 concrete coarse aggregate and shall be graded No. 7 coarse aggregate.

2-1.08. Controlled Low Strength Material (CLSM). CLSM shall consist of a mixture of Portland cement, fly ash, sand, and water and shall be placed at locations indicated on the Drawings or as directed by. The class of CLSM shall be as specified below.

The type of cement in CLSM shall be ASTM C150 Type I. The class of fly ash in CLSM shall be ASTM C618 Class C, except loss on ignition shall not exceed 4 percent. Fine aggregate in CLSM shall be clean natural sand, ASTM C33, except that clay particles shall not exceed one percent. Water in CLSM shall be potable.

Design-Builder shall design and test the CLSM. The mix design shall be such as to ensure that the CLSM hardens sufficiently to support the weight of an average person in one to four hours after placement and support equipment weight in 24 hours. The mixture shall be designed such that when tested in the field with the

Kelly Ball apparatus per ASTM D6024, the maximum depression diameter shall be 3 inches. CLSM shall be self-leveling and shall have an average patty diameter from 8 to 12 inches when the flow is measured in accordance with ASTM D6103.

If a change in sources of materials is proposed, a new mix design shall be developed by Design-Builder before the new material is used. When unsatisfactory results or other conditions make it necessary, Design-Builder shall develop a new mix design to get the desired results.

2-1.08.01. Class A CLSM. The initial trial mixture for Class A CLSM shall consist of the following minimum proportions per cubic yard to provide minimum compressive strength listed below:

Cement	50 lbs
Fly Ash	250 lbs
Sand (SSD)	2860 lbs
Water	370 lbs
Air Entraining admixture	6 percent
Minimum compressive strength at 28 days	130 psi

2-1.08.02. Class B CLSM. The initial trial mixture for Class B CLSM shall consist of the following minimum proportions per cubic yard to provide minimum compressive strength listed below:

Cement	100 lbs
Fly Ash	100 lbs
Sand (SSD)	2760 lbs
Water	386 lbs
Air Entraining admixture	5 percent
Minimum compressive strength at 28 days	200 psi

2-1.08.03. Class C CLSM. The initial trial mixture for Class C CLSM shall consist of the following minimum proportions per cubic yard to provide minimum compressive strength listed below:

Cement	80 lbs
Fly Ash	275 lbs
Sand (SSD)	2795 lbs

Water	370 lbs
Air Entraining Agent	4 percent
Minimum compressive strength at 28 days	370 psi

2-1.09. Geocomposite Sheet Drains. The geocomposite sheet drains shall consist of a continuous plastic three dimensional drainage core wrapped on one side in a non-woven filter fabric permeable to water flow. The filter fabric shall be bonded to the individual dimples of the molded plastic core to minimize fabric intrusion into the flow channels caused by the backfill pressure. The fabric shall extend beyond the edges of the core to provide overlap for the adjacent panels. The geocomposite sheet drain shall be CCW-MIRADRAIN 6000XL as manufactured by CARLISLE, or SITEDRAIN Sheet 186 as manufactured by American Wick Drain Corporation, or equal.

2-2. MATERIAL TESTING.

2-2.01. Review of Materials. All tests required for preliminary review of materials and materials delivered to the Site shall be made by an acceptable independent testing laboratory. Tests performed by the aggregate supplier are not acceptable. Tests shall have been performed within 2 months of submittal and shall be representative of the material that will be delivered to the Site. Acquisition of samples for testing, both for preliminary review of materials and for testing of materials at the Site, shall be by the Design-Builder's independent testing laboratory. Samples acquired at the Site shall be obtained after placement and compaction of the material. Aggregate material shall be sampled in accordance with ASTM D75.

Two initial gradation tests shall be made for each type of general fill, select fill, structure backfill, granular fill, or other specified material, and one additional gradation test shall be made for each additional 500 tons of each material delivered (imported) to the jobsite or suitable onsite material incorporated in select fill or structure backfill. One additional gradation test shall be performed for each additional 2,000 tons of general fill material delivered to the jobsite or suitable onsite material incorporated in general fill. In addition, one set of initial Atterberg Limits test shall be made for each fill material containing more than 20 percent by weight pass the No. 200 sieve and for materials specified by Atterberg Limits. One additional Atterberg Limits test shall be made for each additional 500 tons of each material delivered to the job site or otherwise incorporated in select fill or structure backfill. One additional Atterberg Limits test shall be made for each additional 2,000 tons of general fill material delivered to the jobsite or suitable onsite material incorporated in general fill.

All material testing on CLSM shall be made by an independent testing laboratory at the expense of Design-Builder.

2-2.02. Field Testing Expense. All moisture-density (Proctor) tests and relative density tests on the materials, and all in-place field density tests, shall be made by an independent testing laboratory at the expense of Owner. Design-Builder shall provide access to the materials and work area and shall assist the laboratory as needed in obtaining representative samples.

2-2.03. Required Field Tests. For planning purposes, the Owner's testing laboratory will use the following general guidelines for frequency of field tests. Additional tests will be performed as necessary for job conditions and number of failed tests.

For area fills and embankments, an in-place field density and moisture test for each 1000 cubic yards of material placed.

One in-place field density and moisture test for every 100 to 200 cubic yards of structure backfill or select fill.

One in-place density and moisture test whenever there is a suspicion of a change in the quality of moisture control or effectiveness of compaction.

At least one test for every full shift of compaction operations on mass earthwork.

Testing of CLSM will be as follows.

Compressive Strength. For every 200 cubic yard of CLSM placed, prepare, cure, remove from molds, and test four 6 by 12 inch test cylinders in accordance with ASTM D4832. Cure cylinders in the molds in accordance with ASTM D4832 until time of testing, at least 14 days. Two cylinders will be tested at 7 days and the other two cylinders will be tested at 28 days.

Flow. Once each day, the CLSM material will be tested for flow in accordance with ASTM D6103.

Unit Weight, Yield, and Air Content. Once each day that flowable fill is placed, unit weight, yield and air content will be measured in accordance with ASTM D6023.

Penetration. Once a day that CLSM is placed, the resistance to penetration from ball-drop apparatus (Kelly Ball) will be measured in accordance with ASTM D6103. (Compliance will be based on maximum depression diameter of 3 inches.)

PART 3 - EXECUTION

3-1. SITE PREPARATION. All sites to be occupied by permanent construction or embankments shall be cleared of all logs, trees, roots, brush, tree trimmings, and other objectionable materials and debris. All stumps shall be grubbed.

Subgrades for fills and embankments and sites to be occupied by permanent construction shall be cleaned and stripped of all surface vegetation, sod, and organic topsoil. All waste materials shall be removed from the site and disposed of by and at the expense of Design-Builder.

3-2. EXCAVATION.

3-2.01. General. Permanent excavations shall conform to the lines and grades indicated on the Drawings. Temporary excavations shall provide adequate working space and clearances for the work to be performed therein and for installation and removal of concrete forms. In no case shall excavation faces be undercut for extended footings.

Subgrade surfaces shall be clean and free of loose material of any kind when concrete is placed thereon.

3-2.02. Temporary Excavations. Except where excavation side slopes are cut to a stable slope, excavations for structures and trenches shall be supported as necessary to prevent caving or sliding. Temporary earth retention systems shall be furnished and installed as necessary to limit the extent of excavations for the deeper structures and necessary backfill under adjacent shallower structures, and to protect adjacent structures and facilities from damage due to excavation and subsequent construction.

Design of excavations by a Professional Engineer retained by Design-Builder is required when necessary to protect adjacent existing facilities, or when design by an engineer is required by the OSHA regulations cited herein. The Design-Builder's Professional Engineer shall be licensed in the state of the Project and is responsible for design of entire excavation (both the sloping and supported portions of the excavation). The design of temporary earth retention shall comply with the paragraph of this specification titled, "Temporary Earth Retention."

Before starting construction on a temporary excavation requiring design by a professional engineer in compliance with requirements of this specification (to protect existing structures, utilities, and other facilities), the Design-Builder shall ensure that the temporary excavation design engineer shall complete the Temporary Excavation Design Certificate (Figure 1 – 02200) and the Design-builder shall submit the certificate along with proof of professional liability insurance for the temporary excavation designer. The Design-builder shall use the temporary excavation design and shall submit a separate certificate for each unique design.

3-2.03. Classification of Excavated Materials. No classification of excavated materials will be made for payment purposes. Excavation and trenching work shall include the removal and subsequent handling of all materials excavated or

otherwise removed in performance of the work, regardless of the type, character, composition, or condition thereof.

3-2.04. Preservation of Trees. No trees shall be removed outside excavated or filled areas, unless their removal is authorized by Owner. Trees left standing shall be adequately protected from damage by construction operations.

3-2.05. Unauthorized Excavation. Not applicable.

3-2.06. Blasting. Not used.

3-2.07. Dewatering. Dewatering equipment shall be provided to remove and dispose of all surface water and groundwater and all water, regardless of the source, entering excavations, trenches, or other parts of the work. Each excavation shall be kept dry during subgrade preparation and continually thereafter until the structure to be built, or the pipe to be installed therein, is completed to the extent that no damage from hydrostatic pressure, flotation, or other cause will result.

All excavations for concrete structures or trenches which extend down to or below groundwater shall be dewatered by lowering and keeping the groundwater level to the minimum depth of 24 inches [600 mm] beneath such excavations. The specified dewatering depth shall be maintained below the prevailing bottom of excavation at all times.

Surface water shall be diverted or otherwise prevented from entering excavations or trenches to the greatest extent possible without causing damage to adjacent property.

Design-Builder shall be responsible for the condition of any pipe or conduit used for drainage purposes, and all such pipe or conduit shall be left clean and free of sediment.

3-2.08. Temporary Earth Retention. Temporary excavations shall be supported with temporary earth retention systems when excavation side slopes cannot be excavated to a stable slope.

If the soldier pile and lagging method is used for temporary earth retention, the soldier piles shall be installed by drilling. The lagging shall be seasoned hardwood, with maximum board width (vertical height) of 12 inches. The lagging boards shall be installed from the top down as the excavation advances.

The use of the following devices or systems are prohibited for use as temporary earth retention systems when the retention system is required to limit ground movement to protect structures, utilities, and other adjacent facilities.

1. soldier piles with plate lagging
2. slide rail systems
3. trench shields i.e. trench boxes (trench shields are considered worker protection only, not temporary earth retention systems)

The above prohibition does not prevent Design-builder from using soldier piles with plate lagging, slide rail systems, and trench shields to protect workers in an excavation.

Excavation support systems and sheeting and shoring shall be removed unless specifically otherwise permitted by Structural Engineer of Record.

Unless the excavation support is required to be left in place the design of the excavation support system shall be such as to permit complete removal while maintaining safety and stability in the excavation at all times. Excavation support systems to be left in place shall be designed and constructed of only steel. Excavation support elements left in place, shall be cut off 24 inches minimum below the finish grade indicated on the Drawings.

3-2.09. Foundation Subgrade Preparation. Subgrades for foundations shall be prepared using the same procedure as required for fills and embankments. After preparation, foundation subgrades shall be firm, dense, and thoroughly compacted and consolidated; and shall be sufficiently stable to remain firm and intact under the feet of the workers. Reinforcing steel and concrete shall be placed as soon as possible after subgrade preparation. Subgrades that are disturbed due to weather or other conditions shall be repaired by removing the disturbed material and replacing with crushed rock select fill. Subgrade surfaces shall be clean and free of loose material of any kind when concrete is placed thereon.

3-2.10. Ring-wall Excavation. All surface vegetation, sod, and organic topsoil shall be removed beneath and within ring-wall foundations.

3-2.11. Roadway Excavation. Excavation for the roadways, drives, and parking areas shall conform to the lines, grades, cross sections, and dimensions indicated on the Drawings and shall include the excavation of all unsuitable material from the subgrade. After shaping to line, grade, and cross section, the subgrade shall be compacted to a depth of at least 6 inches and shall meet the following:

Test method to measure maximum density and moisture.	ASTM D1557
Relative compaction and moisture content relative to the optimum.	95%.
Moisture content relative to the optimum.	-2% to +2%.

This operation shall include any reshaping and wetting or drying required to obtain proper compaction. All soft or otherwise unsuitable material shall be removed and replaced with suitable material.

3-3. FILLS AND EMBANKMENTS. Fills and embankments shall be constructed to the lines and grades indicated on the Drawings. Fills and backfills placed beneath and around structures shall comply with the requirements of this specification for select fill and structure backfill, respectively. Construction of fills and embankments shall begin from the lowest elevation in each excavation or area and progress upward. Materials shall be deposited in approximately horizontal layers not to exceed 8 inches in uncompacted thickness. Unless otherwise specified herein, the following governing standards apply:

Test method to measure maximum density and moisture.	ASTM D1557.
Relative compaction.	95%.
Moisture content relative to the optimum.	-2% to +2%.

Where new fill is placed adjacent to an existing sloping surface steeper than 5 horizontal to 1 vertical, the existing slope shall be benched in advance of placement of new fill. The bench shall be of sufficient width to allow compaction of the junction between the new fill and existing earth surface.

Backfilling of excavations and construction of fills and embankments during freezing weather shall not be done. No backfill, fill, or embankment materials shall be installed on frozen surfaces, nor shall frozen materials, snow, or ice be placed in any backfill, fill, or embankment.

3-3.01. Subgrade Preparation. After preparation of the fill or embankment site, the subgrade shall be scarified and moisture conditioned to a minimum depth of 6 inches, leveled and compacted to the same relative compaction and moisture content relative to optimum as specified for fill.

Unless otherwise directed by Design-Builder, the subgrade shall be proof-rolled by a rubber-tired roller, a loaded dump truck, or other suitable rubber-tired equipment acceptable to Design-Builder. A minimum of four passes of the proof-rolling equipment shall be provided such that the last two passes are made perpendicular to the first two passes.

All soft, yielding, or otherwise unsuitable material shall be removed and replaced with compacted fill.

3-3.02. Placement and Compaction. All fill and embankment materials shall be placed in approximately horizontal layers not to exceed 8 inches in un-

compacted thickness, unless approved by the Owner. Material deposited in piles or windrows by excavating and hauling equipment shall be spread and leveled before compaction.

Each layer of material shall have the best practicable moisture content for satisfactory compaction. The material in each layer shall be wetted or dried to achieve the moisture content relative to optimum as specified above, and shall be thoroughly mixed to ensure uniform moisture content and adequate compaction. Each layer shall be thoroughly compacted to the required degree of compaction at the required moisture content. If the material fails to meet the density specified, compaction methods shall be altered. The changes in compaction methods shall include, but not be limited to, changes in compaction equipment, reduction in uncompacted lift thickness, increase in number of passes, and better moisture control.

Wherever a pipe is to installed within a fill or embankment, the fill or embankment material shall be placed and compacted to an elevation not less than 12 inches above the top of pipe elevation before the trench for pipe installation is excavated.

3-3.03. Borrow Pits. Suitable material necessary to complete fills and embankments may be excavated from borrow pits indicated on the Drawings and hauled to the site of the work. The size, shape, depth, drainage, and surfacing of all borrow pits shall be acceptable to Design-Builder. Borrow pits shall be regular in shape, with graded and surfaced side and bottom slopes, when completed. Side slopes of borrow pits shall be not steeper than 3 horizontal to 1 vertical and shall be uniform for the entire length of any one side.

3-4. FILL AND BACKFILL FOR STRUCTURES. Earth and aggregate materials placed for structures include granular fill, structure backfill, select fill, gravel base beneath slabs, and controlled low strength material In addition to the specific requirements specified herein, all requirements for placement of fills and embankments shall apply to granular fill, structure backfill, select fill, and gravel base beneath slabs. These requirements include, but are not limited to subgrade preparation, lift thickness, and moisture conditioning requirements. All fills and backfills for structures shall be constructed to the lines and grades indicated on the Drawings. Backfilling and construction of fills during freezing weather shall not be done. No backfill, fill, or embankment materials shall be installed on frozen surfaces, nor shall frozen materials, snow, or ice be placed in any backfill, fill, or embankment.

3-4.01. Granular Fill. Granular fills shall be provided where indicated on the Drawings. Granular fills shall be placed on suitably prepared sub-grades in uncompacted lift thickness of 6 inches or less and compacted by vibration. Granular fills shall be compacted to not less than 70 percent relative density as measured by ASTM D4253 and D4254. If the thickness of the granular fill is less

than 6 inches, the compaction shall be by a minimum four passes (round trips) of a self-propelled or walk-behind type vibratory roller operating in full vibration mode in accordance with manufacturer's instructions.

Where granular fills are to be covered with concrete, the top surface shall be graded to the required sub-grade elevation. The completed fill shall be covered by polyethylene film.

3-4.02. Structure Backfill. Backfill materials shall be deposited in approximately horizontal layers not to exceed 8 inches in uncompacted thickness and shall meet the following requirements:

Test method to measure maximum density and moisture.	ASTM D1557.
Relative compaction.	95%.
Moisture content relative to the optimum.	-2% to +2%.

Compaction of structure backfill shall be performed in such a manner that damage to the structure is prevented. The compaction equipment used within 8 feet of the walls and for the top 8 feet of backfill shall be the static type. Limit of equipment weight shall be 1 ton. Compaction of structure backfill by inundation with water will not be permitted.

No backfill shall be deposited or compacted in water.

Care shall be taken to compact structure backfill which will be beneath pipes, drives, roads, parking areas, walks, curbs, gutters, or other surface construction or structures. In addition, wherever a pipe is to be installed within structure backfill, the structure backfill shall be placed and compacted to an elevation not less than 12 inches above the top of pipe before the trench for pipe installation is excavated. Compacted areas, in each case, shall be adequate to support the item to be constructed or placed thereon.

3-4.03. Select Fill. Select fill shall be placed in approximately horizontal layers in uncompacted lift thickness of 8 inches or less and shall meet the following requirements:

Test method to measure maximum density and moisture.	ASTM D1557.
Relative compaction.	95%.
Moisture content relative to the optimum.	-2% to +2%.

3-4.04. Gravel Base Beneath Slabs. The gravel base beneath building floor slabs shall be placed in uncompacted lift thickness of 6 inches or less and compacted with a minimum of four passes (round trips) of a self-propelled or walk-behind type vibrating roller. The roller shall be operated in the full vibrating mode and in accordance with the manufacturer's instructions.

3-4.05. Controlled Low Strength Material (CLSM) Fill. CLSM shall not be placed on frozen ground. Batching, mixing, and placing of CLSM may be started when weather conditions are favorable and when the temperature is at least 34°F and rising. At time of placement of CLSM the temperature shall be at least 40°F. Mixing and placing shall stop when the temperature is 38°F and falling. Each filling stage shall be as continuous an operation as is practicable.

CLSM shall be discharged from the mixer by an acceptable procedure into the area to be filled. CLSM shall be placed to limits indicated on the Drawings. Mixing CLSM with in-situ soil shall be avoided.

When CLSM is placed as backfill against structures, the fill shall be placed in lifts of 2 to 3 feet and the next lift shall not be placed until the previous lift can support the weight of workers without indenting the surface and at least 16 hours have elapsed from the end of placement. Lift thickness shall be reduced as necessary to prevent floatation of the structure.

When CLSM is placed over culverts or pipelines, they shall be anchored to prevent flotation during the placement of CLSM. Unless otherwise required, CLSM shall be placed to one foot below the finished grade elevation if the finished grade elevation is not more than 5 feet over the top of the culvert or pipe. If the finished grade is more than 5 feet over the top of the culvert or pipe, CLSM shall be placed to an elevation 2 feet over the top of the culvert or pipe, and the remainder shall be backfilled with the specified backfill or as indicated on the Drawings.

3-4.06. Ringwall Fill. Fill within ringwall foundations shall be granular fill and shall be placed and compacted as indicated on the Drawings and as specified herein. If no treated sand layer is required directly beneath the tank bottom, the fill shall be sloped or crowned up to the center of the tank or reservoir as indicated on the Drawings. If a treated sand layer is required, the fill shall be finished to true grade in preparation for the treated sand layer.

3-5. FILTER FABRIC INSTALLATION. Filter fabric shall be placed as specified herein and at the locations specified or otherwise indicated on the Drawings.

Filter fabric shall be protected from contamination by foreign material and damage. Any contaminated or damaged filter fabric shall be replaced with new filter fabric at no additional cost to the Owner. The fabric shall be covered within 7 calendar days after placement.

The subgrade for placement of filter fabric shall be smooth and free of irregularities and undulations. Filter fabric shall be laid smooth and free of tension, stress, folds, wrinkles, or creases. Type A and B filter fabric shall be overlapped a minimum of 2 feet between adjacent roll ends and adjacent strips.

The joints of Type C filter fabric shall be sewn unless otherwise recommended by the manufacturer for the specific application. All seams shall be formed by mating the edges of the filter fabric panels and sewing them together with continuous stitches located a minimum of three inches from the edges. The thread shall be ultraviolet light resistant and manufactured from the same material as the filter fabric. A two-thread, type 401 double-lock stitch shall be used for all sewn work. Sewing methods shall conform to the latest procedures recommended by the filter fabric manufacturer. The Design-Builder shall demonstrate that the seam efficiency meets the requirements of the specified tabulated properties for the filter fabric as applicable.

All filter fabric placed shall be fixed to the subgrade to prevent filter fabric slippage or movement during placement of subsequent materials. Pins or staples shall not be used to fix the filter fabric to the subgrade when a geomembrane is to be placed on top of the filter fabric.

The Design-Builder shall exercise care during filter fabric installation to prevent damage to the prepared supporting subgrade surface. The shall exercise care to prevent the entrapment of rocks, clods of earth or other material which could damage the filter fabric, clog the filter fabric or hamper seaming. Filter fabric damaged or distressed by foreign objects shall be repaired or replaced.

No foot traffic will be allowed on the filter fabric except with approved smooth-sole shoes. The Design-Builder shall not use the filter fabric surface as a work area or storage area for tools and supplies.

Tracked or rubber tired construction equipment shall not be operated directly upon the filter fabric until a minimum thickness of 6 inches of the cover material is placed over the filter fabric. Turning of construction vehicles shall be minimized to avoid distorting or damaging the filter fabric.

3-6. GEOCOMPOSITE SHEET DRAINS INSTALLATION. The prefabricated geocomposite sheet drains shall be placed on buried structure walls as indicated on the Drawings. The fabric shall extend beyond the edges of the core to provide overlap for the adjacent panels. Before beginning the backfilling operations the geocomposite drains shall be permanently secured to the walls by means of an attachment system recommended by the sheet drain manufacturer. Adjacent sheet drain panels shall be joined as recommended by the manufacturer. Terminal edges of the sheet drain shall be covered by tucking the filter fabric flap behind the core. The bottom end of the sheet drain to be embedded in the granular drainage material shall have the plastic core exposed

by peeling back the fabric a minimum of 3 inches but not so much as to expose the plastic core to intrusion and plugging by soil backfill. Backfill shall be placed and completed within 2 weeks of installation of the sheet drains.

3-7. FINAL GRADING AND PLACEMENT OF TOPSOIL. After other outside work has been finished, and backfilling and embankments completed and settled, all areas which are to be graded shall be brought to grade at the indicated elevations, slopes, and contours. All cuts, fills, embankments, and other areas which have been disturbed or damaged by construction operations shall be surfaced with topsoil to a depth of at least 4 inches. Topsoil shall be of a quality at least equal to the existing topsoil in adjacent areas, free from trash, stones, and debris, and well suited to support plant growth.

Use of graders or other power equipment will be permitted for final grading and dressing of slopes, provided the result is uniform and equivalent to manual methods. All surfaces shall be graded to secure effective drainage. Unless otherwise indicated, a slope of at least 1 percent shall be provided.

Final grades and surfaces shall be smooth, even, and free from clods and stones, weeds, brush, and other debris. Seeding and sod placement shall be in accordance with the Seeding and Sodding section.

3-8. DISPOSAL OF EXCAVATED MATERIALS. Suitable excavated materials may be used in fills and embankments as shown on the Drawings. Excess material shall be disposed of at the locations indicated on the Drawings; all such material shall be graded for drainage and shall be compacted as shown in the Specifications and Drawings.

All debris, stones, logs, stumps, roots, and other unsuitable materials shall be removed from the site and disposed of.

End of Section

Section 31 23 33

TRENCHING AND BACKFILLING

PART 1 - GENERAL

1-1. SCOPE. This section covers clearing, grubbing, and preparation of the site; removal and disposal of all debris; excavation and trenching; tunneled (trenchless construction) crossings; the handling, storage, transportation, and disposal of all excavated material; all necessary sheeting, shoring, and protection work; preparation of subgrades; pumping and dewatering as necessary; protection of adjacent property; backfilling; pipe embedment; surfacing and grading; and other appurtenant work.

1-2. GENERAL. With reference to the terms and conditions of the construction standards for excavations set forth in OSHA "Safety and Health Regulations for Construction", Chapter XVII of Title 29, CFR, Part 1926, Design-Builder shall employ a competent person and, when necessary based on the regulations, a licensed or registered professional engineer, to act upon all pertinent matters of the work of this section.

1-3. SUBMITTALS. Drawings, specifications, and data covering the proposed materials shall be submitted in accordance with the Submittals Procedures section.

At least 30 days before starting construction on the sheeting and shoring, and in accordance with the OSHA requirements identified above, the Design-Builder shall ensure that the sheeting and shoring design engineer shall complete the WTR-FM-EN-1001, Protective System Design Certificate -2 and shall use the sheeting and shoring design. If required by the CalOSHA requirements identified above or to protect existing facilities, the Design-Builder shall submit a separate certificate for each unique design. If required for protection of existing facilities or as required by the CalOSHA regulations identified above, the certificate(s) shall be signed and sealed by the registered professional engineer that designed the protection system.

1-3.01. Filter Fabric Data. Complete descriptive and engineering data for the fabric shall be submitted. Data submitted shall include:

A 12 inch square sample of fabric.

Manufacturer's descriptive product data.

Installation instructions.

1-3.02 Embedment and Backfill Materials. Complete test results covering tests performed by an independent commercial testing laboratory retained by the

Design-Builder for all materials described in the Materials Testing section shall be submitted.

PART 2 - PRODUCTS

2-1. MATERIALS.

2-1.01. Filter Fabric. The fabric shall be provided in rolls wrapped with covering for protection from mud, dirt, dust, and debris.

2-1.01.01. Filter Fabric Type A. Filter fabric Type A shall be provided for installation at locations indicated on the Drawings and as specified herein. Filter Fabric Type A shall be a nonwoven fabric consisting of only continuous chains of polymeric filaments or yarns of polyester formed into a stable network by needle punching. The fabric shall be inert to commonly encountered chemicals; shall be resistant to mildew, rot, ultraviolet light, insects, and rodents; and shall have the indicated properties:

Property	Test Method	Unit	Minimum Average Roll Value *
Fabric Weight	ASTM D3776	oz/yd2	5.7
Grab Strength	ASTM D4632	lb	155
Grab Elongation	ASTM D4632	percent	50
Mullen Burst Strength	ASTM D3786	psi	190
Apparent Opening Size	CW-02215	U.S. Standard Sieve Size	70

* Minimum average roll value in weakest principal direction.

2-1.01.02. Filter Fabric Type B. Filter fabric Type B shall be provided for installation at locations indicated on the Drawings and as specified herein. Filter fabric Type B shall be a nonwoven fabric consisting of only continuous chains of polymeric filaments or yarns of polyester formed into a stable network by needle punching. The fabric shall be inert to commonly encountered chemicals; shall be resistant to mildew, rot, ultraviolet light, insects, and rodents; and shall have the indicated properties:

Property	Test Method	Unit	Minimum Average Roll Value *
Fabric Weight	ASTM D3776	oz/yd2	8.0
Grab Strength	ASTM D4632	lb	215
Grab Elongation	ASTM D4632	percent	50
Mullen Burst Strength	ASTM D3786	psi	375
Apparent Opening Size	CW-02215	U.S. Standard Sieve Size	70

* Minimum average roll value in weakest principal direction.

2-1.02. Polyethylene Film. Polyethylene film beneath concrete slabs or slab base course material shall be Product Standard PS17, 6 mil minimum thickness.

2-1.03. Tunnel Materials. Not used.

2-1.04. Backfill Materials.

2-1.04.01. Job Excavated Material. Job excavated material may be used for either uncompacted or compacted trench backfill when the job excavated material is finely divided and free from debris, organic material, cinders, corrosive material, and stones larger than 3 inches in greatest dimension. Masses of moist, stiff clay shall not be used.

2-1.04.02. Inundated Sand Fill. Sand fill shall be clean, with not more than 25 percent retained on a No. 4 [4.75 mm] sieve and not more than 7 percent passing a No. 200 [75 µm] sieve, and shall have an effective size between 0.10 and 0.30 mm.

2-1.04.03 Graded Gravel Fill. Graded gravel for compacted trench backfill shall conform to the following gradation:

Sieve Size	Percent Passing by Weight
1 inch	100
3/4 inch	85 – 100
3/8 inch	50 – 80
No. 4	35 – 60
No. 40	15 – 30
No. 200	5 – 10

The gravel mixture shall contain no clay lumps or organic matter. The fraction passing the No. 4 sieve shall have a liquid limit not greater than 25 and a plasticity index not greater than 5.

2-1.04.04. Granular Fill. Granular fill material shall be crushed rock or gravel. Granular fill shall be free from dust, clay, and trash; shall be hard, durable, and non-friable; and shall be graded 3/4 inch to No. 4 [19 to 4.75 mm] as defined in ASTM C33 for No. 67 coarse aggregate. Granular fill shall meet the quality requirements for ASTM C33 coarse aggregate.

2-1.05. Controlled Low Strength Material (CLSM) Fill. CLSM shall consist of a mixture of Portland cement, fly ash, sand, and water and shall be placed at locations indicated on the Drawings or as directed by Engineer. The class of CLSM shall be as specified below.

The type of cement in CLSM shall be ASTM C150 Type I. The class of fly ash in CLSM shall be ASTM C618 Class C, except loss on ignition shall not exceed 4 percent. Fine aggregate in CLSM shall be clean natural sand, ASTM C33, except that clay particles shall not exceed one percent. Water in CLSM shall be potable.

Design-builder shall design and test the CLSM. Initial set time shall be 8 hours plus or minus one hour as measured by ASTM C403. CLSM shall have an efflux time of 10 to 26 seconds through a special flow cone with a 1/2 inch discharge tube.

The batch proportions shall apply only for materials from the same source and having the same characteristics as the materials used in the mix design. If a change in sources of materials is proposed, a new mix design shall be developed before the new material is used. When unsatisfactory results or other conditions make it necessary, Design-builder shall develop a new mix design to obtain the desired results.

2-1.05.01. Class A CLSM. The initial trial mixture for Class A CLSM shall consist of the following minimum proportions per cubic yard:

Cement	50 lb
Fly Ash	250 lb
Sand (SSD)	2860 lb
Water	370 lb
Air Entraining Agent	6 percent
Compressive strength range at 56 days	100-150 psi

2-1.05,02. Class B CLSM. The initial trial mixture for Class B CLSM shall consist of the following minimum proportions per cubic yard:

Cement	100 lb
Fly Ash	100 lb
Sand (SSD)	2760 lb
Water	386 lb
Air Entraining Agent	5 percent
Compressive strength Range at 56 days	125-250 psi

2-1.05.03. Class C CLSM. The initial trial mixture for Class C CLSM shall consist of the following minimum proportions per cubic yard:

Cement	80 lb
Fly Ash	275 lb
Sand (SSD)	2795 lb
Water	370 lb
Air Entraining Agent	4 percent
Minimum compressive strength at 56 days	370 psi

2-1.06. Pipe Embedment Material. Pipe embedment material shall be placed as indicated in Figure 1-31 23 33.

2-1.06.01. Granular Embedment. Granular embedment shall consist of crushed rock and crushed gravel, meeting the quality and gradation requirements of coarse aggregate size number 7 of ASTM C33.

2-1.06.02. Hand Placed Embedment. Hand placed embedment shall be finely divided job excavated or imported material, free from organic materials, debris, and stones.

2-1.06.03. Compacted Embedment. Compacted embedment shall be finely divided job excavated material free from debris, organic material, and stones. Graded gravel may be substituted for compacted embedment. Granular embedment may be substituted for all or part of the compacted embedment at the option of the Contractor.

2-2. MATERIALS TESTING.

2-2.01. Preliminary Review of Materials. All tests required for preliminary review of materials shall be made by an acceptable independent testing laboratory at the expense of Design-Builder. Two initial gradation tests shall be made for each type of embedment, fill, backfill, or other material, and one additional gradation test shall be made for each additional 500 tons of each material delivered to the site. In addition, one set of initial Atterberg Limits test shall be made for each fill materials containing more than 20 percent by weight passing the No. 200 sieve. One additional Atterberg Limits test shall be made for each additional 500 tons of each material delivered to the site.

All material testing on CLSM shall be made by an independent testing laboratory.

2-2.02. Field Testing Expense. All moisture-density (Proctor) tests and relative density tests on the materials, and all in-place field density tests, shall be made by an independent testing laboratory at the expense of Design-Builder. Design-builder shall provide access to the materials and work area and shall assist the laboratory as needed in obtaining representative samples.

2-2.03. Required Tests. For planning purposes, the following guidelines shall be used for frequency of field tests. Additional tests shall be performed as necessary for job conditions and number of failed tests. Test results shall be submitted as specified in the Submittals Procedures section.

a. Two moisture density (Proctor) tests in accordance with ASTM D698 (or, when required, ASTM D1557), or two relative density tests in accordance with ASTM D4253 and D4254 for each type of general fill, designated fill, backfill, or other material proposed.

b. In-place field density and moisture tests (ASTM D6938) at intervals of 1000 feet maximum along the trench.

c. One in-place field density and moisture test (ASTM D6938) for every 200 cubic yards of backfill.

d. One in-place density and moisture test (ASTM D6938) whenever there is a suspicion of a change in the quality of moisture control or effectiveness of compaction.

e. Additional gradation, Proctor, and relative density tests whenever the source or quality of material changes.

f. Testing of CLSM shall be as follows:
Compressive Strength. For every 200 cubic yards of CLSM placed, fill four 6 by 12 inch plastic cylinder molds to overflowing and then tap sides lightly. Cure cylinders in the molds covered until time of testing, at least 14 days. Strip the cylinders carefully using a knife to cut away the plastic mold. Cap the cylinders with high strength

gypsum plaster or other capping process that will not break these low strength materials. Test cylinders in accordance with ASTM C39. Two cylinders shall be tested at 7 days and the other two cylinders shall be tested at 56 days.
Flow of Fill. Once each day that CLSM is placed, test the fill material in accordance with ASTM C939 for the efflux time. Wet screening may be required to remove coarse particles.
Unit Weight and Yield. Once each day that CLSM is placed, measure unit weight and yield in accordance with ASTM C138.
Air Content. Once each day that CLSM is placed, measure air content in accordance with ASTM C231.
Penetration Resistance. Once each day that CLSM is placed, measure early bearing strength in accordance with ASTM C403 penetration procedure.

PART 3 - EXECUTION

3-1. CLEARING. All clearing shall be performed as necessary for access, stringing of pipeline materials, and construction of the pipeline and appurtenant structures.

3-2. EXCAVATION. Excavations shall provide adequate working space and clearances for the work to be performed therein and for installation and removal of concrete forms. In no case shall excavation faces be undercut for extended footings.

Subgrade surfaces shall be clean and free of loose material of any kind when concrete is placed thereon.

Except where exterior surfaces are specified to be damp-proofed, monolithic concrete manholes and other concrete structures or parts thereof, which do not have footings that extend beyond the outside face of exterior walls, may be placed directly against excavation faces without the use of outer forms, provided that such faces are stable and also provided that a layer of polyethylene film is placed between the earth and the concrete.

Excavations for manholes and similar structures constructed of masonry units shall have such horizontal dimensions that not less than 6 inches clearance is provided for outside plastering.

3-2.01. Classification of Excavated Materials. No classification of excavated materials will be made for payment purposes. Excavation and trenching work shall include the removal and subsequent handling of all materials excavated or otherwise removed in performance of the work, regardless of the type, character, composition, or condition thereof.

3-2.02. Preservation of Trees. No trees shall be removed outside excavated or filled areas, unless their removal is authorized by Owner. Trees left standing shall be adequately protected from permanent damage by construction operations.

3-2.03. Blasting. Not used.

3-2.04. Dewatering. Dewatering equipment shall be provided to remove and dispose of all surface water and groundwater entering excavations, trenches, or other parts of the work. Each excavation shall be kept dry during subgrade preparation and continually thereafter until the structure or tunnel to be built, or the pipe to be installed therein, is completed to the extent that no damage from hydrostatic pressure, flotation, or other cause will result.

All excavations for concrete structures or trenches which extend down to or below groundwater shall be dewatered by lowering and keeping the groundwater level to the minimum depth of 24 inches, beneath such excavations. The specified dewatering depth shall be maintained below the prevailing bottom of excavation at all times.

Surface water shall be diverted or otherwise prevented from entering excavations or trenches to the greatest extent possible without causing damage to adjacent property.

Design-Builder shall be responsible for the condition of any pipe or conduit which he may use for drainage purposes, and all such pipe or conduit shall be left clean and free of sediment.

Design-Builder shall obtain from the appropriate agencies and authorities, the dewatering and stormwater discharge permits required to remove and dispose of groundwater, surface water, and any other water used in Design-Builder's operations. The permits shall be obtained prior to start of construction.

3-2.05. Sheeting and Shoring. Except where banks are cut back on a stable slope, excavations for structures and trenches shall be supported with steel sheet piling and shoring as necessary to prevent caving or sliding.

Sheet piling or other excavation support systems shall be installed as necessary to limit the extent of excavations for deeper structures and to protect adjacent structures and facilities from damage due to excavation and subsequent construction. Design-Builder shall assume complete responsibility for, and shall install adequate protection systems for prevention of damage to existing facilities.

Sheeting, shoring and excavation support systems shall be designed by a professional engineer registered in the state where the project is located.

Trench sheeting may be removed if the pipe strength is sufficient to carry trench loads based on trench width to the back of sheeting. Trench sheeting shall not be pulled after backfilling. Where trench sheeting is left in place, it shall not be braced against the pipe, but shall be supported in a manner which will preclude concentrated loads or horizontal thrusts on the pipe. Cross braces installed above the pipe to support sheeting may be removed after pipe embedment has been completed. Trench sheeting shall be removed unless removal of the sheeting will cause damage to the facility it is protecting or loss of necessary piping support from the piping embedment. If left in place, the sheeting shall cut off 12 inches below finished grade. The design of the support system shall be such as to permit complete removal while maintaining safety and stability at all times.

A movable trench support may be used, provided care is exercised in placing and moving the trench box or support bracing to prevent movement of the pipe and bedding and backfill material meets the required compaction without voids.

3-2.06. Stabilization. Sub-grades for concrete structures and trench bottoms shall be firm, dense, and thoroughly compacted and consolidated; shall be free from mud and muck; and shall be sufficiently stable to remain firm and intact under the feet of the workers.

Sub-grades for concrete structures or trench bottoms which are otherwise solid, but which become mucky on top due to construction operations, shall be reinforced with crushed rock or gravel as specified for granular fills. The stabilizing material shall be placed in a manner that no voids remain in the granular fill. All excess granular fill with unfilled void space shall be removed. The finished elevation of stabilized sub-grades shall not be above sub-grade elevations indicated on the Drawings.

3-3. TRENCH EXCAVATION. No more trench shall be opened in advance of pipe laying than is necessary to expedite the work. One block or 400 feet, whichever is the shorter, shall be the maximum length of open trench on any line under construction.

Except where tunneling is indicated on the Drawings, and is specified, all trench excavation shall be open cut from the surface.

Prior to excavation, Design-Builder shall contact local underground alert hotlines, “Dig Safe” and/or individual utility owners for marking underground utilities. Once utilities are marked, Design-Builder shall hand dig or pothole to expose the existing utilities. A survey shall be made of the utility size, material, location, and elevation prior to trench excavation and information shall be recorded on the record Drawings maintained by the Design-Builder.

3-3.01. Alignment, Grade, and Minimum Cover. The alignment and grade or elevation of each pipeline shall be fixed and measured from offset stakes. Vertical and horizontal alignment of pipes, and the maximum joint deflection used in connection therewith, shall be in conformity with requirements of the section covering installation of pipe.

Where pipe grades or elevations are not definitely fixed by the Drawings, trenches shall be excavated to a depth sufficient to provide a minimum depth of backfill cover over the top of the pipe as described in the general Yard Piping notes in the drawings. Greater pipe cover depths may be necessary on vertical curves or to provide adequate clearance beneath existing pipes, conduits, drains, drainage structures, or other obstructions encountered at normal pipe grades. Measurement of pipe cover depth shall be made vertically from the outside top of pipe to finished ground or pavement surface elevation, except where future surface elevations are indicated on the Drawings.

3-3.02. Maximum Trench Widths. Not used.

3-3.03. Minimum Trench Widths. Except when maximum trench width is required for certain conduits, trenches shall be excavated to the minimum trench widths indicated in the following table. Trenches shall be excavated to a width which will provide adequate working space and sidewall clearances for proper pipe installation, jointing, and embedment.

Nominal Pipe Size	Minimum Trench Width	Clearance
Less than 27 in	Pipe OD plus 24 in	12 in
27 in through 60 in	Pipe OD plus nominal pipe size	ID/2
Greater than 60 in	Pipe OD plus 70 in	30 in

Clearance = Minimum sidewall clearance
OD = Outside diameter (or span) of conduit
ID = Inside diameter (or span) of conduit.

Specified minimum sidewall clearances are not minimum average clearances but are minimum clear distances which will be required to the trench excavation or the trench protective system.

Cutting trench banks on slopes to reduce earth load to prevent sliding and caving shall be used only in areas where the increased trench width will not interfere with surface features or encroach on right-of-way limits.

3-3.04. Mechanical Excavation. The use of mechanical equipment will not be permitted in locations where its operation would cause damage to trees, buildings, culverts, or other existing property, utilities, or structures above or below ground. In all such locations, hand excavating methods shall be used.

Mechanical equipment used for trench excavation shall be of a type, design, and construction, and shall be so operated, that the rough trench excavation bottom elevation can be controlled, and that trench alignment is such that pipe, when accurately laid to specified alignment, will be centered in the trench with adequate sidewall clearance. Undercutting the trench sidewall to obtain sidewall clearance will not be permitted.

In locations where maximum trench widths are required for designated rigid conduits, mechanical equipment shall be operated so that uniform trench widths and vertical sidewalls are obtained at least from an elevation 12 inches above the top of the installed pipe to the bottom of the trench.

3-3.05. Cutting Concrete Surface Construction. Not used.

3-3.06. Excavation Below Pipe Sub-grade. Except where otherwise required, pipe trenches shall be excavated below the underside of the pipe, as indicated on Figure 1-31 23 33, to provide for the installation of granular embedment.

Bell holes shall provide adequate clearance for tools and methods used for installing pipe. No part of any bell or coupling shall be in contact with the trench bottom, trench walls, or granular embedment when the pipe is jointed.

3-3.07. Artificial Foundations in Trenches. Whenever unsuitable or unstable soil conditions are encountered, Design-Builder shall notify Geotechnical and Structural Engineers of Record and, with approval, trenches shall be excavated below grade and the trench bottom shall be brought to grade with suitable material.

3-3.08. Over-Excavation. Over-excavation carried below the grade shall be backfilled to the required grade and compacted.

3-4. PIPE EMBEDMENT. Embedment materials both below and above the bottom of the pipe, classes of embedment to be used, and placement and compaction of embedment materials shall conform to the requirements indicated on Figure 1-31 23 33 and to the following supplementary requirements.

Embedment material shall contain no cinders, clay lumps, or other material which may cause pipe corrosion.

3-4.01. Embedment Classes.

a. Class A Arch Encasement. When arch encasement is indicated on the Drawings, Class A arch encasement shall be used at all locations so indicated.
When arch encasement is not indicated on the Drawings, Class A arch encasement is not required unless improper trenching or

unexpected trench conditions require its use.
Concrete and reinforcing steel for Class A arch encasement shall conform to the requirements of the Cast-in-Place Concrete and Concrete Reinforcement sections.

b. Class B Embedment. Class B bedding shall be used for all steel, ductile iron, bar-wrapped concrete, and vitrified clay pipelines, and for all other pipelines not otherwise specified.

c. Class B Special Embedment. Class B special embedment shall be used for HDPE, PVC, ABS, FRP, GRP, steel or stainless steel pipe where the process fluid design maximum temperature is 140° F or higher such as for pressurized air service, and when recommended by the pipe manufacturer.

d. Class C Embedment. Class C embedment shall be used for all reinforced concrete and prestressed concrete pipelines.

3-4.02. Embedment for Ductile Iron, Steel, FRP, and PVC Pipelines. Granular embedment for polyethlene tube protected ductile iron, coal tar or tape coated steel, FRP, and PVC pipelines shall be crushed rock or crushed gravel with rounded or subrounded particles. Crushed rock or gravel with sharp edges which could cause significant scratching or abrasion of the pipe or damage to the coating or polyethylene tube protection shall not be used.

Inundated sand may be used for granular embedment in locations where the use of water will cause no damage to adjacent property and where it can be placed and properly compacted without damage to the pipe.

Inundated sand for granular embedment shall be deposited in, or placed simultaneously with the application of water so that the sand is inundated during compaction. During placement, the sand shall be compacted with a mechanical probe type vibrator. Water shall be allowed to escape or shall be removed during vibration, and no ponding shall be allowed to take place. Inundated sand shall be compacted to 70 percent relative density as measured by ASTM D4253 and D4254. If the required density cannot be achieved, placement and compaction methods shall be altered.

3-4.03. Placement and Compaction.

3-4.03.01. Granular Embedment. Granular embedment material shall be spread and the surface graded to provide a uniform and continuous support beneath the pipe at all points between bell holes or pipe joints. It will be permissible to slightly disturb the finished subgrade surface by withdrawal of pipe slings or other lifting tackle.

After each pipe has been graded, aligned, and placed in final position on the bedding material, and shoved home, sufficient pipe embedment material shall be

deposited and compacted under and around each side of the pipe and back of the bell or end thereof by shovel slicing or other suitable methods to hold the pipe in proper position and alignment during subsequent pipe jointing and embedment operations.

Placing and compaction of embedment material shall not damage the pipe coating or polyethylene encasement. Embedment material shall not be dumped directly on the pipe or polyethylene encasement unless a suitable temporary isolation layer such as a 60 mil HDPE sheeting, is used to cover the pipe and polyethylene encasement.

Embedment material shall be deposited and compacted uniformly and simultaneously on each side of the pipe to prevent lateral displacement. Granular embedment shall be placed in layers not more than 6 inches deep and compacted as specified.

Each lift of granular embedment material shall be vibrated with a mechanical probe type vibrator or shovel sliced during placement to ensure that all spaces beneath the pipe are filled. Granular embedment shall be placed in maximum lift thickness of 6 inches and compacted. Each lift of embedment material shall be compacted with three passes (round trip) of a platform type vibrating compactor and to at least 70 percent relative density as measured by ASTM D4253 and D4254.

Where indicated on the Drawings or where silt, fine sand, or soft clay soils are encountered below groundwater, migration of soil into the embedment material shall be prevented by installing filter fabric Type A, or by using graded gravel in place of granular embedment. Filter fabric shall be placed on the trench surfaces so that it completely surrounds the embedment material. Joints shall be lapped 12 inches.

3-4.03.02. Compacted Embedment. Compacted embedment shall be placed in uniform layers not more than 8 inches thick and compacted to not less than 95% maximum density as determined by ASTM D698

Where Class C embedment is required, compacted embedment shall be placed to the top of the pipe in all areas where compacted trench backfill is specified and around restrained pipe sections. Placing and compaction of embedment shall not damage the pipe or coating.

3-4.03.03 Hand Placed Embedment. Hand placed embedment shall be placed by hand shovels or using methods that prevent dropping the material for more than 24 inches above the pipe. Hand placed embedment shall be lightly tamped using hand equipment. Care shall be taken so as to not damage the pipe or coating.

3-4.03.04. Compaction - Trench Box Support Systems. Where trench box support systems are used embedment compaction shall be performed outside the limits of the trench box so that relocating the trench box will not disturb the compacted embedment. Where necessary to protect workers, the compaction may be performed by compaction rollers or other compaction systems that are operated from above the trench and achieve the required compaction.

Trench boxes for earth trenches shall be positioned such that the bottom of the trench box is no lower than approximately two feet above the bottom of pipe invert elevation so that initial compaction of the haunch area of the pipe, from within the trench box, extends the full width of trench. Trenches shall be shaped to support the trench box above the bottom of trench.

When in rock and where it is not practicable to shape the trench to provide the trench box support above the bottom of the trench, initial compaction of the haunch area may be performed within the trench box.

Final compaction of the haunch area and all other compaction shall be performed outside the limits of the trench box after the trench box has advanced into the next section of trench.

3-4.04. Groundwater Barrier. Continuity of embedment material shall be interrupted by low permeability groundwater barriers to impede passage of water through the embedment. Groundwater barriers for sewer lines that contain manholes with cast-in-place bases shall be compacted soil around each manhole, extending through any granular material beneath the manhole, and meeting ASTM D2487 soil classification GC, SC, CL, or ML-CL and shall be compacted to at least 95 percent of maximum density with moisture content within 2 percent of the optimum moisture content (ASTM D698). Material may be finely divided, suitable job excavated material, free from stones, organic matter, and debris.

Groundwater barriers for sewer lines that contain manholes with precast (developed) bases and for all other pipelines shall be soil plugs of 3 feet in width, extending the full depth and width of granular material, and spaced not more than 400 feet apart. The soil plugs shall be constructed from soil meeting ASTM D2487 classification GC, SC, CL, or ML, and compacted to 95 percent of maximum density at near the optimum moisture content (ASTM D698).

3-5. TRENCH BACKFILL. All trench backfill above pipe embedment shall conform to the following requirements.

A layer of backfill material not more than 8 inches deep may be placed over concrete arch encasement or concrete thrust blocking after the concrete has reached its initial set, to aid curing. No additional backfill shall be placed over

arch encasement or blocking until the concrete has been in place for at least 3 days.

3-5.01. Compacted Backfill. Compacted backfill will be required for the full depth of the trench above the embedment in the following locations:

Where beneath pavements, surfacings, driveways, curbs, gutters, walks, or other surface construction or structures.

Where in street, road, or highway shoulders.

In established lawn areas.

The top portion of backfill beneath established lawn areas shall be finished with at least 12 inches of topsoil corresponding to, or better than that which is underlying adjoining lawn areas.

Trench backfill material shall be suitable job excavated material and shall be as specified herein.

3-5.01.01. Job Excavated Material. Job excavated materials shall be placed in uniform layers not exceeding 8 inches in uncompacted thickness. Each layer of material shall have the best possible moisture content for satisfactory compaction. The material in each layer shall be wetted or dried as needed and thoroughly mixed to ensure uniform moisture content and adequate compaction. Increased layer thickness may be permitted for noncohesive material if the specified compacted density will be obtained. The method of compaction and the equipment used shall be appropriate for the material to be compacted and shall not transmit damaging shocks to the pipe. Job excavated material shall be compacted to 95 percent of maximum density at a moisture content within 2 percent of the optimum moisture content as determined by ASTM D1557 when that test is appropriate, or to 70 percent relative density as measured by ASTM D4253 and D4254 when those tests are appropriate.

3-5.01.02. Inundated Sand. Sand shall be deposited in, or placed simultaneously with the application of, water so that the sand is inundated during compaction. During placement, the sand shall be compacted with a mechanical probe type vibrator. Water shall be allowed to escape or shall be removed during vibration and no ponding shall be allowed to take place. Inundated sand shall be compacted to 70 percent relative density as measured by ASTM D4253 and D4254. If the required relative density cannot be achieved, use of inundated sand shall be discontinued.

3-5.01.03. Graded Gravel. Gravel backfill shall be deposited in uniform layers not exceeding 12 inches in uncompacted thickness. The backfill shall be compacted with a suitable vibratory roller or platform vibrator to at least 70 percent relative density as measured by ASTM D4253 and D4254.

Groundwater barriers specified under pipe embedment shall extend to the top of the graded gravel backfill.

3-5.02. Ordinary Backfill. Compaction of trench backfill above pipe embedment in locations other than those specified will not be required except to the extent necessary to prevent future settlement. Design-Builder shall be responsible for backfill settlement as specified.

Ordinary earth backfill material to be placed above embedments shall be free of brush, roots more than 2 inches in diameter, debris, cinders, and any corrosive material, but may contain rubble and detritus from rock excavation, stones, and boulders in certain portions of the trench depth.

Backfill material above embedments shall be placed by methods which will not impose excessive concentrated or unbalanced loads, shock, or impact on installed pipe, and which will not result in displacement of the pipe.

Compact masses of stiff clay or other consolidated material more than 1 cubic foot in volume shall not be permitted to fall more than 5 feet into the trench, unless cushioned by at least 2 feet of loose backfill above pipe embedment.

No trench backfill material containing rocks or rock excavation detritus shall be placed in the upper 18 inches of the trench, nor shall any stone larger than 8 inches in its greatest dimension be placed within 3 feet of the top of pipe. Large stones may be placed in the remainder of the trench backfill only if well separated and so arranged that no interference with backfill settlement will result.

3-5.03. Water-Settled Earth Backfill. Settlement or consolidation of trench backfill using water jetting or ponding shall not be performed.

3-5.04. Structure Backfill. Backfill around manholes and small concrete vaults shall meet the requirements specified for structure backfill specified in the Excavation and Fill for Structures section.

3-5.05. Controlled Low Strength Material (CLSM). CLSM shall not be placed on frozen ground. Batching, mixing, and placing of CLSM may be started when weather conditions are favorable and when the temperature is at least 34°F and rising. At time of placement, CLSM shall have a temperature of at least 40°F. Mixing and placing shall stop when the temperature is 38°F and falling. Each filling stage shall be as continuous an operation as is practicable.

CLSM shall be discharged from the mixer by an acceptable procedure into the area to be filled. CLSM shall be placed to limits indicated on the Drawings. Mixing CLSM with in-situ soil shall be avoided.

When CLSM is placed as backfill against structures, the fill shall be placed in lifts of 2 to 3 feet and the next lift shall not be placed until the previous lift has taken initial set and at least 16 hours have elapsed from the end of placement. Lift thickness shall be reduced as necessary to prevent floatation of the structure.

When CLSM is placed over culverts or pipelines, they shall be anchored to prevent flotation during the placement of CLSM. Unless otherwise required, CLSM shall be placed to one foot below subgrade elevation if the subgrade elevation is not more than 5 feet over the top of the culvert or pipe. If the subgrade is more than 5 feet over the top of the culvert or pipe, CLSM shall be placed to an elevation 2 feet over the top of the culvert or pipe, and the remainder shall be backfilled with soil designated by Design-Builder.

3-6. TUNNEL EXCAVATION. Not used.

3-7. DRAINAGE MAINTENANCE. Trenches across roadways, driveways, walks, or other trafficways adjacent to drainage ditches or watercourses shall not be backfilled prior to completion of backfilling the trench on the upstream side of the trafficway, to prevent impounding water after the pipe has been laid. Bridges and other temporary structures required to maintain traffic across such unfilled trenches shall be constructed and maintained by Design-Builder. Backfilling shall be done so that water will not accumulate in unfilled or partially filled trenches. All material deposited in roadway ditches or other watercourses crossed by the line of trench shall be removed immediately after backfilling is completed, and the original section, grades, and contours of ditches or watercourses shall be restored. Surface drainage shall not be obstructed longer than necessary.

3-8. PROTECTION OF TRENCH BACKFILL IN DRAINAGE COURSES. Not used.

3-9. FINAL GRADING AND PLACEMENT OF TOPSOIL. After other outside work has been finished, and backfilling and embankments completed and settled, all areas which are to be graded shall be brought to grade at the indicated elevations, slopes, and contours. All cuts, fills, embankments, and other areas which have been disturbed or damaged by construction operations shall be surfaced with topsoil to a depth of at least 4 inches. Topsoil shall be of a quality at least equal to the existing topsoil in adjacent areas, free from trash, stones, and debris, and well suited to support plant growth. Topsoil required to provide the minimum thickness shall be imported and placed at no additional cost to the Owner.

Use of graders or other power equipment will be permitted for final grading and dressing of slopes, provided the result is uniform and equivalent to manual methods. All surfaces shall be graded to secure effective drainage. Unless otherwise indicated, a slope of at least 1 percent shall be provided.

Final grades and surfaces shall be smooth, even, and free from clods and stones, weeds, brush, and other debris.

3-10. DISPOSAL OF EXCESS EXCAVATED MATERIALS. Disposal of excess material from trench excavations on plant and major facility construction sites shall be accomplished as specified in the Excavation and Fill for Structures section of the Specifications for the major construction.

Disposal of excess material from trench excavation sites shall be as follows. Except as otherwise permitted, all excess excavated materials shall be disposed of away from the site.

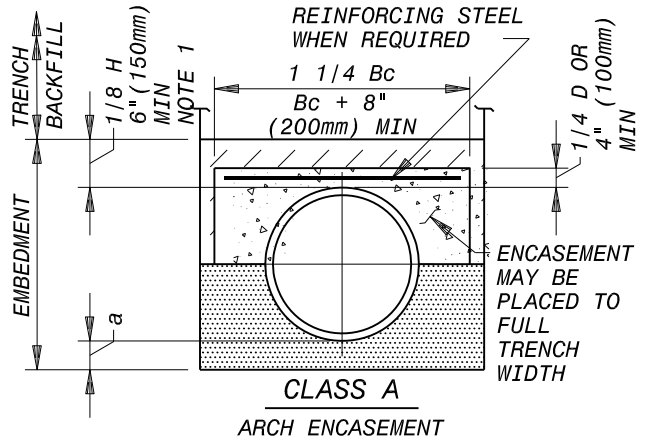
Broken concrete and other debris resulting from pavement or sidewalk removal, excavated rock in excess of the amount permitted to be installed in trench backfill, debris encountered in excavation work, and other similar waste materials shall be disposed of away from the site.

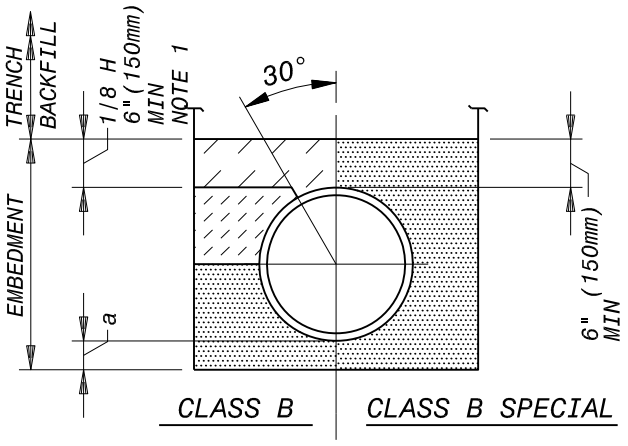
Excess earth from excavations located in unimproved property may be distributed directly over the pipe trench and within the pipeline right-of-way to a maximum depth of 6 inches above the original ground surface elevation at and across the trench and sloping uniformly each way. Material thus wasted shall be carefully finished with a drag, blade machine, or other suitable tool to a smooth, uniform surface without obstructing drainage at any point. Wasting of excess excavated material in the above manner will not be permitted where the line of trench crosses or is within a railroad, public road, or highway right-of-way.

3-11. RESODDING. Not used.

3-12. SETTLEMENT. Design-Builder shall be responsible for all settlement of trench backfill which may occur within the correction period stipulated in the General Conditions.

End of Section





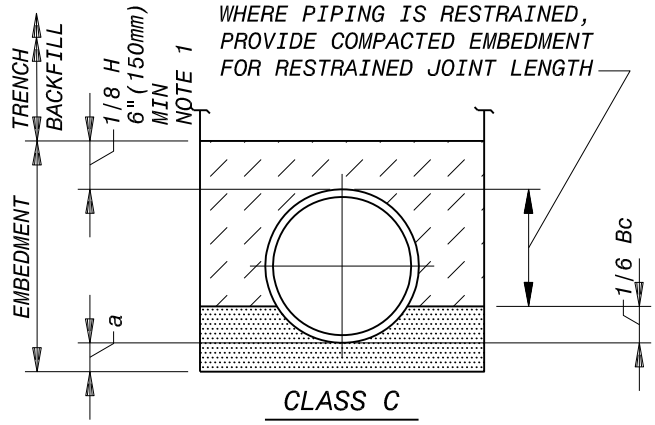


TABLE OF EMBEDMENT DEPTHS BELOW PIPE

D	a MIN SOIL		a MIN ROCK	
	in	mm	in	mm
27"(675 mm) & SMALLER	3	75	6	150
30"(750 mm) TO 60"(1500 mm)	4	100	9	225
66"(1650 mm) & LARGER	6	150	12	300

NOTES:

1. EMBEDMENT ABOVE THE TOP OF THE PIPE SHALL BE AN UNCOMPACTED LAYER FOR ALL INSTALLATIONS.
2. REFER TO SPECIFICATIONS FOR GEOTECHNICAL FABRIC OR SPECIAL EMBEDMENT REQUIREMENTS FOR TRENCHES IN FINE SOILS EXTENDING BELOW GROUNDWATER LEVEL.
3. TRENCH OUTLINES DO NOT INDICATE ACTUAL TRENCH EXCAVATION SHAPE, SOIL CONDITIONS, OR PRESENCE OF SHEETING LEFT IN PLACE. EMBEDMENT MATERIAL SHALL EXTEND THE FULL WIDTH OF THE ACTUAL TRENCH EXCAVATION.
4. FOR RESTRAINED JOINT PIPE LENGTH WITH CLASS C EMBEDMENT THE BACKFILL ABOVE THE GRANULAR EMBEDMENT AND BELOW THE TOP OF THE PIPE SHALL BE COMPACTED EMBEDMENT.

LEGEND

Bc OUTSIDE DIAMETER OF PIPE
H COVER ABOVE TOP OF PIPE
D NOMINAL PIPE SIZE
a EMBEDMENT BELOW PIPE (SEE TABLE)

HAND PLACED EMBEDMENT *

COMPACTED EMBEDMENT *

GRANULAR EMBEDMENT

CONCRETE

* OR GRANULAR EMBEDMENT

EMBEDMENTS FOR CONDUITS

BLACK & VEATCH	TRENCHING AND BACKFILLING	FIG 1-31 23 33

Section 33 14 00

PIPELINE PRESSURE AND LEAKAGE TESTING

PART 1 - GENERAL

1-1. SCOPE. This section covers field hydrostatic pressure and leakage testing of piping. The term "piping" shall be used in this section to refer to piping systems, pipelines, or sections thereof.

Testing of other piping is covered in the Sewer Pipe Installation and Testing section. Cleaning and disinfection of piping is covered in the Cleaning and Disinfection of Water Pipelines section.

1-2. GENERAL. Design-Builder shall coordinate pressure and leakage testing with adjacent work as necessary to preclude work interferences or duplication of effort and to expedite the overall progress of the work.

Design-Builder shall provide all necessary piping, piping connections, temporary valves, backflow preventers, and all other items of equipment or facilities necessary to complete the pressure and leakage testing.

In all cases where it is necessary to interrupt service to customers, permission of the Owner shall be obtained and each customer affected shall be notified of the proposed service interruption and its possible duration in accordance with the Project Requirements section.

Engineer or Engineer's representative shall be present during testing and shall be notified of the time and place of testing at least 3 days prior to commencement of testing. All testing shall be performed in accordance with all governing standards and regulations.

1-2.01. Testing Schedule and Procedure. A testing schedule and procedure shall be submitted not less than 21 days prior to commencement of testing. The schedule and procedure shall include, but not be limited to the following information for each pipe section to be tested:

limits of each pipe test section;
proposed time and sequence;
physical locations and set positions of all valves;
locations of temporary bulkheads, stops, caps, restraints, supports, and other temporary equipment needed;
manner of filling and source of water;
method and location of metering volumes;

method and location of gauging pressures; and
method and location of disposal of test water.

1-2.02. Special Testing Requirements. Special testing requirements include the following:

Unless otherwise acceptable to Design-Builder, the general sequence of work for each pipeline, or valved or bulkheaded section thereof, shall be as follows, as applicable:

Initial cleaning and flushing of pipeline.
Filling pipeline.
Hydrostatic pressure and leakage testing.
Disinfection.
Final flushing and neutralization of heavily chlorinated water.
Bacteriological tests.

During testing of the pipeline, all valves, except for auxiliary hydrant valve(s), shall be in the open position.

Temporary bulkheads shall be provided during testing so that the test pressure is not applied to existing or new valves and hydrants, or to existing water lines, or to any portion of water lines installed under this Contract that have already been put into service.

Upon completion of testing and/or disinfection, connections made to existing water lines or to any portion of water lines installed under this Contract that have already been put into service, and any other portion of the pipeline not subject to the pressure test, shall be visually inspected for leakage after placing the water line into service and before backfilling the connection.

1-2.03. Water. Water for testing shall be furnished as stipulated in the general Terms and Conditions section. Following completion of testing, the water shall be disposed of in accordance with the requirements of regulatory agencies and in a manner acceptable to Design-Builder.

PART 2 - PRODUCTS

2-1. TEST EQUIPMENT. All necessary connections between the piping to be tested and the water source, together with pumping equipment, water meter, pressure gauges, backflow prevention, and all other equipment, materials, and facilities required to perform the specified tests, shall be provided. All required blind flanges, valves, bulkheads, bracing, blocking, and other sectionalizing devices shall also be provided. All temporary sectionalizing devices shall be

removed upon completion of testing. Vents shall be provided in test bulkheads where necessary to expel air from the piping to be tested.

Test pressure shall be applied by means of a force pump sized to produce and maintain the required pressure without interruption during the test.

Water meters and pressure gauges shall be accurately calibrated and shall be subject to review and acceptance by Design-Builder.

Permanent or temporary gauge connections shall be installed at each location where test gauges are connected to the piping during the required test. Drilling and tapping of pipe walls will be permitted where specifically approved by Design-Builder. Upon successful completion of testing, each permanent gauge connection shall be fitted with an isolation valve and a permanent gauge, and each temporary gauge connection, if used, shall be fitted with a permanent sealed plug or cap acceptable to the Design-Builder.

Permanent or temporary fill and vent connections shall be installed as needed for the required test. Drilling and tapping of pipe walls will be permitted where specifically approved by Design-Builder. Upon successful completion of testing, each permanent fill and vent connection shall be fitted with the permanent fill or vent piping, and each temporary fill and vent connection, if used, shall be fitted with a permanent sealed plug or cap acceptable to the Design-Builder.

PART 3 - EXECUTION

3-1. FILLING AND VENTING. Before filling the piping with water, care shall be taken to ensure that all air release valves and other venting devices are properly installed and operating properly. Hand-operated vent valves shall not be closed until an uninterrupted stream of water is flowing from each valve. The rate of filling the piping with water must not exceed the venting capacity of the installed air vent valves and devices.

3-2. BLOCKING AND BACKFILLING. Piping shall be adequately blocked, anchored, and supported before the test pressure is applied. Piping may be tested after backfilling.

3-3. PRESSURE TESTING. After the piping to be tested has been filled with water, the test pressure shall be applied and maintained without interruption within plus or minus 5 psi of test pressure for 2 hours plus any additional time required for Design-Builder to examine all piping being tested and for Design-Builder to locate any defective joints and pipe materials. The test pressure shall be in accordance with the requirements specified for pipeline or plant piping.

3-3.01. Pipeline Test Pressure. Not used.

3-3.02. Plant Piping Test Pressure. Piping shall be subjected to the test pressure as indicated in the Plant Piping Test Pressure Schedule

3-4. PLANT PIPING LEAKAGE TESTING. All plant piping shall be watertight and free from leaks.

End of Section

Section 40 05 05.11

MISCELLANEOUS PIPING AND ACCESSORIES INSTALLATION

PART 1 - GENERAL

1-1. SCOPE. This section covers the installation of piping and accessories as indicated on the Drawings for the following piping sections:

Section Title
Miscellaneous Piping and Accessories
Stainless Steel Pipe and Alloy Pipe, Tubing, and Accessories
Miscellaneous Steel Pipe, Tubing, and Accessories
Miscellaneous Plastic Pipe, Tubing, and Accessories
Copper Tubing and Accessories

Design-Builder or system supplier, whoever installs the equipment, shall furnish all necessary jointing materials, coatings, and accessories that are specified herein.

Pipe supports and anchors shall be furnished by Design-Builder. Pipe trenching and backfilling are covered in the Trenching and Backfilling section.

1-2. GENERAL.

1-2.01. Coordination. Materials installed under this section shall be installed in full conformity with Drawings, Specifications, engineering data, instructions, and recommendations of the manufacturer, unless exceptions are noted by Design-Builder.

1-3. SUBMITTALS.

1-3.01. Drawings and Data. Complete specifications, data, and catalog cuts or drawings shall be submitted in accordance with the Submittals Procedures section. Items requiring submittals shall include, but not be limited to, the following:

Watertight/dusttight pipe sleeves.

Materials as specified herein.

1-4. QUALITY ASSURANCE.

1-4.01. Welding and Brazing Qualifications. All welding and brazing procedures and operators shall be qualified by an independent testing laboratory in accordance with the applicable provisions of Section IX of the ASME Code. All procedure and operator qualifications shall be submitted to the Engineer for review.

1-4.02. Tolerances. These tolerances apply to in-line items and connections for other lines.

The general dimension, such as face-to-face, face or end-to-end, face- or end-to center, and center-to-center shall be 1/8 inch.

The inclination of flange face from true in any direction shall not exceed 3/64 inch per foot.

Rotation of flange bolt holes shall not exceed 1/16 inch.

1-5. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the general Terms and Conditions section. All materials shall be stored in a sheltered location above the ground, separated by type, and shall be supported to prevent sagging or bending.

Plastic pipe, tubing, and fittings shall be stored between 40°F and 90°F.

PART 2 - PRODUCTS

2-1. SERVICE CONDITIONS. Pipe, tubing, and fittings covered herein shall be installed in the services indicated in the various pipe sections.

2-2. MATERIALS.

Threaded Fittings

Anti-Seize Thread Lubricant	Jet-Lube "Nikal", John Crane "Thred Gard Nickel", Never-Seez "Pure Nickel Special", or Permatex "Nickel Anti-Seize".
Teflon Thread Sealer	Paste type; Hercules "Real-tuff", John Crane "JC-30", or Permatex "Thread Sealant with Teflon".
Teflon Thread Tape	Hercules "Tape Dope" or John Crane "Thread-Tape".

Solvent Welded Fittings	
Solvent cement for PVC Systems	ASTM D2564.
Solvent cement for CPVC Systems	ASTM F493.
Sodium Hypochlorite, Sodium Hydroxide, and Sodium Bisulfite Service	IPS Corporation "Weld-On 724"
Primer for PVC Systems	ASTM F656.
Solder or Brazed Fittings	
Solder	Solid wire, ASTM B32, ANSI/NSF 61 certified, Alloy Grade Sb5, (95-5).
Soldering Flux	Paste type, ASTM B813.
Brazing Filler Metal	AWS A5.8, BCuP-5; Engelhard "Silvaloy 15", Goldsmith "GB-15", or Handy & Harman "Sil-Fos".
Brazing Flux	Paste type, Fed Spec O-F-499, Type B.
Insulating Fittings	
Threaded	Dielectric steel pipe nipple, ASTM A53, Schedule 40, polypropylene lined, zinc plated; Perfection Corp. "Clearflow Fittings".
Flanged	Epco "Dielectric Flange Unions" or Central Plastics "Insulating Flange Unions". Shall be suitable for the temperature and service.
Pipe Insulation	See Mechanical Insulation section.
Watertight/Dusttight Pipe Sleeves	O-Z Electrical Manufacturing "Thruwall" and "Floor Seals", or Thunderline "Link-Seals"; with modular rubber sealing elements, nonmetallic pressure plates, and galvanized bolts.
Pipe Sleeve Sealant	Polysulfide or urethane, as specified in the Caulking section or as indicated on the Drawings.

Protective Coatings	
Tape Wrap	ANSI/AWWA C209, except single ply tape thickness shall not be less than 30 mils; Protecto Wrap "200" or Tapecoat "CT".
Primer	As recommended by the tape manufacturer.
Coal Tar Epoxy	High-build coal tar epoxy; PPG Amercoat "Amercoat 78HB Coal Tar Epoxy", Carboline "Bitumastic 300 M", Tnemec "46H-413 Hi-Build Tneme-Tar", or Sherwin-Williams "Hi-Mil Sher-Tar Epoxy".

PART 3 - EXECUTION

3-1. INSPECTION. All piping components shall be inspected for damage and cleanliness before being installed. Any material damaged or contaminated in handling on the job shall not be used unless it is repaired and recleaned to the original requirements by Design-Builder or system supplier, whoever installs the equipment. Such material shall be segregated from the clean material and shall be inspected and approved by Owner or his representative before its use.

3-2. PREPARATION.

3-2.01. Field Measurement. Pipe shall be cut to measurements taken at the site, not from the Drawings. All necessary provisions shall be made in laying out piping to allow for expansion and contraction. Piping shall not obstruct openings or passageways. Pipes shall be held free of contact with building construction to avoid transmission of noise resulting from expansion.

3-3. INSTALLATION.

3-3.01. General. All instruments and specialty items shall be installed according to the manufacturer’s instructions and with sufficient clearance and access for ease of operation and maintenance.

Flat faced wrenches and vises shall be used for copper tubing systems. Pipe wrenches and vises with toothed jaws will damage copper materials and shall not be used. Bends in soft temper tubing shall be shaped with bending tools.

3-3.02. Pipe Sleeves. Piping passing through concrete or masonry shall be installed through sleeves that have been installed before the concrete is placed or when masonry is laid. Pipe sleeves installed through floors with a special

finish, such as ceramic or vinyl composition tile, shall be flush with the finished floor surface and shall be provided with nickel or chromium plated floor plates. Unless otherwise indicated on the Drawings, in all other locations where pipes pass through floors, pipe sleeves shall project not less than 1 inchnor more than 2 inches above the floor surface, with the projections uniform within each area. In the case of insulated pipes, the insulation shall extend through pipe sleeves. Where the Drawings indicate future installation of pipe, sleeves fitted with suitable plastic caps or plugs shall be provided.

Holes drilled with a suitable rotary drill will be considered instead of sleeves for piping which passes through interior walls and through floors with a special finish.

Unless otherwise indicated on the Drawings, all pipes passing through walls or slabs which have one side in contact with earth or exposed to the weather shall be sealed watertight with special rubber-gasketed sleeve and joint assemblies, or with sleeves and modular rubber sealing elements.

3-3.03. Pipe Joints. Pipe joints shall be carefully and neatly made in accordance with the indicated requirements.

3-3.03.01. Threaded. Pipe threads shall conform to ANSI/ASME B1.20.1, NPT, and shall be fully and cleanly cut with sharp dies. Not more than three threads at each pipe connection shall remain exposed after installation. Ends of pipe shall be reamed after threading and before assembly to remove all burrs. Unless otherwise indicated, threaded joints shall be made up with teflon thread tape, thread sealer, or a suitable joint compound.

Threaded joints in plastic piping shall be made up with teflon thread tape applied to all male threads. Threaded joints in stainless steel piping shall be made up with teflon thread sealer and teflon thread tape applied to all male threads. Threaded joints in steel piping for chlorine service shall be made up with teflon thread tape or litharge and glycerine paste applied to all male threads.

3-3.03.02. Compression. Ends of tubing shall be cut square and all burrs shall be removed. The tubing end shall be fully inserted into the compression fitting and the nut shall be tightened not less than 1-1/4 turns and not more than 1-1/2 turns past fingertight, or as recommended by the fitting manufacturer, to produce a leaktight, torque-free connection.

3-3.03.03. Flared. Ends of annealed copper tubing shall be cut square, and all burrs shall be removed prior to flaring. Ends shall be uniformly flared without scratches or grooves. Fittings shall be tightened as needed to produce leaktight connections.

3-3.03.04. Soldered and Brazed. Where solder fittings are specified for lines smaller than 2 inches, joints may be soldered or brazed at the option of Design-Builder or system supplier, whoever installs the equipment. Brazing alloy shall contain no tin.

Surfaces to be joined shall be thoroughly cleaned with flint paper and coated with a thin film of flux. At each joint, tubing shall enter to the full depth of the fitting socket.

Care shall be taken to avoid overheating the metal or flux. Each joint shall be uniformly heated to the extent that filler metal will melt on contact. While the joint is still hot, surplus filler metal and flux shall be removed with a rag or brush.

3-3.03.05. Solvent Welded. Solvent welded connections shall only be used for PVC or CPVC pipe. All joint preparation, cutting, and jointing procedures shall comply with the pipe manufacturer's recommendations and ASTM D2855. Pipe ends shall be beveled or chamfered to the dimensions recommended by the manufacturer. Newly assembled joints shall be suitably blocked or restrained to prevent movement during the setting time recommended by the manufacturer. Pressure testing of solvent welded piping systems shall not be performed until the applicable curing time, as set forth in Table X2.1 of ASTM D2855, has elapsed. Solvent welding shall be performed by bonding operators who have met the requirements of ASME B31.3 and A328.

3-3.03.06. Epoxy and Adhesive Bonded. Not used.

3-3.03.07. Heat Fusion Bonded. Heat fusion bonded joints shall be used for polyethylene pipe with socket and butt fusion fittings. All joint preparation, cutting, jointing equipment, and jointing procedures shall comply with the pipe manufacturer's recommendations. The heating time, temperature, pressure applied to the joint during bonding, and cooling time shall consistently produce leaktight joints as strong as the pipe being joined.

3-3.03.08. Flanged. Flange bolts shall be tightened sufficiently to slightly compress the gasket and effect a seal, but shall not be torqued less than the minimum value required by the gasket manufacturer. Flange bolts shall not be so tight as to fracture or distort the flanges. A plain washer shall be installed under the head and nut of bolts connecting plastic pipe flanges. Anti-seize thread lubricant shall be applied to the threaded portion of all stainless steel bolts during assembly.

Flange bolt holes shall be oriented as follows, unless otherwise indicated on the spool drawings:

Vertical flange face:	Bolt holes to straddle the vertical centerlines.
Horizontal flange face:	Bolt holes shall be aligned with connecting pipe.

Pipe sealants, thread compounds, or other coatings shall not be applied to flange gaskets unless recommended by the gasket manufacturer for the specified service and approved by Design-Builder.

Welds at orifice flanges shall have internal surfaces ground smooth to the pipe wall.

Slip-on flanges shall be welded inside and outside. There shall be a distance of approximately 1/16 to 1/8 inch between the edge of the fillet weld and the face of the flange. The seal weld shall be applied so that the flange face shall be free of weld spatter and does not require refacing.

Flat-faced flanges shall be used when mating to Class 125 flanges. Full-face gaskets shall be used with flat-faced flanges and ring gaskets shall be used with raised faced flanges.

Weld neck flanges shall be used with butt-weld fittings. The bore of weld neck flanges shall match the pipe wall thickness.

Insulating joints connecting submerged (buried) piping to exposed piping shall be installed above the maximum water surface elevation and before the first pipe support not having coated anchor bolts or adhesive-bonded concrete anchors. All submerged (buried) metallic piping shall be isolated from the concrete reinforcement. Insulating flanges shall be tested for electrical isolation after installation and bolt-up but prior to introduction of conducting fluid.

3-3.03.09. Welded. Welding shall conform to the specifications and recommendations contained in the "Code for Pressure Piping", ANSI B31.1.

Weld cross-sections shall be equal to or greater than the pipe wall thickness. Welds shall be smooth and continuous and shall have interior projections no greater than 1/16 inch [1.5 mm]. Backing strips or rings shall not be used except with specific prior review by Design-Builder as to use, material, and design. Root gap inserts that are completely melted and consumed in the weld bead are acceptable only when reviewed in advance by Design-Builder.

Stainless steel welding shall be inert gas tungsten arc (TIG) or the direct current, straight polarity, inert gas metal arc process (MIG). Refer to the stainless steel piping section for additional information on stainless steel welding.

Carbon steel welding shall be made by the shielded metal arc process.

For socket weld joints, fully engage the two pipe ends, then separate them by 1/16 inch prior to welding to all space for shrinkage.

3-3.03.10. Grooved Couplings. Grooves for grooved couplings shall be cut with a specially designed grooving tool. Grooves cut in steel pipe shall conform to flexible grooving dimensions, as set forth in AWWA C606, and shall be clean and sharp without burrs or check marks.

3-3.03.11. Push-on. Gasket installation and other jointing procedures shall be in accordance with the recommendations of the manufacturer. Each spigot end shall be suitably beveled to facilitate assembly. All joint surfaces shall be lubricated with a heavy vegetable soap solution immediately before the joint is completed. Lubricant shall be suitable for use in potable water, shall be stored in closed containers, and shall be kept clean.

3-3.03.12. Rubber-Gasketed. Not used.

3-3.03.13. Other Pipe Joints. Coupled joints in tempered glass pipe, plastic joints in vitrified clay pipe, and other proprietary type joints shall be made in accordance with the manufacturer's recommendations.

3-3.04. Pipe. Pipe shall be installed as specified, as indicated on the Drawings.

Piping shall be installed without springing or forcing the pipe in a manner which would induce stresses in the pipe, valves, or connecting equipment.

Piping shall be supported in conformance with the Pipe Supports section.

Piping shall be connected to equipment by flanges or unions as specified in the various piping sections. Piping connecting to equipment shall be supported by a pipe support and not by the equipment.

Water, gas, and air supply piping shall be provided with a shutoff valve and union at each fixture or unit of equipment, whether or not indicated on the Drawings, to permit isolation and disconnection of each item without disturbing the remainder of the system. Air supply piping shall be provided with sectionalizing valves and valved air inlet connections as needed for isolation of portions of the system for periodic testing. Gas supply lines to buildings shall be provided with a shutoff valve and union located above grade immediately outside the building. A capped drip leg shall be provided at the bottom of the vertical riser of gas supply piping adjacent to gas-fired appliances.

A union shall be provided within 2 feet [600 mm] of each threaded-end valve unless there are other connections which will permit easy removal of the valve. Unions shall also be provided in piping adjacent to devices or equipment which may require removal in the future and where required by the Drawings or the Specifications.

All air piping shall be graded to points of drainage collection where drip legs and drain valves shall be provided. Air piping shall be sized for the service conditions, with the indicated minimum sizes:

Service	Minimum Size
Air signal	1/4 inch OD
Power air	1/2 inch OD
Air supply	1/2 inch OD
Bubbler drop pipes	3/4 inch
Buried piping	3/4 inch

Water supply piping within structures shall be arranged, and facilities provided, for complete drainage. All piping serving metering equipment shall be uniformly graded so that air traps are eliminated and complete venting is provided.

Stuffing box leakage from water sealed pumps shall be piped to the nearest point of drainage collection.

Taps for pressure gauge connections on the suction and discharge of pumping units shall be provided with a nipple and a ball type shutoff valve.

Drilling and tapping of pipe walls for installation of pressure gauges or switches will not be permitted.

In all piping, insulating fittings shall be provided to prevent contact of dissimilar metals, including but not limited to, contact of copper, brass, or bronze pipe, tubing, fittings, valves, or appurtenances, or stainless steel pipe, tubing, fittings, valves, or appurtenances with iron or steel pipe, fittings, valves, or appurtenances. Insulating fittings shall also be provided to prevent contact of copper, brass, or bronze pipe, tubing, fittings, valves or appurtenances with stainless steel pipe, tubing, fittings, valves, or appurtenances.

Branch connections in horizontal runs of steam, air, and gas piping shall be made from the top of the pipe.

Buried PVC piping shall be "snaked" in the trench and shall be kept as cool as possible during installation. PVC pipe shall be kept shaded and shall be covered with backfill immediately after installation.

All chemical piping shall be installed so that lines are readily accessible for cleaning. Tees shall be provided at regular intervals in all chemical piping except chlorine piping, with extra openings plugged, to facilitate cleaning. Teflon thread tape or teflon thread sealer shall be applied to the threads of the plugs so that

they can be easily removed. At each point where hose or reinforced plastic tubing is connected to rigid piping, a quick-disconnect coupling shall be provided.

Double-contained chemical feed piping shall be installed according to the manufacturer's recommendations. Joints shall be solvent cemented. Splitting and rewelding of fittings will not be acceptable. Suitable drains and vents shall be provided to permit complete drainage of both the primary and secondary containment piping. Interstitial supporting devices shall be designed to allow continuous drainage in the annular space to the drain ports. Drain fittings shall be designed to allow a valve attachment to be made so that the secondary containment compartment can be readily drained and manually inspected for leaks.

Polyethylene piping shall be installed in accordance with the manufacturer's recommendations. A continuous 12 AWG THHN insulated copper tracer wire shall be placed 6 inches [150 mm] above all portions of the buried pipe, but no more than 18 inches [450 mm] below the ground surface. Where the pipe extends above grade, a 2 foot [0.6 m] length of wire shall be coiled and attached to the pipe.

Due to the potential for corrosion, copper piping shall not be installed in direct contact with soil, sand, or other backfill materials. Buried copper piping shall be sleeved inside socket welded schedule 40 or schedule 80 PVC piping (PVC-1 or PVC-2). Tape wrap is not considered sufficient corrosion protection. The ends of sleeve pipes shall be thoroughly sealed and shall be water tight. Silicon caulk is not suitable for sealing sleeve ends due to the potential for offgassing of ammonia leading to corrosion within the sleeve. Similarly, cement products shall not be used to seal sleeve ends due to the potential for fracturing at the rigid connections. End seals shall be either Fernco or equal elastomeric clamps or non-toxic non-hardening sealing conduit typically used for electrical conduits.

Piping adjacent to flow sensors shall be installed in accordance with the requirements of the manufacturer of the flow sensor and commonly accepted design practices of the appropriate straight pipe runs both upstream and downstream.

Drains required for operation are shown on the Drawings. However, vents at all high points and drains at all low points in the piping that are required for complete draining for pressure test may not be shown on these Drawings. Design-Builder or system supplier, whoever installs the equipment, shall add such items as found to be necessary during detail piping design and/or piping installation.

3-3.05. Reducers. Eccentric reducers shall be installed flat on the bottom for steam, condensate return and digester gas services.

3-3.06. Valves. Isolation valves provided with equipment and instruments shall be located in a manner which will allow ease of access and removal of the items to be isolated. Prior to soldering or brazing valves, teflon and elastomer seats and seals shall be removed to prevent damage.

3-4. PIPING ASSEMBLY.

3-4.01. General. Design-Builder or system supplier, whoever installs the equipment, shall only use labor that has been qualified by training and experience to capably perform the specified activities required to accomplish the work in a satisfactory manner

3-4.02. Buttwelded Piping. The specification and qualification of weld joints and welders for buttwelded piping shall be in accordance with ASME Boiler Pressure Vessel Code, Section IX, Welding and Brazing.

Nondestructive examination (NDE) shall be in accordance with the ASME Boiler and Pressure Vessel Code, Section V, Nondestructive Examination. The minimum level of NDE shall be as follows:

(1) 100 percent visual examination of welds by a qualified examiner (per ASME B31.1), and

(2) Radiographic testing (RT) of 10 percent random sampling of welds.

Welding shall not begin until weld joint and welder qualification submittals have been reviewed and approved. NDE shall be performed before the pressure and leakage testing of the piping. Weld acceptance standards shall be in accordance with ASME B31.1, Chapter VI. If a weld fails the NDE, it shall be repaired and the test repeated at no additional cost to the Owner.

3-5. PROTECTIVE COATING. Standard weight or extra strong steel pipe in buried locations, whether or not coated, is not allowed.

3-5.01. Inspection. All shop-applied plastic coatings and tape wrap on pipe or fittings shall be inspected for holidays and other defects after receipt of the pipe or fitting on the job and immediately before installation. All field-applied tape wrap on pipe, joints, fittings, and valves shall be inspected for holidays and other defects following completion of wrapping. Inspection of plastic coatings after installation of the pipe or fitting in the trench shall be made where the coating may have been damaged during installation. Holidays and defects disclosed by inspection shall be repaired in accordance with the recommendations of the coating or tape wrap manufacturer, as applicable.

The inspection shall be made using an electrical holiday detector. The detector and inspection procedures shall conform to the requirements of Section 4.4 of ANSI/AWWA C209.

3-6. PRESSURE AND LEAKAGE TESTING. All specified tests shall be made by and at the expense of Design-Builder or system supplier, whoever installs the equipment. Each piping system shall be tested for at least 1 hour with no loss of pressure. The Design-Builder shall coordinate this section with the Pipeline Pressure and Leakage Testing section. Piping shall be tested at the indicated pressures:

Service	Test Pressure	Test Medium
Water supply	1-1/2 times working pressure but not less than 120 psi [828 kPa]	Water
Gas supply	1-1/2 times working pressure but not less than 60 psi [414 kPa]	Compressed air
Air supply and signal (See paragraph 3-6.01)	1-1/2 times working pressure but not less than 50 psi [345 kPa]	Compressed air with 100 percent of all oil 0.025 micron and larger removed
Other piping	1-1/2 times working pressure but not less than 50 psi [345 kPa]	Suitable fluid or gas; for distilled water piping, distilled water or filtered oil-free compressed air may be used

Compressed air or pressurized gas shall not be used for testing plastic piping unless specifically recommended by the pipe manufacturer.

Leakage may be determined by loss-of-pressure, soap solution, chemical indicator, or other positive and accurate method. All fixtures, devices, or accessories which are to be connected to the lines and which would be damaged if subjected to the specified test pressure shall be disconnected and the ends of the branch lines plugged or capped as needed during the testing.

Unless otherwise required by the applicable codes, drainage and venting systems shall be water tested. For water testing, the drainage and venting system shall be filled with water to the level of the highest vent stack. For air testing, the system shall be charged with air to a minimum pressure of 5 psig [35 kPa]. Openings shall be plugged as necessary for either type of test. To be considered free of leaks, the system shall hold the water or air for 30 minutes without any drop in the water level or air pressure.

All necessary testing equipment and materials, including tools, appliances and devices, shall be furnished and all tests shall be made by and at the expense of Design-Builder or system supplier, whoever installs the equipment.

All joints in piping shall be tight and free of leaks. All joints which are found to leak, by observation or during any specified test, shall be repaired, and the tests repeated.

3-6.01. Air Pressure Tests. Pressure tests shall be performed on all air piping systems as specified herein to conform to ASME B31.1.

The test pressure shall be as specified herein and shall not exceed the maximum allowable test pressure of any non-isolated component, such as vessels, compressors, blowers, or valves, in the system. The pressure in the system shall gradually be increased to not more than one-half of the test pressure, after which the pressure shall be increased in steps of approximately one-tenth of the test pressure until the required test pressure has been reached. The pressure shall be continuously maintained for a minimum duration of 10 min. It shall then be reduced to the blower rated discharge pressure held for such time as may be necessary to conduct the examination for leakage.

Examination for leakage detected by soap bubble or equivalent method shall be made at all joints and connections. The piping system, exclusive of possible localized instances at the compressor, blower, or valve packing, shall show no evidence of leaking.

Design-Builder or system supplier, whoever installs the equipment shall be responsible for ensuring that all air piping is free of leaks. All joints which are found to be leaking shall be repaired and the test repeated.

3-7. CLEANING. The interior of all pipe, valves, and fittings shall be smooth, clean, and free of blisters, loose mill scale, sand, dirt, and other foreign matter when installed. Before being placed in service, the interior of all lines shall be thoroughly cleaned.

Tin-lined copper tubing for distribution of distilled water shall be flushed and cleaned with distilled water in accordance with the tubing manufacturer's recommendations.

3-8. ACCEPTANCE. Owner reserves the right to have any section of the piping system which he suspects may be faulty cut out of the system by Design-Builder or system supplier, whoever installs the equipment, for inspection and testing. Should the joint prove to be sound, Owner will reimburse Design-Builder or system supplier, whoever installs the equipment, on a time-and-material basis as specified in the Contract. Should the joint prove to be faulty, the destructive test will continue joint by joint in all directions until sound joints are found. Costs for

replacement of faulty work and/or materials shall be the responsibility of Design-Builder or system supplier, whoever installs the equipment.

End of Section

Section 40 05 17

COPPER TUBING AND ACCESSORIES

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of copper tubing and accessories. Copper tubing shall be furnished complete with all fittings, flanges, unions, and other accessories specified herein.

1-2. SUBMITTALS.

1-2.01. Drawings and Data. Complete specifications, data, and catalog cuts or drawings shall be submitted in accordance with the Submittal Procedures section. Submittals are required for all piping, fittings, gaskets, sleeves, and accessories, and shall include the following data:

Name of Manufacturer
Type and model
Construction materials, thickness, and finishes
Pressure and temperature ratings

shall obtain and submit a written statement from the gasket material manufacturer certifying that the gasket materials are compatible with the joints specified herein and are recommended for the specified field test pressures and service conditions.

1-3. DELIVERY, STORAGE, AND HANDLING. Shipping, handling and storage shall be in accordance with the general Terms and Conditions section. All materials shall be stored in a sheltered location above the ground, separated by type, and shall be supported to prevent sagging or bending.

PART 2 - PRODUCTS

2-1. MATERIALS. Copper tubing materials and service shall be as specified herein.

2-1.01. Material Classification CU-1.

CU-1 – Water Tubing with Flared Fittings Buried water supply, 2 inch and smaller.	Tubing	Soft annealed copper tubing, ASTM B88, Type K.
	Fittings	Flared, material to match tubing. Fittings shall conform to ANSI/ASME B16.26.

Differential pressure lines from flow elements to transmitters. All instrument tubing not otherwise specified.	

2-1.02. Material Classification CU-2.

CU-2 – Water Tubing with Brazed Joints Buried water supply, 2-1/2 and 3 inch.	Tubing Fittings	Hard drawn copper tubing, ASTM B88, Type K. Brazed joint, material to match tubing. Fittings shall conform to ANSI B16.18 or ANSI/ASME B16.22.

2-1.03. Material Classification CU-3.

CU-3 – Water Tubing with Solder and Brazed Joints Potable, non-potable, and plant effluent water supply, 3 inch and smaller. Hot water supply. Heating water. Differential pressure lines for flow transmitters. Chilled water. Compressed air, in-plant and exposed. Laboratory vacuum.	Tubing Fittings Flanges	Hard drawn copper tubing, ASTM B88, Type L. Solder joint (smaller than 2 inch except compressed air piping), Brazed joint (2 inch and larger for piping other than compressed air and all sizes for compressed air piping), material to match tubing. Fittings shall conform to ANSI B16.18, or ANSI/ASME B16.22. Where required for connection to equipment, valves, and accessories, ANSI B16.24, class 150, cast bronze, brazed joint.

2-1.04. Material Classification CU-4.

CU-4 – Air Tubing with Solder and Brazed Joints Buried or submerged compressed air supply piping.	Tubing Fittings	Soft annealed copper tubing, ASTM B88, Type K. Solder joint (smaller than 2 inch except liquid oxygen), Brazed joint (any size), material to match tubing. Fittings shall conform to ANSI B16.18, or ANSI/ASME B16.22.

2-1.05. Material Classification CU-5. Not used.

2-1.06. Material Classification CU-6.

CU-6 – Instrument Tubing with Compression Fittings Panel mounted compressed air piping, 3/4 inch and smaller. Instrument air piping 3/4 inch and smaller.	Tubing	Soft annealed copper tubing, ASTM B280. Dimensions shall be in accordance with ASTM B280.
	Fittings	Compression type, brass, Crawford "Swagelok" or Parker Hannifin "CPI".

2-1.07. Material Classification CU-7.

CU-7 – ARC Tubing with Brazed Fittings Refrigerant piping.	Tubing	Hard drawn ACR copper tubing, ASTM B280. Dimensions shall be in accordance with ASTM B280.
	Fittings	Brazed.

2-1.08. Material Classification CU-8.

CU-8 – Hydraulic Tubing with Compression Fittings As shown on Drawings.	Tubing	ASTM B75, seamless, soft annealed, wall thickness as required. Tubing size: As shown on Drawings. Required wall thickness: As required.
	Fittings	Compression type, brass, Crawford "Swagelok" or Parker Hannifin "CPI".

2-1.09. Accessory Materials. Accessory materials for the copper tubing systems shall be as indicated.

Flange Bolts and Nuts	ASTM A307, Grade B, length such that, after installation, the bolts will project 1/8 to 3/8 inch beyond outer face of the nut.
Flange Gaskets	ASTM D1330, Grade I, red rubber, ring type, 1/8 inch thick.
Expansion Joints	Tempflex "Model HB Expansion Compensators" with copper tube ends.

Insulating Fittings

Threaded	Dielectric steel pipe nipple, ASTM A53, Schedule 40, poly-propylene lined, zinc plated; Perfection Corp. "Clearflow Fittings".
Flanged	Epco "Dielectric Flange Unions" or Central Plastics "Insulating Flange Unions".

PART 3 - EXECUTION

3-1. INSTALLATION. Materials furnished under this section will be installed in accordance with the Miscellaneous Piping and Accessories Installation section.

End of Section

Section 40 05 19

DUCTILE IRON PIPE

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing and installation of ductile iron pipe. Ductile iron pipe shall be furnished complete with all fittings, specials, adapters, closure pieces, blowoffs, outlets, caps and plugs, temporary bulkheads, access manholes, jointing materials, pipe hangers and supports, anchors, blocking, encasement, appurtenances, and accessories specified and indicated on the Drawings, and as required for proper installation and functioning of the piping.

The size, service, and locations of ductile iron pipelines are covered in the Pipeline Schedule section and on the Drawings.

Piping furnished hereunder shall be complete with all joint gaskets, bolts, nuts and other jointing materials required for installation of any valves and equipment furnished by the equipment supplier, Design-Builder or others for installation under this Contract.

Pipe hangers and supports, pressure and leakage testing, and cleaning and disinfection are covered in other sections. Pipe trenching, embedment, and backfill are covered in the Trenching and Backfilling section.

1-2. GOVERNING STANDARDS. Except as modified or supplemented herein, all ductile iron pipe, fittings, and specials shall conform to the applicable requirements of the following standards and other standards named in this section:

ANSI/AWWA Standards	Title
C151	Ductile-Iron Pipe, Centrifugally Cast, For Water
C600	Installation of Ductile Iron Water Mains and Their Appurtenances
M41	Ductile Iron Pipe and Fittings - Manual of Water Supply Practices
C104	Cement Mortar Lining for Ductile Iron Pipe and Fittings
C105	Polyethylene Encasement for Ductile Iron Pipe Systems
C110	Ductile-Iron and Gray-Iron Fittings
C111	Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings

C115	Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges
C153	Ductile-Iron Compact Fittings

1-3. PIPE MANUFACTURER AND FIELD SERVICES. The pipe manufacturer responsibilities, which shall include, at a minimum; coordinating and furnishing all pipe materials, gaskets, bolts, and other jointing materials, and pipe appurtenances (except for furnished coupled joints and other similar products by a specified manufacturer) for a complete piping system that meets the specified test pressures and service conditions; ensuring and certifying that all pipe, fittings, specials, and other pipe materials, pipe gaskets and bolts specified herein, are being manufactured in full accordance with the Contract Documents; preparing and submitting all submittal information and shop drawings; and making any corrections that may be required to submittal information and shop drawings.

All ductile iron pipe shall be installed in accordance with the pipe manufacturer's recommendations.

1-4. SUBMITTALS. Drawings, details, specifications, and installation schedules covering all ductile iron pipe and accessories shall be submitted in accordance with the Submittals Procedures section. The drawings and data shall include, but shall not be limited to, the following:

Certification by manufacturer (affidavit of compliance) for each item furnished in accordance with the ANSI/AWWA Standards.

Restrained joints details.

Certification of gaskets by pipe manufacturer, certifying that gasket material is suitable for test pressures and services intended.

Certification that all materials in contact with treated or potable water are ANSI/NSF 61 approved.

Certification of joint lubricant.

Certification of proof-of-design tests for joints, including restrained joints.

Certification of proof-of-design tests for welded-on outlets and experience documentation. Air test documentation for the welded-on outlets used for this project.

Pipe laying schedule complete with a sequence of laying and an explanation of all abbreviations used in the schedule. For long, straight pipe runs, the pipe laying schedule shall list the pipeline station and either the pipe centerline or invert elevation coordinated with the Drawings at least every 100 feet.

Two samples of the polyethylene encasement, each sample clearly identified as required by the Governing Standards and test results from an independent third party laboratory of the requirements specified in ANSI/AWWA C105/A21.5.

Submittal data shall clearly indicate the country of origin of pipe, fittings, flanges, restraining devices, and accessories. When requested by Design-Builder, certified copies of physical and chemical test results as outlined in ANSI/AWWA C151/A21.51 shall be submitted for the materials to be provided.

1-5. SPARE MATERIALS. Not used.

1-6. SHIPPING, HANDLING, AND STORAGE. Shipping shall be in accordance with the general Terms and Conditions. Handling and storage on-site shall be as recommended by the pipe manufacturer, and as specified herein.

Pipe, fittings, and accessories shall be handled in a manner that will ensure installation in sound, undamaged condition. Equipment, tools, and methods used in handling and installing pipe and fittings shall not damage the pipe and fittings. Hooks inserted in ends of pipe shall have broad, well-padded contact surfaces. Unpadded hooks, wire brushes or other abrasive tools shall not be permitted to come into contact with polyethylene lining if such lining is specified.

Any damage to pipe coatings and linings shall be repaired before the pipe is installed.

PART 2 - PRODUCTS

2-1. PIPE CLASS. The class of ductile iron pipe shall be as indicated in the following table for those services indicated in the Pipeline Schedule section. The specified class includes service allowance and casting allowance.

Pipe wall thickness for grooved and threaded end pipe shall be increased if necessary to comply with the following minimum thickness:

Pipe Size	Minimum Thickness Class	
inches	Threaded Ends (1)	Grooved Ends (2)
4-16	53	53
18	53	54
20	53	55
24	53	56
30-54	53	--

Pipe Size	Minimum Thickness Class	
inches	Threaded Ends (1)	Grooved Ends (2)
60 & 64	350 (3)	--

(1) Complies with ANSI/AWWA C115/A21.15 for minimum pipe wall thickness for threaded flanges.

(2) Complies with ANSI/AWWA C606 for grooved and shouldered joint ductile iron pipe.

(3) Minimum class for 60 and 64 inch pipe is pressure class 350.

2-2. MATERIALS.

Pipe	Ductile iron, ANSI/AWWA C151/A21.51
Gaskets – All Joint Types	Synthetic rubber unless otherwise specified; natural rubber will not be acceptable. All gaskets shall be furnished by the pipe manufacturer unless another manufacturer's product is indicated. Pipe manufacturer shall submit certificates of gasket suitability certifying that the gasket materials are compatible with the joints specified, are recommended for the specified field test pressure and service conditions. Gaskets for treated or potable water service shall be certified for chlorinated and chloraminated potable water. Gas and oil-resistant gaskets shall be made of Nitrile (NBR [Acrylonitrile Butadiene]) rubber. The name of the material shall be permanently marked or molded on the gasket. Gaskets shall also be certified as suitable where soils may be contaminated with gas and oil products.
Joint Lubricant	Vegetable-based lubricant recommended by the pipe manufacturer. Petroleum or animal-based lubricants will not be acceptable. Lubricants that will be in

	contact with treated or potable water shall be certified as being in compliance with ANSI/NSF 61.
Fittings	ANSI/AWWA C110/A21.10 (except shorter laying lengths will be acceptable for U.S. Pipe), or ANSI/AWWA C153/A21.53, minimum working pressure rating as follows, unless indicated otherwise on the Drawings.

Fitting Size in.	Material	Type	Min. Working Pressure Rating, psi
4 to 24	DI	Mechanical and Push-on joints	350
4 to 24	DI	Flanged joints	250
30 to 48	DI	All joints	250

All fittings shall be ductile iron and suitable for the rated working pressure plus a surge or test pressure allowance of 100 psi or 1.5 times rated working pressure, whichever is less, without leakage or damage.

Push-on Joints ANSI/AWWA C111/A21.11.

	Restrained Push-on Joints, gaskets with stainless steel gripping segments, (4 inch through 12 inch), working pressure rating 350 psi.	American “Fast Grip”. U.S. Pipe "Field Lok 350 Gasket", or McWane Sure Stop 350 Gasket.
	Restrained Push-on Joints, locking wedge type, (4 inch through 24 inch), working pressure rating 350 psi for 4 through 16 inch and at least 250 psi for 18 through 24 inch.	EBAA Iron "Megalug" Series 1700; U.S. Pipe “TR Flex Gripper Ring”; Star Pipe Products “StarGrip 3100P”; or American “Field Flex Ring”, or accepted equal.
	Restrained Push-on Joints, positive locking segments and/or rings, (4 inch through 24 inch), working pressure rating 350 psi.	American "Flex-Ring,"; U.S. Pipe or McWane "TR Flex"

	Restrained Push-on Joints, positive locking segments and/or rings, (30 inch through 48 inch), working pressure rating at least 250 psi.	American "Flex-Ring," or "Lok-Ring"; U.S. Pipe or McWane "TR Flex"; U.S. Pipe HP LOK.
	Restrained Push-on Joints, positive locking segments and/or rings, (54 inch thru 64 inch), working pressure rating at least 250 psi.	American "Lok Ring"; or U.S,Pipe "H.P. LOK".
Restrained push-on joints shall be suitable for a test or working pressure plus surge pressure of the rated working pressure plus 100 psi (680 kPa)		
Flanged Joints		ANSI/AWWA C115/A21.15.
	Flanges	
	Class 250 (Where identified on the Drawings)	Ductile iron, flat faced, with ANSI/ASME B16.1, Class 250 diameter and drilling.
	All Others	Ductile iron, Class 125, ANSI/AWWA C115/A21.15.
	Flanges	All flanges shall be suitable for test pressure of 1.5 times rated pressure without leakage or damage.
	Bolts	ASTM A307, chamfered or rounded ends projecting 1/4 to 1/2 inch beyond outer face of nut.
	Nuts	ASTM A563, hexagonal, ANSI/ASME B18.2.2, heavy semifinished pattern.
	Gaskets	ASTM D1330, Grade I rubber, full face type, 1/8 inch thick unless otherwise required by pipe manufacturer and accepted by Design-Builder. Pipe manufacturer shall submit certification of gaskets furnished as indicated above under Gaskets - All Joint Types.
Insulated Flanges		
	Flanges	As specified herein, except bolt holes shall be enlarged as needed to accept bolt insulating sleeves.
	Insulation Kits	As manufactured by Advanced Products or Pipeline Seal and Insulator, Inc.

		Insulating Gaskets	Type E, G-10, 1/8 inch thick, with Nitrile or EPDM sealing element for water and air service and Viton sealing elements for wastewater service unless otherwise required by pipe manufacturer and accepted by Design-Builder. Pipe manufacturer shall submit certification of gaskets furnished as indicated above under Gaskets - All Joint Types.
		Bolt Insulating Sleeves	G-10, 1/32 inch thick.
		Insulating Washers	G-10, 1/8 inch thick, two for each flange bolt.
		Backing Washers	Steel, 1/8 inch thick, two for each flange bolt.
Mechanical Joints			ANSI/AWWA C111/A21.11., with ductile iron glands.
	Restrained Mechanical Joints (factory prepared spigot), (4 inch through 48 inch), working pressure rating at least 250 psi.		American "MJ coupled Joints", or Griffin "Mech-Lok".
	Restrained Mechanical Joints, (field cut spigot), (4 inch through 24 inch), working pressure rating 350 psi for 4 through 16 inch and at least 250 psi for 18 through 24 inch.		EBAA Iron "Megalug" Series 1100, Sigma “One Lok” SLDE series, or Star Pipe Products “StarGrip 3000” or accepted equal.
Restrained mechanical joints shall be suitable for a test or working pressure plus surge pressure of the rated working pressure plus 100 psi			
	Wall Pipes or Castings		Mechanical joint with water stop and tapped holes; single casting or fabricated ductile iron pipe; holes sized in accordance with the details on the Drawings and provided with removable plugs.
	Mechanical Joints with Tie Rods		As indicated on the Drawings.
		Tie Rods	ASTM A307.

		Steel Pipe	ASTM A53, Schedule 40 or 80 as indicated on the Drawings.
		Washers	ANSI/ASME B18.22.1, plain steel.
Threaded Connections			ANSI/ASME B1.20.1, NPT; with boss or tapping saddle wherever wall thickness minus the foundry tolerance at the tapped connection is less than that required for 4-thread engagement as set forth in Table A.1, Appendix A, of ANSI/AWWA C151/A21.51.
Mechanical Couplings			
	Couplings		Dresser "Style 38"; Smith-Blair "411 Steel Coupling"; or Romac “Style 400” or "Style 501"; without pipe stop.
	Gaskets		Oil-resistant synthetic rubber gaskets shall be as recommended by the coupling manufacturer. Pipe manufacturer shall submit certification of gaskets furnished as indicated above under Gaskets - All Joint Types.
Restrained Mechanical Couplings			American Pipe “Restrained Coupling Gland Joint” coordinated with mechanical couplings furnished.
Grooved-End Joints			AWWA C606.
	Pipe Ends (rigid joints)		Grooved, with dimensions conforming to AWWA C606, Table 3.
	Pipe Ends (flexible joints)		Shouldered, with dimensions conforming to AWWA C606, Table 4.
	Couplings (non-shouldered pipe)		Tyco/Grinnell "Figure 772," or Victaulic "Style 31."
	Couplings (shouldered pipe)		Victaulic "Style 41" or "Style 44".
Flanged Coupling Adapters			
	Restrained (4 inch through 12 inch). Unless otherwise indicated on the Drawings, flanged coupling adapters shall be restrained.		Smith-Blair "Type 912", Romac "Style FCA501", or equal, with anchor studs of sufficient size and number to withstand test pressures.
	Unrestrained (14 inch and larger)		Smith-Blair "Type 913", Romac "Style FC400", or equal.

Dismantling Joints		
	Restrained (3 inch and larger) Unless otherwise indicated on the Drawings, dismantling joints shall be restrained.	Romac "DJ400"; Dresser "Style 131 Dismantling Joint", Viking Johnson, or equal. For use in potable water systems, coating to be in accordance with NSF-61.
Tapping Saddles		Ductile iron, with stainless steel straps and synthetic rubber sealing gasket, 250 psi pressure rating.
Watertight/Dusttight Pipe Sleeves		GPT " Link-Seal", insulating type with modular rubber sealing elements, nonmetallic pressure plates, and stainless steel bolts and nuts.
Shop Coating and Lining		
	Cement Mortar Lining with Seal Coat	ANSI/AWWA C104/A21.4. Double thickness.
	Protective Fusion-Bonded	ANSI/AWWA C116/A21.16.
	Ceramic Epoxy Lining	Induron "Protecto 401 Ceramic Epoxy".
	Glass Lining	Two-coat system applied over blast-cleaned surface; ground and finish coats separately fired; finished lining thickness at least 10 mils, Mohs' Hardness 5 to 6 density as determined by ASTM D792; Fast Fabricators, Inc. "MEH 32" or "SG-14".
	Universal Primer	Manufacturer's standard. If in contact with treated or potable water, certify as being in compliance with ANSI/NSF 61.
	Asphaltic Coating	Manufacturer's standard.
	Zinc Coating	ISO 8179
	Coal Tar Epoxy	Manufacturer's standard.
	Liquid Epoxy	ANSI/AWWA C210, non-coal tar modified, or when in contact with treated or potable water, certify as being in compliance with ANSI/NSF 61.

Anti-Seize Thread Lubricant		Jet-Lube "Nikal", John Crane "Thred Gard Nickel", Bostik/Never-Seez "Pure Nickel Special" or Permatex "Nickel Anti-Seize".
Corrosion Protection		
	Polyethylene Encasement	Seamless, ANSI/AWWA C105/A21.5; LLDPE - 8 mil or HDCLPE - 4 mil.
	Heat-shrinkable Coating and Primer (Shrink Sleeve)	ANIS/AWWA C216, cross-linked polyethylene sheeting precoated with adhesive; minimum 80 mils; type and recovery as recommended by Shrink Sleeve manufacturer; Canusa-CPS or Berry Plastics Water Wrap.
	Wax Tape and Primer	ANSI/AWWA C217, cold-applied petroleum wax primer and cold-applied petroleum wax tape; Trenton Wax-Tape and Primer.
	Medium Consistency Coal Tar	Carboline "Bitumastic 50" or Tnemec "46-465 H.B. Tnemecol." Applied to manufacturer's maximum recommended thickness.

2-3.

2-3. OUTLETS. Where a 12 inch or smaller branch outlet is indicated and the diameter of the parent pipe is at least twice the diameter of the branch, a tee, a factory welded-on boss, or a tapping saddle will be acceptable.

Where a 4 inch or larger branch outlet is indicated on the Drawings and the diameter of the branch pipe for a given diameter of parent pipe is less than or equal to the maximum diameter listed herein, a factory welded-on outlet fabricated from centrifugally cast ductile iron pipe will be acceptable.

Parent Pipe Diameter Versus Maximum Branch Pipe Diameter for Welded-On Outlets

Parent Pipe Dia inches	Max Branch Pipe Dia inches	Parent Pipe Dia inches	Max Branch Pipe Dia inches
8	4	30	20
10	6	36	24
12	8	42	30
14	8	48	30

Parent Pipe Diameter Versus Maximum Branch Pipe Diameter for Welded-On Outlets

Parent Pipe Dia inches	Max Branch Pipe Dia inches	Parent Pipe Dia inches	Max Branch Pipe Dia inches
16	10	54	36
18	12	60	36
20	14	64	36
24	16		

All 30 inch and smaller branch pipe diameter welded-on outlets shall be rated for a working pressure of 250 psi, 36 inch branch diameter welded-on outlets shall be rated for a working pressure of 200 psi, and all outlets shall have a minimum factor of safety of 2.0. The pipe manufacturer shall provide test data and certification of proof of design. It is not necessary that these tests be performed on pipe manufactured specifically for this project. Certified reports covering tests made on other pipe of the same size and design as specified herein and manufactured from materials of equivalent type and quality may be accepted as adequate proof of design.

Welded-on outlets may be provided as a radial (tee) outlet, a tangential outlet, or a lateral outlet fabricated at a specific angle to the parent pipe (in 15 degrees [0.262 rad] increments between 45 degrees and 90 degrees [0.785 to 1.570 rad] from the axis of the parent pipe), as indicated on the Drawings. The fillet weld dimensions for welded-on outlets shall be as specified herein. Parent pipe and branch pipe shall meet hydrostatic test requirements in accordance with ANSI/AWWA C151/A21.51 prior to fabrication.

Welded-on Outlet Fillet Weld Dimensions for Specified Outlet Configurations

Radial and Lateral Outlets			Tangential Outlets		
Parent Pipe Dia inches	Branch Pipe Dia inches	Weld Fillet Size inches	Parent Pipe Dia inches	Branch Pipe Dia inches	Weld Fillet Size inches
24 and smaller	24 and smaller	1 x 1	8-30	24 and smaller	1-1/4 x 1-1/4
30-48	24 and smaller	1-1/4 x 1-1/4	36-54	24 and smaller	1-1/2 x 1-1/2
54-64	24 and smaller	2-1/4 x 2-1/2	60-64	24 and smaller	2-1/2 x 2-1/2

Welded-on Outlet Fillet Weld Dimensions for Specified Outlet Configurations

Radial and Lateral Outlets			Tangential Outlets		
Parent Pipe Dia inches	Branch Pipe Dia inches	Weld Fillet Size inches	Parent Pipe Dia inches	Branch Pipe Dia inches	Weld Fillet Size inches
42-64	30	2-1/2 x 2-1/2	42-54	30	2-1/2 x 2-1/2

All joints on welded-on branch outlets shall be made in accordance with the latest revision of ANSI/AWWA C111/A21.11 and/or ANSI/AWWA C115/A21.15, as applicable. All outlets shall be fabricated from centrifugally cast ductile iron pipe designed in accordance with ANSI/AWWA C150/A21.50 and manufactured and tested in accordance with ANSI/AWWA C151/A21.51. Ni-Rod FC 55® electrodes manufactured by International Nickel Corporation (or an electrode with equivalent properties) shall be used in the manufacture of the fillet welds. Carbon steel electrodes will not be acceptable. Special Thickness Class 53 pipe shall be used for all branch pipe and parent pipe in 4 to 54 inch sizes. Pressure Class 350 pipe shall be used for 60 inch and 64 inch parent pipe. After welding, each fabricated outlet shall be subjected to a 15 psi air test. A soap and water solution shall be applied during the testing procedure to inspect the weld for leakage. Any welds that show air seepage shall be refabricated and retested.

Welded-on outlets shall be fabricated by the pipe manufacturer at its production facilities. Manufacturers of welded-on outlets shall have at least 5 years of satisfactory experience in the manufacture and performance of these products. The manufacturer shall have a documented welding quality assurance system and shall maintain resident quality assurance records based on ANSI/AWS D11.2, the Guide for Welding Iron Castings. The manufacturer shall also maintain appropriate welding procedure specifications (WPS) and procedure qualification (PQR), and welder performance qualification (WPQR) records.

The type of pipe end for the branch outlet shall be as specified or indicated on the Drawings. The maximum size and laying length of the welded-on branch outlet shall be as recommended by the pipe manufacturer and shall be acceptable to Design-Builder for the field conditions and the connecting pipe or valve.

At locations acceptable to Design-Builder, drilling and tapping of the pipe wall for2 inch and smaller pipe connections will also be acceptable, provided that the wall thickness, minus the casting allowance, at the point of connection equals or exceeds the wall thickness required for 4-thread engagement in accordance with Table A.1, Appendix A of ANSI/AWWA C151/A21.51.

2-4. JOINTS. Joints in buried and tunnel locations shall be mechanical or push-on type unless otherwise indicated on the Drawings or where required to connect to existing piping or to valves. Bells on wall castings and wall sleeves shall be mechanical joint type, with tapped holes for tie rods or stud bolts. All other joints shall be flanged unless otherwise indicated on the Drawings.

Certification of joint design shall be provided in accordance with ANSI/AWWA C111/A21.11, Performance Requirements, as modified herein. The joint test pressure shall be not less than 2 times the working pressure rating of the joint. The same certification and testing shall also be provided for restrained joints. For restrained joints, the piping shall not be blocked to prevent separation and the joint shall not leak or show evidence of failure. It is not necessary that such tests be made on pipe manufactured specifically for this project. Certified reports covering tests made on other pipe of the same size and design as specified herein and manufactured from materials of equivalent type and quality may be accepted as adequate proof of design. Any new proof-of-design testing to meet the requirements for this project shall be independently verified and the Owner shall be given the opportunity to witness the testing.

Unless otherwise indicated on the drawings or acceptable to the Design-Builder, field closure pieces shall be located away from the bends or dead ends beyond the length over which joints are to be restrained.

The length of pipe having restrained joints shall be as indicated on the drawings or specified. All vertical bends and eccentric reducers shall have restrained joints.

2-4.01. Flanged Joints. Pipe shall extend completely through screwed-on flanges. The pipe end and flange face shall be finish machined in a single operation. Flange faces shall be flat and perpendicular to the pipe centerline.

2-4.02. Flanged Coupling Adaptors. Flanged coupling adapters shall be provided for restrained couplings 12 inch and smaller where indicated on the Drawings and as specified herein. Unless indicated otherwise on the Drawings, all flange coupling adapters 12 inch and smaller shall be restrained. Flange coupling adapters 14 inch and larger may only be used in unrestrained pipe applications.

The inner and outer surfaces of couplings, except flange mating surfaces, shall be prepared for coating in accordance with instructions of the coating manufacturer and shall then be shop coated with liquid epoxy in accordance with ANSI/AWWA C210. The flange mating surfaces shall be cleaned and shop primed with universal primer.

2-4.03. Dismantling Joints. Dismantling joints shall be provided for restrained couplings 6 inch and larger piping where indicated on the Drawings and as specified herein. Dismantling joints shall comply with AWWA C219 and shall be

restrained flange by flange couplings manufactured as a single unit. Unless otherwise indicated on the Drawings, dismantling joints shall be restrained.

The inner and outer surfaces of dismantling joints, except flange mating surfaces, shall be prepared for coating in accordance with instructions of the coating manufacturer and shall then be shop coated with liquid epoxy in accordance with ANSI/AWWA C210. The flange mating surfaces shall be cleaned and shop primed with universal primer.

2-4.04. Mechanical Couplings. The piping layout for mechanical couplings shall provide a space of at least 1/4 inch , but not more than 1 inch , between the pipe ends.

All surfaces, including the interior surfaces of the middle rings, shall be prepared for coating in accordance with instructions of the coating manufacturer and shall be shop coated with 16 mils liquid epoxy in accordance with ANSI/AWWA C210.

A ductile iron pipe factory spacer shall be provided for the piping where indicated on the drawings. The spacer shall be shop lined and coated with 16 mils of liquid epoxy. Piping surfaces within the coupling shall be shop coated with 16 mils of liquid epoxy.

Tie bolts shall be provided to restrain mechanical coupling connections where indicated on the Drawings. The connecting pipe shall be furnished with welded retainer rings as recommended by pipe manufacturer. The pipe manufacturer shall also coordinate the restrained connection with the pressure rating, length, and diameter dimensions of the mechanical coupling being furnished to assure proper clearance is provided for completing the restrained coupling installation.

2-4.05. Grooved-End Couplings. Grooved-end couplings shall not be used in the following applications: chemical service, except lime slurry piping, flammable liquid or flammable gas piping, compressed air or compressed gas piping operating at pressures above 25 psig , toxic gas piping, hot liquid with operating temperatures above 120°F, or steam piping.

2-5. REDUCERS. Reducers shall be eccentric or concentric as indicated on the Drawings. Reducers of eccentric pattern shall be installed with the straight side on top, so that no air traps are formed.

2-6. BLOWOFFS. Each blowoff shall be located and arranged as indicated on the Drawings.

2-7. ACCESS OPENINGS. Not used.

2-8. WALL AND FLOOR PIPES. Wall and floor pipes shall be installed where ductile iron pipes pass through concrete walls or floors, unless otherwise indicated on the Drawings.

Where a flange and mechanical joint pipe piece is to connect to a mechanical joint wall pipe or casting, the bolt holes in the bell of the wall pipe or casting shall straddle the top centerline of the horizontal pipe or casting and shall align with the bolt holes in the flange and mechanical joint piece. The top centerline shall be marked on the wall pipe or casting at the foundry or fabrication shop.

In vertical piping, the bolt holes of flanged and mechanical joint floor pipes or castings shall be aligned with the bolt holes of the flange or mechanical joint connecting piece. The required centerline alignment and orientation of the floor pipe or casting shall be marked on the floor pipe or casting at the foundry or fabrication shop.

2-9. WALL AND FLOOR SLEEVES. Wall and floor sleeves shall be installed where indicated on the Drawings and shall be installed where ductile iron pipe passes through concrete walls and floors or masonry walls, unless otherwise noted. To minimize sleeve size, piping on either side of the sleeve shall be provided with a screw-on flange, grooved coupling, or mechanical coupling with anchor studs to allow the pipe to pass through the sleeve. Where required, sleeves in masonry walls may be enlarged enough for flange or other joint restraint to pass through the sleeve.

Where specified or indicated on the Drawings, one or two sets of modular casing seals shall be installed at the face of walls to seal against soil or provide a dust or water tight seal. Design-Builder shall coordinate the diameter of wall or floor sleeves with the modular casing seal manufacturer. When soil may be present at wall sleeves, two sets of modular casing seals shall be installed, one at each face of the wall. Unless otherwise indicated on the Drawings, modular casing seals shall not be used in submerged conditions unless the hydrostatic pressure is less than 20 feet and piping is less than 24 inch size.

2-10. SHOP COATING AND LINING. The interior of all pipe and fittings, unless noted otherwise, shall be cement mortar lined. See the Ductile Iron Pipe Schedule.

The exterior surfaces of all pipe and fittings which will be exposed in both interior and exterior locations shall be shop primed. For System Supplier packages, piping shall be coated in the shop with the final coating as indicated in the various System Supplied packages. Field painting of exposed exterior surfaces is covered in the Protective Coatings section for Design-Builder installed piping. Flange faces shall be coated with a suitable rust-preventive compound. Exterior surfaces of all other pipe and fittings shall be coated with asphaltic coating.

2-11. OWNER'S SHOP INSPECTION AND TESTING. Not used.

PART 3 – EXECUTION

3-1. INSPECTION. Pipe and fittings shall be carefully examined for cracks and other defects immediately before installation; pipe ends shall be examined with particular care. All defective pipe and fittings shall be removed from the site.

3-2. PROTECTION AND CLEANING. The interior of all pipe and fittings shall be thoroughly cleaned of all foreign material prior to installation and shall be kept clean until the work is completed. Before jointing, all joint contact surfaces shall be wire brushed if necessary and wiped clean.

Precautions shall be taken to prevent foreign material from entering the pipe during installation. Debris, tools, clothing, or other objects shall not be placed in or allowed to enter the pipe.

Whenever pipe laying is stopped, the open end of the pipe shall be closed to prevent entry of dirt, mud, rodents, and other material. All water in the trench shall be removed prior to removing the closure.

3-3. CUTTING PIPE. Cutting shall be done in a neat manner, without damage to the pipe or the lining. Cuts shall be smooth, straight, and at right angles to the pipe axis. After cutting, the ends of the pipe shall be dressed with a file or a power grinder to remove all roughness and sharp edges. The cut ends of push-on joint pipe shall be suitably beveled.

All field cutting of existing gray cast iron pipe shall be done with mechanical pipe cutters, except where the use of mechanical cutters would be difficult or impracticable.

Ends of ductile iron pipe shall be cut with a portable guillotine saw, abrasive wheel, saw, milling cutter, or oxyacetylene torch. The use of hydraulic squeeze type cutters will not be acceptable. Field-cut holes for saddles shall be cut with mechanical cutters; oxyacetylene cutting will not be acceptable.

Design-Builder shall use factory prepared pipe ends unless a field cut is required for connections.

3-4. ALIGNMENT AND GRADE. Buried piping shall be laid to the lines and grades indicated on the Drawings and as specified. Pipelines or runs intended to be straight shall be laid straight. Deflections from a straight line or grade shall not exceed the values stipulated for full-length push-on joint pipe for full-length mechanical joint pipe of AWWA C600, unless specially designed bells and spigots are provided. Design-Builder shall submit his proposed methods to measure deflection of deflected joints in accordance with the Submittal section.

Whenever deflections would exceed the values stipulated in AWWA C600, either shorter pipe sections or fittings shall be installed where needed to conform to the alignment or grade indicated on the Drawings.

Unless otherwise specified or acceptable to Design-Builder, laser beam equipment, surveying instruments, or other suitable means shall be used to maintain alignment and grade. At least one elevation reading shall be taken on each length of pipe. If laser beam equipment is used, periodic elevation measurements shall be made with surveying instruments to verify accuracy of grades. If such measurements indicate thermal deflection of the laser beam due to differences between the ground temperature and the air temperature within the pipe, precautions shall be taken to prevent or minimize further thermal deflections.

Additional requirements for alignment and grade are covered in the Project Requirements and Trenching and Backfilling sections and on the Drawings.

3-4.01. Tolerances. Each section of pipe shall be laid to the alignment and grade indicated on the Drawings and pipe laying schedule with pipe ends within the following tolerances;

+/- 0.10 foot in grade at any point
+/- 0.20 foot in alignment at any point

In addition, piping shall be visually straight or on a smooth curve between the points of defection or curvature indicated on the Drawings. Stricter tolerances than specified above shall be used as necessary to maintain minimum cover, to maintain required clearances, to make connections to existing pipe, to maintain the correct slope to avoid high or low points along the pipeline other than at locations indicated on the Drawings, or to meet other restrictions as required or directed by the Design-Builder.

3-5. LAYING PIPE. Buried pipe shall be protected from lateral displacement by placing the specified pipe embedment material installed as specified in the Trenching and Backfilling section. Under no circumstances shall pipe be laid in water, and no pipe shall be laid under unsuitable weather or trench conditions. Pipe embedment material and trench backfill shall be placed and compacted under and around each side of outlets and fittings to hold the pipe in proper position and alignment during the subsequent pipe jointing, embedment, and backfilling.

Pipe shall be laid with the bell ends facing the direction of laying, except where reverse laying is specifically acceptable to Design-Builder.

3-6. JOINTS.

Each joint, including restrained joints, shall be checked by Design-Builder as recommended by the pipe manufacturer to verify that the joint and the restraints are installed properly. Restrained joints shall be extended after they are assembled to minimize further take-up.

3-7. MECHANICAL JOINTS. Mechanical joints shall be carefully assembled in accordance with the pipe manufacturer's recommendations. If effective sealing is not obtained, the joint shall be disassembled, thoroughly cleaned, and reassembled. Bolts shall be uniformly tightened to the torque values listed in Appendix A of ANSI/AWWA C111/A21.11. Over tightening of bolts to compensate for poor installation practice will not be acceptable.

The holes in mechanical joints with tie rods shall be carefully aligned to permit installation of the tie rods. In flange and mechanical joint pieces, holes in the mechanical joint bells and the flanges shall straddle the top centerline for horizontal piping.

3-8. PUSH-ON JOINTS. The pipe manufacturer's instructions and recommendations for proper jointing procedures shall be followed. All joint surfaces shall be lubricated with a soap solution provided by the pipe manufacturer immediately before the joint is completed. Lubricant shall be suitable for use in potable water, shall be stored in closed containers, and shall be kept clean. Each spigot end shall be suitably beveled to facilitate assembly.

Pipe ends for restrained joint pipe shall be prepared in accordance with the pipe manufacturer's recommendations.

3-9. FLANGED JOINTS. When bolting flanged joints, care shall be taken to avoid restraint on the opposite end of the pipe or fitting which would prevent uniform gasket compression or would cause unnecessary stress in the flanges. One flange shall be free to move in any direction while the flange bolts are being tightened. Bolts shall be tightened gradually in a crisscross pattern and at a uniform rate, to ensure uniform compression of the gasket around the entire flange. All flange joint bolting procedures shall be in accordance with the pipe manufacturer's recommendations.

Special care shall be taken when connecting piping to any pumping equipment to ensure that piping stresses are not transmitted to the pump flanges. All connecting piping shall be permanently supported to obtain accurate matching of bolt holes and uniform contact over the entire surface of flanges before any bolts are installed in the flanges.

Pump connection piping shall be free to move parallel to its longitudinal centerline while the bolts are being tightened. Each pump shall be leveled, aligned, and wedged into position which will fit the connecting piping, but shall

not be grouted until the initial fitting and alignment of the pipe, so that the pump may be shifted on its foundation if necessary to properly install the connecting piping. Each pump shall, however, be grouted before final bolting of the connecting piping.

After final alignment and bolting, the pump connections shall be tested for applied piping stresses by loosening the flange bolts which, if the piping is properly installed, should result in no movement of the piping relative to the pump or opening of the pump connection joints. If any movement is observed, the piping shall be loosened and re-aligned as needed and then the flanges bolted back together. The flange bolts shall then be loosened and the process repeated until no movement is observed.

3-9.01. Insulated Flanged Joints. Insulated flanged joints shall be installed where indicated on the Drawings. In addition to one full-faced insulated gasket, each flange insulating assembly shall consist of one full-length sleeve, two insulating washers, and two backing washers for each flange bolt. The insulating gasket ID shall be 1/8 inch less than the ID of the flange in which it is installed. The insulated flanged joint accessories shall be installed in accordance with the instructions and recommendations of the insulating kit manufacturer.

3-10. FLANGED COUPLING ADAPTERS. Flange coupling adapters shall be installed in accordance with the coupling manufacturer's recommendations. Unless indicated on the Drawings, all flange coupling adapters shall be restrained. Through-wall anchor studs requiring drilling the pipe wall are not acceptable.

3-11. DISMANTLING JOINTS. Dismantling joints shall be installed in accordance with the coupling manufacturer's recommendations.

3-12. MECHANICAL COUPLINGS. Mechanical couplings shall be installed in accordance with the coupling manufacturer's recommendations. A space of at least 1/4 inch , but not more than 1 inch , shall be left between the pipe ends. Pipe and coupling surfaces in contact with gaskets shall be clean and free from dirt and other foreign matter during assembly. All assembly bolts shall be uniformly tightened so that the coupling is free from leaks, and all parts of the coupling are square and symmetrical with the pipe. Following installation of the coupling, damaged areas of shop coatings on the pipe and coupling shall be repaired to the satisfaction of Design-Builder.

3-13. GROOVED-END JOINTS. Grooved-end joints with rigid type grooving shall be installed in accordance with the coupling manufacturer's recommendations. Completed joints shall be rigid and shall allow no angular deflection or longitudinal movement. Except for closure pieces, field grooving of pipe will not be acceptable.

3-14. GAS AND OIL-RESISTANT GASKETS. Not used.

3-15. CORROSION PROTECTION.

3-15.01. Polyethylene Encasement. All buried pipe including all straight pipe, bends, tees, adapters, closure pieces, and other fittings or specials, shall be provided with at least one wrap of polyethylene encasement, except where encased in concrete. However, where a locking wedge restrained joint is cast in concrete, the joint restraint is to be enclosed in a minimum of 16 mils of polyethylene wrap to prevent intrusion of the cement around the locking wedges and rendering them ineffective. Other locations where ductile iron pipe and accessories shall be double wrapped with polyethylene encasement shall be as specified herein. Where the ductile iron pipe is embedded within a concrete structure wall, floor or footing, the polyethylene encasement for the pipe shall end at the outside faces of the structure. Ductile iron pipe embedded within concrete structures shall not be wrapped with polyethylene encasement except as described above.

All buried flanged valves, mechanical joint couplings with tie rods, mechanical couplings, restrained mechanical couplings and other pipe harness assemblies at valves or structure walls shall be provided with two wraps of polyethylene encasement in addition to other corrosion protection coatings as specified herein.

Polyethylene tube protection shall be installed in accordance with ANSI/AWWA C105/A21.5, Method A. Preparation of the pipe shall include, but shall not be limited to, removal of lumps of clay, mud, cinders, etc., prior to installation.

The terms "polyethylene tube protection" and "polyethylene encasement" are interchangeable and shall have the same meaning in these Contract Documents.

3-15.01.01. Inspection and Testing. Tests for preliminary acceptance of polyethylene encasement materials as required in the submittal paragraph shall be made at the expense of the Design-Builder.

At the Owner’s expense, the Owner may obtain samples from the material supplied in the field and have test conducted of the requirements specified in ANSI/AWWA C105/A21.5 by an independent third-party laboratory.

3-15.02. Mechanical Joint Couplings with Tie Rods. The mechanical joint tie rods, bolt studs, pipe spacers and washers of buried mechanical joint couplings as detailed on the Drawings shall be protected by wrapping them with wax tape in accordance with ANSI/AWWA C217. A primer shall be applied prior to applying the wax tape. The application of the wax tape shall be as recommended by the wax tape manufacturer. There shall be no bare or unprotected ferrous metal surfaces.

Following application of the wax tape protection, the entire mechanical joint coupling assembly shall be wrapped with two layers of polyethylene encasement

as specified herein. The two wraps of polyethylene encasement shall be lapped a minimum of 12 inches with the polyethylene encasement of the piping on each side of the coupling assembly.

3-15.03. Flanged Joints. The flange bolts and nuts on buried flanges, including valve flanges, shall be protected by wrapping them with wax tape in accordance with ANSI/AWWA C217. A primer shall be applied prior to applying the wax tape. The application of the wax tape shall be as recommended by the wax tape manufacturer. There shall be no bare or unprotected ferrous metal surfaces.

Following application of the wax tape protection, the entire flanged joint shall be wrapped with two layers of polyethylene encasement as specified herein. The two wraps of polyethylene encasement shall be lapped a minimum of 12 inches with the polyethylene encasement on each side of the joint.

3-15.04. Valves. Buried portions of the valve and the actuator to the wrench nut shall be wrapped with two layers of polyethylene encasement as specified herein. The two wraps of polyethylene encasement shall be lapped a minimum of 12 inches with the polyethylene encasement of the piping on each side of the valve.

3-15.05. Mechanical Couplings. The tie bolts and nuts on all buried mechanical couplings shall be coated with two coats of medium consistency coal tar.

After the protective coating has been applied to the tie bolts, the entire mechanical coupling shall be encapsulated with a shrink sleeve as indicated on the Drawings. The shrink sleeve shall extend a minimum of 6 inches on to the pipe on each side of the coupling. A primer shall be applied to the piping on each side of the coupling prior to installing the shrink sleeve. The application of the shrink sleeve shall be in accordance with ANSI/AWWA C216 and as recommended by the shrink sleeve manufacturer. There shall be no bare or unprotected ferrous metal surfaces. Following installation of the shrink sleeve, the entire assembly shall be encapsulated with two wraps of polyethylene encasement lapped a minimum of 12 inches with the polyethylene encasement of the piping on each side of the assembly as specified herein.

3-15.06. Restrained Mechanical Couplings. The corrosion protection for the mechanical coupling and its tie bolts and nuts of all buried restrained mechanical coupling assemblies shall be protected with two coats of medium consistency coal tar and shrink sleeve as specified herein for buried mechanical couplings.

The tie rods and bolts of the coupling assembly shall be protected by wrapping them with wax tap in accordance with ANSI/AWWA C217 and as detailed on the Drawings. A primer shall be applied prior to applying the wax tape. The application of the wax tape shall be as recommended by the wax tape manufacturer. There shall be no bare or unprotected ferrous metal surfaces.

Following the application of the wax tape, the entire restrained mechanical coupling assembly shall be encapsulated with two wraps of polyethylene encasement lapped a minimum of 12 inches with the polyethylene encasement of the piping on each side of the assembly as specified herein.

3-15.07. Other Assemblies. All ferrous metal clamps, tie rods, bolts, and other components of buried joint harnesses, tapping saddles, or pipe reaction anchorages in contact with earth or other fill material and not encased in concrete, shall be protected by wrapping them with wax tape in accordance with ANSI/AWWA C217. A primer shall be applied prior to applying the wax tape. The application of the wax tape shall be as recommended by the wax tape manufacturer. There shall be no bare or unprotected ferrous metal surfaces.

Following the application of the wax tape, the entire assembly shall be encapsulated with two wraps of polyethylene encasement lapped a minimum of 12 inches with the polyethylene encasement of the piping on each side of the assembly as specified herein.

3-15.08. Surfaces Exposed in Manholes and Vaults. Unless otherwise specified, all uncoated surfaces exposed in manholes and vaults shall be cleaned and coated with two coats of medium consistency coal tar. The first coat shall be dry and hard before the second coat is applied. There shall be no unprotected, bare, or uncoated ferrous metal surfaces.

3-16. PROVISIONS FOR CATHODIC PROTECTION SYSTEMS. 3-16.01. Electrical Bond Across Rubber-Gasketed Joints. Two electrical bonding cables shall be provided across each mechanical coupling and each rubber-gasketed bell-and-spigot joint. Before applying the field joint coating to mechanical couplings, two small areas of the metal surface shall be exposed on each side of the coupling, on the middle ring, and on each follower ring. Each exposed area shall be thoroughly cleaned, and two cathodic protection cables shall be connected to the top of the pipe at least 12 inches apart, one end of each on either side of the joint, and to the middle ring and follower rings of mechanically coupled joints, using the thermite process. The completed connections and exposed metal surfaces shall be coated as specified for field repair of coatings.

Joint bond cables shall contain at least 6 inches of slack wire to compensate for pipe movement and backfill settlement.

3-16.01. Electrical Bond Across Valves and Flanges. Two electrical bonding cables shall be provided across valves and flanged connections other than insulating flanges in the same manner as specified for rubber-gasketed joints.

3-16.02. Bonding Cables. Bonding cable and test lead wires shall be at least 8 AWG, Type CP copper cathodic protection cable, with low density, high molecular weight polyethylene insulation.

3-17. CONNECTIONS WITH EXISTING PIPING. Not used.

3-18. CONCRETE ENCASEMENT. Concrete encasement shall be installed where indicated on the Drawings. A pipe joint shall be provided within 12 inches of each end of the concrete encasement. Concrete and reinforcing steel shall be as specified in the Cast-in-Place Concrete section. All pipe to be encased shall be suitably supported and blocked in proper position, and shall be anchored to prevent flotation.

3-19. REACTION ANCHORAGE AND BLOCKING. Concrete blocking shall be installed where indicated on the Drawings. Concrete and reinforcing steel shall be as specified in the Cast-in-Place Concrete section.

The blocking size shall be of the dimensions indicated on the Drawings, shall extend from the fitting to solid, undisturbed earth, and shall be installed so that all joints are accessible for repair. If adequate support against undisturbed ground cannot be obtained, restrained joints shall be installed to provide the necessary support.

Reaction blocking, anchorages, or other supports for fittings installed in fills or other unstable ground, installed above grade, or exposed within structures, shall be provided as indicated on the Drawings.

All ferrous metal clamps, rods, bolts, and other components of tapping saddles, reaction anchorages, or joint harness, subject to submergence or in contact with earth or other fill material and not encased in concrete, shall be protected from corrosion as specified in the Corrosion Protection paragraph of this section.

3-20. PRESSURE AND LEAKAGE TESTS. After installation, pipe and fittings shall be subjected to a pressure test and a leakage test in accordance with the Pipeline Pressure and Leakage Testing section.

3-21. CLEANING AND DISINFECTION. The interior of all pipe and fittings shall be thoroughly cleaned before installation and shall be kept clean of any foreign matter until the work has been accepted. All joint contact surfaces shall be kept clean until the joint is completed.

After installation, all potable water pipelines shall be cleaned and disinfected as specified in the Cleaning and Disinfection of Water Pipelines section.

End of Section

Section 40 05 23

STAINLESS STEEL PIPE AND ALLOY PIPE, TUBING, AND ACCESSORIES

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of stainless steel pipe and alloy pipe, tubing and accessories through 24" diameter for the services as indicated herein. Pipe and tubing shall be furnished complete with all fittings, flanges, unions, and other accessories specified herein.

1-2. SUBMITTALS.

1-2.01. Drawings and Data. Complete specifications, data, and catalog cuts or drawings shall be submitted in accordance with the Submittals Procedures section. Submittals are required for all piping, fittings, gaskets, sleeves, and accessories, and shall include the following data:

Name of Manufacturer
Type and model
Construction materials, thickness, and finishes
Pressure and temperature ratings

Gasket materials shall be compatible with the joints specified herein and shall be recommended by the manufacturer for the specified field test pressures and service conditions.

All welding and brazing procedures and operators shall be qualified by an independent testing laboratory in accordance with the applicable provisions of Section IX of the ASME Code. All procedure and operator qualifications shall be in written form and submitted to the Design Builder for review.

Pipe for liquid chemical service shall comply with ASME B31.3. Pipe for all other services shall comply with ASME B31.1.

1-3. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the general Terms and Conditions. Handling and storage after delivery onsite shall be in accordance with manufacturer recommendations and this section. All materials shall be stored in a sheltered location above the ground, separated by type, and shall be supported to prevent sagging or bending.

PART 2 - PRODUCTS

2-1. MATERIALS. Stainless steel pipe and alloy pipe materials shall be as specified herein.

2-1.01. Material Classification SS-1. Not used.

2-1.02. Material Classification SS-2.

SS-2 – Schedule 10S with Beveled Ends. Aeration air piping. Reverse osmosis concentrate piping. 2-1/2 inch and larger.	Pipe Fittings	ASTM A312 or ASTM A778 with longitudinal seams only, TP304L, Buttwelded, ASTM A403 WP-W or A774, wrought stainless steel, grade equivalent to pipe. Fittings shall conform to ANSI/ASME B16.9, Schedule 10S with beveled ends.

2-1.03. Material Classification SS-3.

SS-3 – Schedule 10S with Beveled Ends. Engine exhaust piping. 2-1/2 inch and larger.	Pipe Fittings	ASTM A312, Grade TP304L. Buttwelded, ASTM A403, WP304L. Fittings shall conform to ANSI/ASME B16.9, Schedule 10S with beveled ends.

2-1.04. Material Classification SS-4.

SS-4 – Schedule 40S with Beveled Ends. Microfiltration filtrate piping Reverse osmosis piping per Drawings 2-1/2 inch and larger	Pipe Fittings	ASTM A312, Grade TP304L,. Buttwelded, ASTM A403, WP304L, Fittings shall conform to ANSI/ASME B16.9, Schedule 40S with beveled ends.

2-1.05. Material Classification SS-5.

SS-5 – Schedule 40S with Beveled Ends Reverse Osmosis piping per Drawings. 2-1/2 inch and larger.	Pipe Fittings	ASTM A312, Grade TP316L. Buttwelded, ASTM A403, WP316L. Fittings shall conform to ANSI/ASME B16.9, Schedule 40S with beveled ends.

2-1.06. Material Classification SS-6.

SS-6 – Schedule 40S with Threaded Ends. Gauge piping in stainless steel piping systems (to match pipe). 2 inch and smaller.	Pipe Fittings	ASTM A312, TP316. Threaded, material to match pipe. Fittings shall conform to ANSI/ASME B16.3, Class 150.

2-1.07. Material Classification SS-7.

SS-7 – Schedule 40S with Plain Ends. Gauge piping in stainless steel piping systems. Hydrogen peroxide solution piping. 2 inch and smaller with socket welded ends.	Pipe Fittings	ASTM A312, Grade TP304L, Socket welded, ASTM A182, F304L. Fittings shall conform to ANSI/ASME B16.11, Class 3000.

2-1.08. Material Classification SS-8. Not used.

2-1.09. Material Classification SS-9.

SS-9 – SS Tubing with Compression Fittings Grease piping for grit removal equipment. Lubrication water to grit removal equipment.	Tubing	ASTM A269, seamless, TP316, annealed, max hardness Rockwell B80; with the following min wall thicknesses: Tube OD inches: 1/4 to 3/8; 1/2 to 7/8; 1 to 2 Wall Thickness inches: 0.065; 0.083; 0.109

	Fittings	Compression type, AISI Type 316 stainless steel; Crawford "Swagelok", or Parker Hannifin "CPI" or "Ferulok".

2-1.10. Material Classification SS-10. Not used.

2-1.11. Material Classification SS-11.

SS-11 – Schedule 10S with Beveled Ends. Aeration air piping. Filter air scour piping. Above grade in dry, noncorrosive atmospheres. 2-1/2 inch and larger.	Pipe Fittings	ASTM A312 or ASTM A778 with longitudinal seams only, TP316L, Buttwelded, ASTM A403 WP-W or A774, wrought stainless steel, grade equivalent to pipe. Fittings shall conform to ANSI/ASME B16.9, Schedule 10S with beveled ends.

2-1.12. Material Classification CRP-1.

CRP-1 – Carpenter 20-Cb3 Pipe with Socket Weld Fittings Sulfuric acid piping, except where indicated otherwise.	Welded Seamless Fittings	ASTM B464 - UNS NO8020, Schedule 40. ASTM B729 - UNS NO8020, Schedule 40. Forged Fittings, ASTM B462; Socket weld, Class 3000, ASTM B462 - UNS NO8020. The use of flanged fittings shall be limited to equipment connections.

2-1.13. Material Classification HST-1.

-1 – Hastelloy C276 - Pipe with Socket Weld Fittings Sodium hypochlorite piping, except where indicated otherwise	Pipe Seamless Fittings	ASTM B622; Hastelloy C276 ASTM B622 - UNS N10276, Schedule 40 Forged Fittings ASTM B366; Welded Fittings ASTM B366; Hastelloy C276. The use of flanged fittings shall be limited to equipment connections.

2-1.14. Material Classification SS-12.

SS-12 – Alloy 2205 Duplex stainless Schedule 10S. Reverse Osmosis Piping with high chlorides	Pipe	ASTM A790 S31803 SMLS
	Fittings	Buttwelded A815 S31803 or Socketwelded A182 F51 Fittings shall conform to ANSI/ASME B16.9 Schedule 10S with beveled ends or B16.11.

2-1.15. Accessory Materials. Accessory materials for the stainless steel pipe systems shall be as indicated. Flanges shall be flat faced for water service and shall be raised face for air or gas service except when connecting to flat face equipment or valve flanges.

Flanges

SS-1, SS-2 and SS-3 Pipe Backing Flanges: Stainless steel plate, AISI Type 304 or 316 to match fittings. Provide stub ends or angle face rings with material and thickness to match fittings. The angle or radius between the angle face ring or stub end and the pipe shall match the angle or radius of the backing flange for proper seating. Flanges shall conform with ANSI/ASME B16.5, Class 150 diameter and drilling; with the following thicknesses:

Nominal Pipe Size inches	Flange Thickness inches
1/2-8	1/2
10-16	5/8
18-20	3/4
24-30	1
36	1-1/4

SS-4 and SS-5 Pipe Flanges: ANSI/ASME B16.5, Class 150, AISI Type 304, 304L, 316, or 316L, to match piping.

SS-10 Pipe Flanges: Except where otherwise permitted or required, ANSI/AWWA C207, Class D, slip-on constructed of stainless steel plate or ANSI/ASME B16.5, Class 150, AISI Type 304, 304L, 316, or 316L, to match piping.

SS-11 Pipe Backing Flanges

Epoxy coated carbon steel to match fittings. Provide stub ends or angle face rings with material and thickness to match fittings. The angle or radius between the angle face ring or stub end and the pipe shall match the angle or radius of the backing flange for proper seating. Flanges shall conform with ANSI/ASME B16.5, Class 150 diameter and drilling; with the following thicknesses:

Nominal Pipe Size inches	Flange Thickness inches
1/2-8	1/2
10-16	5/8
18-20	3/4
24-30	1
36	1-1/4

Flange Bolts

ASTM A193 Class 2, AISI Type 304, ANSI B18.2.1, heavy hex head, length such that, after installation, the bolts will project 1/8 to 3/8 inch beyond outer face of the nut.

Flange Nuts

ASTM A194, AISI Type 304, ANSI/ASME B18.2.2, heavy hex pattern. Washers shall be installed under the nuts.

Flange Gaskets

Process air

Raised Face Flanges

Non-asbestos inorganic fiber with EPDM binder; dimensions to suit flange contact face, 1/16 inch minimum thickness for plain finished surfaces, 3/32 inch minimum thickness for serrated surfaces, rated for 275°F service; Garlock "IFG 5507".

Flat Faced Flanges

Premium Grade, EPDM, full face type, 1/8 inch thick, rated for 275°F service; Garlock "8314".

Chemical services.

Gaskets in chemical service shall be compatible with chemical.

All other services.

Flexitalic "Style CG", spiral wound, AISI Type 304 stainless steel, non-asbestos filler, 3/16 inch nominal thickness, with compression ring 1/8 inch thick to match required flange dimensions.

Elbows	Except for elbows in chemical service lines 4 inches [100 mm] and smaller, elbows shall be long radius type for which the laying length is 1.5 times the pipe diameter.
Protective Coatings – High Temperature Buried Service	
Epoxy for buried aeration and process air piping	Shop or field applied high solids epoxy; suitable for protection at continuous pipe wall temperatures up to 300 F. Coating shall be abrasion resistant. The finished coating shall have a minimum total film thickness of 10 mils. The surface shall be prepared in accordance with SSPC-SP7 as a minimum unless otherwise recommended by the coating manufacturer. The coating shall be Carboline “Thermaline 450”, PPG Amercoat “Amerlock 400”, or equal.
Expansion Joints	
Process air	Expansion joints shall be the elastomeric, arched type and shall be Mercer “Type 450” with “Type 500” retaining rings and Kevlar reinforcement, or equal. The number of arches shall be as indicated on the Drawings. The connection shall be suitable for a maximum pressure of 15 psig [105 kPa gauge] and maximum temperature of 275 F [122 C]. Expansion joints shall have the following minimum ratings:

Number of Arches:	1
Spring rate:	1,846 lbs/inch
Movement:	1.25 inch
Number of Arches:	2
Spring rate:	TBD lbs/inch
Movement:	TBD inch
Number of Arches:	3
Spring rate:	5,412 lbs/inch
Movement:	0.75 inch

Anti-Seize Thread Lubricant	
Insulating Fittings	
Threaded	Dielectric steel pipe nipple, ASTM A53, Schedule 40, polypropylene lined, zinc plated; Perfection Corp. "Clearflow Fittings".
Flanged	Epco "Dielectric Flange Unions" or Central Plastics "Insulating Flange Unions". Shall be suitable for temperature and service.

2-1.15.01. Branch Connections. Branch connections 2-1/2 inches and smaller shall be made with welding fittings. Welded or Threaded outlets shall be used. Where the exact outlet size desired is in doubt, but is known to be less than 1 inch, a 1 inch outlet shall be provided and reducing bushings used as needed.

Branch connections sized 3 and larger shall be made with pipe nipples or with welding fittings with welded outlets. Pipe nipples and welding fittings shall be welded to the pipe shell and reinforced as needed to meet design and testing requirements. The pressure rating of branch and branch connections shall equal or exceed the pressure rating of the main pipe it is connected to.

Small branch connections shall be so located that they will not interfere with joints, supports, or other details, and shall be provided with caps or plugs to protect the threads during shipping and handling.

2-2. WELDING OF STAINLESS STEEL AND ALLOYS. Filler metal for welding austenitic stainless steel and alloys, P-number 8 base materials shall be in accordance with the following:

Material Type/Grade 304 shall use Type 308 filler metal.

Material Type/Grade 304L shall use Type 308L filler metal.

Material Type/Grade 316, shall use Type 316 filler metal.

Material Type/Grade 316L shall use Type 316L filler metal.

Material Type/Carpenter 20 shall use Carpenter 20 filler metal.

Material Type/Hastelloy C276 shall use Hastelloy C276 filler metal.

The following requirements shall apply when fabricating austenitic stainless steel and alloy components.

Grinding shall be by aluminum oxide, zirconium oxide, or silicon carbide grinding wheels that shall not have been used on carbon or low alloy steels. Hand or power wire brushing shall be by stainless steel brushes that shall not have been used on carbon or low alloy steels for stainless steel pipe. Hand or power wire

brushing shall be by Carpenter 20 brushes that shall not have been used on carbon or low alloy steels for Carpenter 20 pipe. Hand or power wire brushing shall be by Hastelloy C276 brushes that shall not have been used on carbon or low alloy steels for Hastelloy C276 pipe. All tools used in fabrication shall be protected to minimize contact with steel alloys or free iron. Grinding wheels and brushes shall be identified and controlled for their use on these materials only to ensure that contamination of these materials does not occur.

Antispatter compounds, marking fluids, marking pens, tape, temperature indicating crayons, and other tools shall have a total halogen content of less than 200 parts per million.

Heat input control for welding shall be specified in the applicable WPS and shall not exceed 55,000 joules per inch (22,000 joules per cm) as determined by the following formula:

$$\text{Heat Input (J/in.)} = \frac{\text{Voltage x Amperage x 60}}{\text{Travel Speed (in./min.)}}$$

Complete penetration pressure retaining welds shall be made using the Gas Tungsten Arc Welding (GTAW) process for the root and second layer as a minimum.

Austenitic stainless steel instrument tubing shall be welded using only the GTAW process.

Socket welds or butt welds in all austenitic stainless steel instrument tubing lines shall require an inert gas backing (purge) using argon during welding to avoid oxidation.

The application of heat to correct weld distortion and dimensional deviation without prior written approval from the Design-Builder is prohibited.

Unless otherwise approved in writing, the GTAW process shall require the addition of filler metal.

The maximum preheat and interpass temperature for austenitic stainless steel shall be 350° F (176° C). The minimum preheat temperature shall be 50° F (10° C).

Complete joint penetration welds welded from one side without backing, weld repairs welded from one side without backing, or weld repairs in which the base metal remaining after excavation is less than 0.1875 inch (5 mm) from being through wall, which are fabricated from austenitic stainless steel ASME P-number 8 base metal or unassigned metals with similar chemical compositions, shall have the root side of the weld purged with an argon backing gas prior to

welding. Backing gas (purge) shall only be argon. The argon backing gas shall be classified as welding grade argon or shall meet Specification SFA-5.32, AWS Classification SG-A. The backing gas (purge) shall be maintained until a minimum of two layers of weld metal have been deposited.

2-3. SHOP CLEANING AND PICKLING OF STAINLESS STEEL PIPING AND WELDS. All stainless steel piping shall be thoroughly cleaned and pickled at the mill in accordance with ASTM A380.

Pickling shall produce a modest etch and shall remove all embedded iron and heat tint. After fabrication, pickled surfaces shall be subjected to a 24 hour water test or a ferroxyl test to detect the presence of residual embedded iron. All pickled surfaces damaged during fabrication including welded areas shall either be mechanically cleaned or repickled or passivated in accordance with ASTM A380. Materials that have been contaminated with steel alloys or free iron shall not be used until all contamination is removed. When cleaning to remove steel or iron contamination is required, it shall be performed in accordance with ASTM A380, Code D requirements. All stainless steel surfaces shall be adequately protected during fabrication, shipping, handling, and installation to prevent contamination from iron or carbon steel objects or surfaces. Particulate matter shall be removed from piping and welds. Labels shall be affixed to the piping sections to indicate shop cleaning has been performed. Welds shall be either mechanically cleaned or pickled or passivated on the exterior of the pipe.

For buried piping, at least the exterior of all welds shall be passivated.

2-4. HIGH TEMPERATURE EPOXY COATING. Not used.

2-5. INSULATING FITTINGS. In all piping, insulating fittings shall be provided to prevent contact of dissimilar metals, including but not limited to, contact of copper, brass, or bronze pipe, tubing, fittings, valves, or appurtenances, or stainless steel pipe, tubing, fittings, valves, or appurtenances with iron or steel pipe, fittings, valves, or appurtenances. Insulating fittings shall also be provided to prevent contact of copper, brass, or bronze pipe, tubing, fittings, valves or appurtenances with stainless steel pipe, tubing, fittings, valves, or appurtenances.

PART 3 - EXECUTION

3-1. INSTALLATION. Materials furnished under this section will be installed in accordance with the Miscellaneous Piping and Accessories Installation section.

End of Section

Section 40 05 24

STEEL PIPE

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing and installation of steel pipe 6 inches in diameter and larger. Steel pipe shall be furnished and installed complete with all fittings, specials, adapters, closure pieces, blowoffs, outlets, caps and plugs, temporary bulkheads, access manholes, jointing materials, pipe hangers and supports, anchors, blocking, encasements, cathodic protection, appurtenances, and accessories specified and indicated on the Drawings, and as required for proper installation and functioning of the piping.

Steel pipe smaller than 6 inches in diameter, light wall steel pipe, miscellaneous small piping, pipe hangers and supports, cathodic protection, pressure and leakage tests, and cleaning and disinfection are covered in other sections. Pipe trenching, embedment, and backfill are covered in the Trenching and Backfilling section.

The size, service, and location of steel pipelines are covered in the Pipeline Schedule section.

Piping furnished hereunder shall be complete with all joint gaskets, bolts, nuts and other jointing materials required for installation of any valves and equipment, including any valves and equipment furnished by Design-Builder or others for installation under this Contract.

1-2. GOVERNING STANDARDS. Except as modified or supplemented herein, all steel pipe, fittings, and specials shall conform to the applicable requirements of the following standards:

ANSI/AWWA Standards	Title
C200	Steel Water Pipe - 6 In. [150 mm] and Larger
C205	Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 In. (100 mm) and Larger - Shop Applied
C206	Field Welding of Steel Water Pipe
C207	Steel Pipe Flanges for Waterworks Service – Sizes 4 In. through 144 In. [100 mm through 3,600 mm]

C208	Dimensions for Fabricated Steel Water Pipe Fittings.
C209	Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines
C210	Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines
C214	Tape Coating Systems for the Exterior of Steel Water Pipelines
C216	Heat-Shrinkable Cross-Linked Polyolefin Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines
C217	Petrolatum and Petroleum Wax Tape Coatings for the Exterior of Connections and Fittings for Steel Water Pipelines
C222	Polyurethane Coatings for the Interior and Exterior of Steel Water Pipe and Fittings
C602	Cement Mortar Lining of Water Pipelines in Place – 4 In. [100 mm] and Larger
C604	Installation of Steel Water Pipe – 4 In. (100 mm) and Larger
C606	Grooved and Shouldered Joints
M11	Steel Pipe – A Guide for Design and Installation

ANSI/ASME Standards

B1.1	Unified Inch Screw Threads (UN and UNR Thread Form)
B16.47	Large Diameter Steel Flanges NPS 26 through NPS 60
B18.2.1	Square and Hex Bolts and Screws (Inch Series)
B18.2.2	Square and Hex Nuts (Inch Series)
B36.10	Welded and Seamless Wrought Steel Pipe

1-3. QUALIFICATIONS. Pipe manufacturer shall be ISO-9001 or SPFA certified with 5 years' experience in the manufacture of steel pipe, fittings, coatings, and linings specified. All pipe, fittings, specials, coatings, linings, and appurtenances shall be fabricated at one company facility for quality control purposes, unless otherwise acceptable to the Engineer.

1-3.01. Pipe Manufacturer's Experience and Services. Unless otherwise acceptable to Design-Builder, all steel pipe, fittings, specials, bolts, gaskets, other jointing materials and appurtenances shall be fabricated, lined, coated, and furnished under the direction and management of one pipe manufacturer. The pipe manufacturer's responsibilities, shall include, at a minimum; coordinating and furnishing all pipe materials, gaskets, bolts, and other jointing materials and pipe appurtenances (except for furnishing coupled joints and other similar products by a specified manufacturer) for a complete piping system that meets the specified pipe test pressure and service conditions; certifying that all pipe, fittings, specials, and other pipe materials, gaskets, and bolts specified herein are being manufactured in full accordance with the Contract Documents; preparing and submitting all submittal information and shop drawings; and making any corrections that may be required to submittal information and shop drawings.

The pipe manufacturer's minimum required experience qualifications shall include manufacture of buried steel plant piping of similar diameters for at least two water or wastewater plants with the same type joints, linings, and coatings and suitable for the same or higher pressure rating.

All steel pipe shall be installed as specified herein and indicated on the drawings, in accordance with the pipe manufacturer's recommendations.

1-4. SUBMITTALS. Drawings, details, specifications, installation schedules, welding procedures and welder qualifications, and other data showing complete details of the fabrication, construction, weld locations, joint details and certification, and installation of pipe, fittings, specials, and connections, together with complete data covering all materials proposed for use, shall be submitted in accordance with the Submittals Procedures section. The drawings and data shall include, but shall not be limited to, the following:

a. Certifications and Affidavits of Compliance: Suppliershall submit all certifications and affidavits of compliance, as applicable. Performing and paying for sampling and testing as necessary shall be the Design-Builder's responsibility. The following certifications and affidavits of compliance are required for all pipe and other products or materials furnished, as specified in ANSI/AWWA C200 and herein.

   (1) Mill Certificates. Material lists and steel reinforcement schedules which describe all materials to be utilized. Metallurgical test reports for steel proposed for use on the project. Chemical and physical

test reports from each heat of steel that indicate the steel conforms to the Contract Documents. Records shall indicate heat of steel for each pipe joint listed in the pipe laying schedule.

(2) List cross-referencing pipe mark numbers with pipe sequence numbers, heat numbers, and can numbers.

(3) Hydrostatic test reports.

(4) Results of production weld tests.

(5) Sand, cement and mortar tests.

(6) Rubber gasket tests and gaskets certification by pipe manufacturer, including a written statement from the gasket material manufacturer, certifying that the gasket materials are compatible with the joints specified and are recommended for the specified field test pressure and service conditions.

(7) All materials in contact with treated or potable water are ANSI/NSF 61 approved.

(8) Certification of the proof-of-design tests for rubber gasketed bell and spigot joints (stab joints), or field experience documentation, as specified.

(9) Pipe temperature complies with Contract Documents prior to placing backfill material and prior to and during welding.

(10) All welds were performed in conformance with these Contract Documents.

(11) Affidavit of compliance for each ANSI/AWWA standard covering materials and work furnished for the project.

(12) Certification of pipe manufacturer's minimum experience requirements. Certification to be submitted prior to award of contract if required in the bidding documents or requested by Engineer.

b. Shop Drawings: Submit Shop Drawings of piping in accordance with the requirements of ANSI/AWWA C200 and the following supplemental requirements:

(1) Certified dimensional drawings of all pipe, fittings, specials, and appurtenances. The ASTM designation for the material from which each class of pipe is fabricated.

(2) Production schedule for manufacturing/fabricating pipe for the work as part of Design-Builder's Progress Schedule. Steel pipe production schedule shall be included in all versions of the Design-Builder's Progress Schedule beginning with the first Progress Scheduled submittal.

(3) Joint and pipe wall construction details which indicate the type and thickness of cylinder; the position, type, size and area of wire or other reinforcement; coatings and linings including holdbacks; manufacturing tolerances; maximum angular joint deflection limitations; and all other pertinent information required for the manufacture and installation of the product. Joint details and design criteria shall be submitted for all welded joint types, including beveled ends for alignment conformance and any deep butt strap joints required for control of temperature stresses.

(4) Pipe design criteria sufficient to ascertain conformance of pipe and fittings with the Contract Documents. Pipe design criteria shall include, but shall not be limited to, minimum pipe diameter, minimum pipe wall thickness, pressures, external loads, yield strength, allowable fiber stress, longitudinal stress for restraint, temperature changes, lining and coating materials, and other factors used for pipe design.

(5) Table(s) showing E', K, soil weight, deflection lag factor, external loads, and percent deflection from minimum to maximum cover depth in one foot increments covering each size and class of pipe. Two tables shall be submitted for each size and class of pipe, one with live load and the design deflection lag factor specified herein and one without live load and a deflection lag factor of 1.0.

(6) Ground Elevation and Utility Locations:

(a) Design-Builder shall verify the existing ground elevations and the location and depth of all underground utilities using centerline stakes at no more than 100 feet intervals.

(7) Pipe Laying Schedule Information:

(a) Pipe laying schedule and marking diagrams compatible with the requirements of AWWA Manual 11 (M11) which indicate the specific number of each pipe, fitting, and special and the

location and direction of each pipe fitting, and special in the completed pipeline. In addition, the pipe laying schedule shall include: the station and centerline or invert elevation coordinated with the Drawings to which the bell end of each pipe will be laid; all elements of curves and bends, both in horizontal and vertical alignment; and the limits within each reach of restrained and/or welded joints or of concrete encasement. The location of all mitered pipe sections, beveled ends for alignment conformance, and any deep butt strap joints for temperature stress control shall be clearly indicated on the diagrams.

The pipe laying schedule shall have a sequence of laying and an explanation of all abbreviations used in the schedule. For long, straight pipe runs, the pipe laying schedule shall list the pipeline station and either the pipe centerline or invert elevation coordinated with the Drawings at least every 100 feet.

(b) Drawings showing the location and details of bulkheads for hydrostatic testing of the pipeline including details for removal of test bulkheads and repair of the lining.

(c) Details and locations of closures and cutoffs for length adjustment, temporary access manholes, vents and weld lead pass holes as specified or indicated on the Drawings, and as required for construction convenience.

(d) The method that the Design-Builder proposes to use for measuring deflection of pipe joints.

(e) Annotated laying schedule showing all changes made during the progress of the Work.

(8) Welding Information: Submit the following prior to performing any welding work:

(a) Full and complete information regarding location, type, size and extent of all welds with reference called out for Welding Procedure Specifications (WPS) numbers shall be shown on the Shop Drawings. The Shop Drawings shall distinguish between shop and field welds. Shop Drawings shall indicate welding symbols for the details of the welded joints, and the preparation of parent metal required to make them. Joints or groups of joints in which welding sequence or technique are

especially important shall be carefully controlled to minimize shrinkage stresses and distortion.

(b) Written welding procedures for shop and field welds (including Welding Procedure Specifications (WPS's) and Procedure Qualification Records (PQR's). All WPS used to fabricate and install pipe shall be qualified under the provisions of ANSI/AWS D1.1 – Structural Welding code – Steel or the ASME Boiler and Pressure Vessel Code (BPVC) for shop welds and ANSI/AWS D1.1 for field welds. Written WPS shall be required for all welds, both shop and field. WPS's qualified per the ASME BPVC shall include Supplementary Essential Variables for notch-tough welding. All provisions of ANSI/AWS D1.1 pertaining to notch-tough welding shall apply.

(c) Written nondestructive testing (NDT) procedure specifications and NDT personnel qualifications.

(d) Current welder performance qualifications (WPQ'S) shall be submitted for each welder prior to performing any work either in the shop or field. Qualification testing shall be in accordance with ASME Section IX or AWS B2.1 and as defined in Section 4 of ANSI/AWWA C206 or ANSI/AWWA C200, as applicable.

(e) Credentials of the Design-Builder's certified welding inspectors (CWI's) and quality control specialists for review prior to starting any welding in the shop or field. The credentials shall include, but not be limited to, American Welding Society QC-1 Certification. Other NDT quality control personnel shall be certified as required by AWS D1.1 and in accordance with written practice ASNT SNT-TC-1A.

(f) All NDT data for each shop-welded and field-welded joint. This data shall include all testing on each weld joint, including re-examination of repaired welds, using visual, radiographic, magnetic particle, dye penetrant examination, ultrasonic or air test examination methods specified. Test data shall be reviewed and signed by the welding inspector(s).

(g) Welder logs for field and shop welding. Logs shall list all welders to be used for the work, the welding process, position, welder stamp number, certification date and certification status for each welder.

(h) A welding map showing the sequence of welds for all field welds.

(i) A written weld repair procedure for each type of shop and field weld proposed for use on the project.

(j) A written rod control procedure for shop and field operations demonstrating how the Design-Builder intends to maintain rods in good condition throughout the work. The rod control procedure shall also demonstrate how the Design-Builder intends to ensure that the proper rods are used for each weld.

(9) Control of Temperature Stresses for Welded Joints:

(a) Plan and installation instructions to avoid the accumulation of expansion and contraction to minimize temperature stresses in the pipe wall during installation and when the pipeline is in service. The plan and installation instructions shall include the sequencing of events during and after installation, including backfilling and welding, use of a lengthened bell, and other methods to control temperature stresses in the pipeline.

(b) Plan for monitoring pipeline temperatures.

(10) Detail drawings indicating the type, number and other pertinent details of slings, strutting, and other methods proposed for pipe support and handling during manufacturing, transport, and installation. The recommended methods of handling and placement of the pipe shall be submitted as a record copy prior to transporting any pipe to the Site. All pipe handling equipment and methods shall be acceptable to the Engineer.

(11) For record copy, detailed drawings indicating loading and shipping procedures that are designed to minimize damage to coating.

(12) Pipe manufacturer's written Quality Assurance/Control Program.

1-5. SHIPPING, HANDLING, AND STORAGE. Pipe, fittings, and accessories shall be handled and stored as recommended by the pipe manufacturer and shall be handled in a manner that will ensure installation in sound, undamaged condition. Equipment, tools, and methods used in handling and installing pipe and fittings shall not damage the pipe and fittings. Forks and other lifting devices shall have broad, well-padded contact surfaces.

Any damage to pipe coatings and linings shall be repaired before the pipe is installed.

1-5.01. Stulling. Adequate stulling shall be designed and provided by the pipe manufacturer on all specials, fittings, and straight pipe so as to avoid damage to the pipe during handling, storage, hauling, and installation. The stulling shall be tight fitting to prevent pipe deflection and to maintain roundness of +/- 1.0 percent. Stulling shall not damage the lining. The stulling shall be placed as soon as practicable after the pipe lining is applied and shall remain in place while the pipe is loaded, transported, unloaded, and installed at the site.

PART 2 - PRODUCTS

2-1. BASIS OF DESIGN. Steel pipe, fittings, and specials shall be fabricated type for pipe 14 inches and larger, and may be either fabricated or mill type for pipe 12 inches and smaller. All items shall be the sizes, dimensions, and shapes indicated on the Drawings or specified herein.

The specified size of fabricated pipe, fittings, and specials shall be the nominal inside diameter, in inches, where 12 inches and smaller, and the actual inside diameter of pipe lining, where 14 inches and larger. Where stab joint pipe is permitted and two or more wall thicknesses are required for pipe of the same size, pipe size may be adjusted slightly to allow the different classes of pipe to be stabbed together.

The specified size of mill pipe, fittings, and specials shall be the nominal pipe size as set forth in ANSI/ASME B36.10.

Pipe ellipticity (out-of-roundness) shall not exceed one percent.

Pipe design shall be performed by the pipe manufacturer. Minimum design criteria shall be as specified.

2-1.01. Pipe Wall Thickness. Pipe shall be designed for all conditions indicated in the Pipe Schedule and on the drawings.

The wall thickness for internal pressure due to hoop stress shall be determined by the following formula.

t = (PD)/(2s),
where

t = the pipe wall thickness in inches

s = the allowable fiber stress in psi , shall not exceed 50 percent of the minimum yield strength of the steel plate at working pressure or 75 percent of the minimum yield strength at the larger of field test pressure or working pressure plus surge pressure. The yield strength used in the calculation for cement mortar coated pipe shall not exceed 36,000 psi. The yield strength used in the calculation for cement mortar lined pipe shall not exceed 45,000 psi.

P = the pipe working pressure or the larger of field test pressure or working pressure plus surge pressure in psi .

D = the pipe outside diameter, in inches, of straight pipe sections or the larger outside diameter of tapered sections.

Unless otherwise indicated, the working pressure and the working pressure plus surge pressure shall be as indicated in the Pipe Schedule.

The pipe wall thickness shall be in accordance with ANSI/AWWA M11, except that all pipe shall have a wall thickness of at least 1/4 inch, and a diameter to wall thickness ratio not to exceed 165.

Pipe wall thickness shall be constant for the entire length of pipe for each pipe class, location, or service indicated in the Pipe Schedule unless otherwise indicated on the drawings or specified.

External loads on buried pipe shall be based on the prism load and the following design conditions.

Maximum pipe deflection, percent of nominal pipe diameter	3.0
Minimum design cover depth	See Drawings
Maximum design cover depth	See Drawings
Total design external load on pipe	See Pipe Schedule
E', Modulus of Soil Reaction	1,400 psi
K, Bedding Constant	0.090 for Class B embedment
Weight of soil	127 lbs/cu. ft.
Deflection Lag Factor	1.25 for Class B embedment
Live load	AASHTO HS-20
Impact Factor	1.5

The maximum pipe deflection shall be reduced if required by the jointing system furnished.

Linings or coatings shall not be used in the pipe deflection calculations.

The pipe shall be designed to withstand full internal vacuum (0 psia) under the buried conditions and for external loading under the flood conditions at ground surface or as otherwise indicated on the Drawings, when empty.

2-1.02. Fitting Dimensions. The dimensions of steel pipe fittings shall be as indicated on Figures 1-40 05 24(A) and 1-40 05 24(B) and shall be designed by the pipe manufacturer. Any fittings used for buried vertical bends and buried eccentric reducers shall be restrained.

2-1.03. Reinforcement of Fittings and Specials. Whether or not shown on the drawings, all bends, fittings, branch connections, reducers, and special sections shall be reinforced, or the pipe wall thickness shall be increased, so that the combined stresses due to internal pressure (circumferential and longitudinal) and bending will not exceed the allowable stresses specified in the Pipe Wall Thickness paragraph. Where external piping reinforcement interferes with other construction the pipe wall thickness shall be increased and external reinforcement eliminated as necessary for acceptable clearances.

Where suspended, the design of reinforcement or wall thickness shall also take into consideration the weight of the piping and appurtenances full of water. Where buried, the design of reinforcement or wall thickness shall also take into consideration the external load.

Wall thicknesses of reducing sections shall be not less than the required thicknesses for the larger ends.

2-1.04. Joints. Acceptable joints of the type indicated on the Drawings and as specified herein shall be provided for all pipe installations in the locations indicated or accepted by Engineer. To facilitate installation, additional field-welded or mechanically coupled joints may be provided, but shall be kept to a minimum, and their locations shall be acceptable to Engineer. Field-welded joints shall not be used in pipe smaller than 30 inches , except in locations where the interior coating can be satisfactorily repaired and inspected.

Buried pipelines shall have lap-weldedjoints unless otherwise specified or indicated on the drawings. Restrained joints shall be lap-welded unless otherwise specified or indicated on the drawings.
Each joint, including restrained joints,shall be checked as recommended by the pipe manufacturer to verify that the joint and the restraints are installed properly. The pipe manufacturer shall furnish a metal gauge or other tools as required to measure joints.

2-2. MATERIALS.

Pipe, Fittings, and Specials	ANSI/AWWA C200. All steel shall be fully killed, with a maximum carbon content of 0.25 percent, made to a fine austenitic grain size practice, and manufactured from continuous cast steel. Minimum yield strength (point) for the grade of steel used shall not exceed 46,000 psi *or be less than 36,000 psi.*
Gaskets – All Joint Types	Synthetic rubber unless otherwise specified; natural rubber will not be acceptable. All gaskets shall be furnished by the pipe manufacturer, unless another manufacturer's product is specified. Pipe manufacturer shall submit certificates of gasket suitability, certifying that the gasket materials are compatible with the joints specified and are recommended for the specified field test pressure and service conditions. Gaskets for treated or potable water service shall also be certified for chlorinated and chloraminated potable water. Representative plant outfall (POW) pipe water quality parameters are expected as follows: <u>99.9% of the time:</u> Sulfate: 125-165 mg/L. Chloride: 250-315 mg/L +20 mg/L for disinfection. pH: 6.7-8.5. Alkalinity: 100 - possibly up to 350 mg/L as CaCo3. <u>0.1% of the time:</u>

	Sulfate : 1,100 mg/L. Chloride: 4,170 mg/L +20 mg/L for disinfection. pH: 7.6 Alkalinity: 730 mg/L as CaCo3.
	Gas and oil-resistant gaskets shall be made of Nitrile (NBR [Acrylonitrile Butadiene]) rubber unless a different gasket material is recommended by the pipe manufacturer and accepted by the Engineer. The name of the material shall be permanently marked or molded on the gasket. Gaskets shall also be certified as suitable where soils may be contaminated with gas and oil products.
Joint Lubricant	Vegetable-based lubricant recommended by the pipe manufacturer. Petroleum or animal-based lubricants will not be acceptable. Lubricants that will be in contact with treated or potable water shall be certified as being in compliance with ANSI/NSF 61.
Joint Diapers	
Diapers	Non-woven polypropolene fabric, lined with polyethylene foam, minimum weight 3 oz. per square yard. “Typar” as recommended by pipe manufacturer for the joint furnished.
Liner	100 percent closed cell polyethylene foam, 1.9 to 2.1 pounds per cubic foot density, Dow Chemical Company “Ethafoam 221”, minmum thickness of ¼ inch and full width of diaper.

Steel Straps			Class 1, Type 1, hot-rolled or heat treated cold rolled, Fed Spec QQ-S-781H, 0.020” thick, waxed or painted and waxed.
Seal Clips			Push or overlap type, providing single notch-joint on ½ inch or 5/8 inch wide seals; double notch joint on on ¾ inch wide seals.
Flanged Joints			
	Flanges		ANSI/AWWA C207, slip-on, except where otherwise specified or indicated on the Drawings.
		Dimensions and Drilling	ANSI/AWWA C207, Class D except as otherwise indicated on the Drawings or specified.
	Blind Flanges		ANSI/AWWA C207, Class D except as otherwise indicated on the Drawings or specified.
	Gaskets		ANSI/AWWA C207. Pipe manufacturer shall submit certification of gaskets furnished as indicated above under Gaskets – All Joint Types.
	Insulated Flanges		
		Flanges	As specified herein, except bolt holes shall be enlarged as needed to accept bolt insulating sleeves.
		Insulation Kits	As manufactured by Advanced Products or Pipeline Seal and Insulator, Inc.
		Insulating Gaskets	Type E, G10, 1/8 inch thick, with Nitrile or EPDM sealing element unless otherwise required by pipe manufacturer and acceptable by Engineer. Pipe manufacturer shall submit

		certification of gaskets furnished as indicated above under Gaskets – All Joint Types.
	Bolt Insulating Sleeves	G-10, 1/32 inch thick.
	Insulating Washers	G-10, 1/8 inch thick, two for each flange bolt.
	Backing Washers	Steel, 1/8 inch thick, two for each flange bolt.
Flange Bolting		
Material		ANSI/AWWA C207, unless otherwise required by the pipe manufacturer including higher strength and accepted by the Engineer.
Type		Bolt and nut; bolt-stud and two nuts permitted for 1 inch [25 mm] and larger.
Bolts and Bolt-Studs		
	Length	As required for ends to project 1/4 to 1 inch beyond outer face of nut.
	Ends	Chamfered or rounded.
	Threading	ANSI/ASME B1.1, coarse thread series, Class 2A fit. Bolt-studs may be threaded full length.
Bolt Head Dimensions		ANSI/ASME B18.2.1; regular pattern for square, heavy pattern for hexagonal.
Nuts		Hexagonal.
	Dimensions	ANSI/ASME B18.2.2, heavy, semi-finished pattern.
	Threading	ANSI/ASME B1.1, coarse thread series, Class 2B fit.
Stab Joints		Bell-and-spigot, with rubber

		gasket as sole element depended upon for water tightness.
	Bells and Spigots	Rolled groove, Carnegie shape, or fabricated type, as permitted.
	Rubber Gaskets	Continuous O-ring; ANSI/AWWA C200, Section 4.13, except basic polymer shall be synthetic rubber. Natural rubber will not be acceptable. Pipe manufacturer shall submit certification of gaskets furnished as indicated above under Gaskets – All Joint Types.
Coupled Joints		
Mechanical Couplings		
Gaskets		Gaskets shall be as recommended by the coupling manufacturer. Coupling manufacturer shall submit certification of gaskets furnished as indicated above under Gaskets – All Joint Types.
Full Ring Type		
	Insulating	Baker "Series 216", Dresser "Style 39", or Smith-Blair "416"; without pipe stop.
	Reducing	Baker "Series 220", Dresser "Style 62", or Smith-Blair "413" and "415"; without pipe stop.
	All Others	Baker "Series 200", Dresser

		"Style 38", or Smith-Blair "411 Steel Coupling"; without pipe stop.
Split Ring Type – Nonrestrained		Victaulic Depend-O-Lok, Inc. "ExE Type 1" or "ExE Type 2".
Split Ring Type - Restrained		
	16 inches or smaller	Victaulic Depend-O-Lok, Inc. “FxF Type 1”.
	Larger than 16 inches	Victaulic Depend-O-Lok, Inc. “FxF Type 2”.
	Buried Service	Victaulic Depend-O-Lok, Inc. “FxF Type 2 HP (RC)”.
Flanged Coupling Adapters		
	Restrained (4 inch through 12 inch). Unless otherwise indicated on the Drawings, flanged coupling adapters shall be restrained.	Dresser “Style 128”, Smith-Blair "Type 913", or Romac "Style FCA501", with anchor studs of sufficient size and number to withstand test pressure.
	Unrestrained (14 inch and larger)	Smith-Blair "Type 913" or Romac "Style FC400", 14 inches and larger.
Dismantling Joints		
	Restrained 3 inch [350] mm and larger. Unless otherwise indicated on the Drawings, dismantling joints shall be restrained.	Romac "DJ400", Dresser "Style 131 Dismantling Joint", or Viking Johnson. For use in potable water systems, coating to be in accordance with NSF-61.
Grooved Couplings		

When Joint Movement and Deflection is not Acceptable	ANSI/AWWA C606; Victaulic "07 Zero-Flex".
When Joint Movement and Deflection is Acceptable	ANSI/AWWA C606; Victaulic "Style 77".
Restrained Joints	
Welded	ANSI/AWWA C200 and C206.
Lugs or Collars	ASTM A283, Grade B or C; or ASTM A36.
Tie Bolts	ASTM A193, Grade B7.
Threading	ANSI/ASME B1.1, Class 2A fit, coarse thread series for 7/8 inch and smaller, and 8-thread series for 1 inch and larger.
Ends	Chamfered or rounded.
Nuts	Hexagonal, ASTM A194, Grade 2H or better.
Threading	As specified for tie bolts, except Class 2B fit.
Dimensions	ANSI/ASME B18.2.2, heavy semifinished pattern.
Flat Washers	Hardened steel, ASTM A325.
Small Branch Connections	
Pipe Nipples	Seamless black steel pipe, ASTM A53, standard weight (Schedule 40).
Welding Fittings	
Threaded Outlets	Bonney Forge "Thredolets" or Flowserve/Vogt "Weld Couplets".
Welded Outlets	Bonney Forge "Weldolets" or Flowserve/Vogt "Weld Couplets".

Coatings and Linings	All materials in contact with treated or potable water shall be certified as being in compliance with ANSI/NSF 61.
Liquid Epoxy	ANSI/AWWA C210.
Polyurethane	ANSI/AWWA C222
Tape Coating	ANSI/AWWA C209 and C214 or C216, with ultraviolet light stabilizers, manufactured by PolyKen.
Cement Mortar	ANSI/AWWA C205 and C602.
Cement	ASTM C150, Type II.
Sand	ANSI/AWWA C205, Section 4.2.3, except sand for field-applied lining shall pass a No. 16 sieve.
Epoxy Bonding Agent	ASTM C881, Type II, moisture insensitive and suitable for service conditions.
Latex Admixture	Euclid "Flex-Con" or Sika "SikaLatex".
Universal Primer	Pipe manufacturer’s standard.
Watertight/Dusttight Pipe Sleeves	“GPT Link-Seal", insulating type with modular rubber sealing elements, nonmetallic pressure plates, and stainless steel bolts and nuts.
Anti-Seize Thread Lubricant	Jet-Lube "Nikal", John Crane "Thred Gard Nickel", Bostik/Never-Seez "Pure Nickel Special" or Permatex "Nickel Anti-Seize".
Anchor Bolts	ASTM A307.
Joint Grout and Diapers	ANSI/AWWA C205.

Corrosion Protection	
Heat–shrinkable Coating and Primer (Shrink Sleeve)	ANSI/AWWA C216, cross-linked polyethylene sheeting precoated with adhesive; minimum 80 mils; type and recovery as recommended by Shrink Sleeve manufacturer; Canusa-CPS or Berry Plastics Water Wrap.
Underlying Sleeve	Heavy cross-linked polyethylene backing; Canusa-CPS I2/PE Backing.
Wax Tape and Primer	ANSI/AWWA C217. Cold-applied petroleum wax primer and cold-applied petroleum wax tape; Trenton Wax-Tape and Primer.
Medium Consistency Coal Tar	Carboline "Bitumastic 50" or Tnemec "46-465 H.B. Tnemecol".

2-3. ENDS OF SECTIONS.

2-3.01. For Field Welding. Ends of pipe, fittings, and specials for joints butt-welded in the field shall have the ends beveled for butt welding in accordance with the governing standards.

Ends of pipe, fittings, and specials for field-welded lap joints, Figures3-40 05 24(A) and 3-40 05 24(B), shall have both the bell and the spigot expanded by pressing, if necessary, (not rolling) to obtain the required shape and welding tolerances.

2-3.02. For Fitting with Flanges. Ends to be fitted with slip-on flanges shall be prepared to accommodate the flanges in accordance with the governing standards.

2-3.03. For Stab Joints. Stab joints shall be designed so that the gasket will maintain a watertight joint under all conditions of service, including expansion, contraction, and earth settlement. The gasket shall not support the entire weight of the pipe. Spigot ends shall have a groove to retain the gasket. Pipe ends shall be self-centering without the aid of the gasket.

2-3.04. For Mechanical Couplings. Ends to be joined by mechanical couplings shall be plain end type. Pipe seam welds on ends to be joined by mechanical couplings without pipe stops shall be ground flush to permit slipping the coupling in at least one direction to clear the pipe joint. The welds on ends to be joined by split ring type couplings shall be ground flush to allow uniform contact of the shoulder and pipe wall. Outside diameter and out-of-round tolerances shall be within the limits specified by the coupling manufacturer.

Where retainer rings for split ring mechanical couplings are required to be fixed to the ends of pipe to provide restraint within a mechanical coupling, at least one of the restraint rings shall be welded in place in the field to assure the coupling is installed with the pipe in a fully-extended position.

2-3.05. For Grooved Couplings. Ends to be joined by grooved couplings shall be of the shouldered type, conforming to the governing standard and as recommended by the coupling manufacturer for the size and wall thickness of the pipe, fitting, or special being coupled, and for the maximum test or working pressure to which the couplings will be subjected.

2-3.06. For Flanged Coupling Adapters. Ends to be fitted with flanged coupling adapters shall be plain end type in accordance with the governing standard for mechanical couplings. Welds shall be ground flush to permit installation of the coupling. For restrained flange coupling adapters, holes shall be field drilled at the proper location for anchor studs.

2-3.07. For Connection to Dissimilar Pipe Materials. Steel pipe connections to buried or submerged concrete pipe or cast or ductile iron pipe shall be made with insulated flanges.

2-4. SEAMS. Except for seamless mill-type pipe, all piping shall be made from steel plates rolled into cylinders or sections thereof with the longitudinal seams butt-welded, or shall be spirally formed and butt-welded. There shall be not more than two longitudinal seams. Girth seams shall be butt-welded and shall be spaced not closer than 10 feet apart except in specials and fittings.

2-5. PIPE LENGTHS. Straight pipe section lengths shall be pipe manufacturer's standard lengths, unless otherwise indicated on the Drawings.

All pipe to be connected with mechanical couplings shall be fabricated so that the space between pipe ends within the couplings will not exceed the amount recommended by the coupling manufacturer, but shall be at least 1/2 inch.

2-6. SMALL BRANCH CONNECTIONS. Branch connections 2-1/2 inches and smaller shall be made with welding fittings with threaded outlets. Where the exact outlet size desired is in doubt, but is known to be less than 1 inch, a 1 inch outlet shall be provided and reducing bushings used as needed.

Branch connections sized 3 through 12 inches shall be made with pipe nipples or with welding fittings with welded outlets. Pipe nipples and welding fittings shall be welded to the pipe shell and reinforced as needed to meet design and testing requirements.

Small branch connections shall be so located that they will not interfere with joints, supports, or other details, and shall be provided with caps or plugs to protect the threads during shipping and handling.

2-7. ACCESS MANHOLES. Not used.

2-8. DRAINS AND VENTS. Not used.

2-9. FLANGED JOINTS. Flange faces of flanged joints shall be normal to the pipe axis. Angular deflection (layback) of the flange faces shall not exceed the allowable set forth in ANSI/AWWA C207. All flanges shall be refaced after welding to the pipe, if necessary to prevent distortion of connecting valve bodies from excessive flange bolt tightening and to prevent leakage at the joint.

Pipe lengths and dimensions and drillings of flanges shall be coordinated with the lengths and flanges for valves, pumps, and other equipment to be installed in the piping. All mating flanges shall have the same diameter and drilling and shall be suitable for the pressures to which they will be subjected.

Flanges shall be of the slip-on type, except that welding-neck or slip-on flanges welded to short lengths of pipe shall be used where installation of flanges in the field is permitted or required.

For welding neck flanges, the pipe shall be concentrically reduced as necessary for proper alignment of the pipe wall with the welding neck flange for butt welding. The interior of the weld joint and flange shall be cement lined in the shop as specified in ANSI/AWW C205.

2-10. STAB JOINTS. Rubber-gasketed bell-and-spigot (stab type) steel pipe are not used.

2-11. MECHANICAL COUPLINGS. The middle ring of mechanical couplings shall have a thickness at least equal to the wall thickness specified herein for the size of pipe on which the coupling is to be used. If the coupling manufacturer's standard thickness is less, that thickness may be used unless allowable pressures are exceeded. The length of each middle ring shall be not less than 10 inches for 36 inches and larger pipe and not less than 7 inches for pipe smaller than 36 inches.

All surfaces, including the interior surfaces of the middle rings, shall be prepared for coating in accordance with the coating manufacturer's instructions and shall then be coated with liquid epoxy in accordance with ANSI/AWWA C210.

Factory pipe spacers shall be provided where indicated on the drawings. The spacers shall be factory coated and lined with 16 mils of liquid epoxy.

All split ring style couplings shall be designed for not less than 150 psi working pressure. Where pressure may exceed 150 psi, the coupling shall be designed for the required pressure and provided with the coupling manufacturer's "high pressure modification". Use of the FxF Type 1 split ring coupling shall be limited to piping 16 inches and less in diameter. A FxF Type 2 split ring coupling shall be provided for pipe diameter greater than 16 inches size. Where split ring couplings are permitted in buried applications, they shall be FxF Type 2 HP (RC).

2-12. GROOVED COUPLINGS. Grooved couplings shall be sized for proper installation on the pipe ends provided. The couplings shall be restrained or have movement and deflection requirements as required.

After fabrication, all housing clamps forming the coupling shall be cleaned and primed (as specified for the pipe) by the coupling manufacturer.

2-13. FLANGED COUPLING ADAPTERS. Flanged coupling adapters shall be provided for restrained couplings 12 inches and smaller and unrestrained couplings 14 inches and larger. Unless otherwise indicated on the Drawings, all 12 inches and smaller flange coupling adapters shall be restrained and all 14 inches and larger flange coupling adapters may only be used in unrestrained applications.

The inner and outer surfaces of couplings, except flange mating surfaces, shall be prepared for coating in accordance with instructions of the coating manufacturer and shall then be coated with liquid epoxy in accordance with ANSI/AWWA C210. The flange mating surfaces shall be cleaned and shop primed with universal primer.

2-14. DISMANTLING JOINTS. Dismantling joints shall be provided for restrained couplings 6 inches and larger. Dismantling joints shall comply with AWWA C219 and shall be restrained flange by flange couplings manufactured as a single unit. Unless otherwise indicated on the Drawings, dismantling joints shall be restrained.

The inner and outer surfaces of dismantling joints, except flange mating surfaces, shall be prepared for coating in accordance with instructions of the coating manufacturer and shall then be coated with liquid epoxy in accordance with ANSI/AWWA C210. The flange mating surfaces shall be cleaned and shop primed with universal primer.

2-15. RESTRAINED JOINTS. Restrained joints shall be flanged, welded, flanged coupling adapters with anchor studs, split ring fixed type couplings, rigid groove couplings, or harnessed, as specified or as indicated on the Drawings.

Where indicated on the Drawings, mechanically coupled or stab type joints shall be restrained with harness bolts and lugs or collars. Joint harnesses shall conform to the details indicated on the Drawings. Lugs or collars shall be shop welded to the pipe and coated as specified for the adjacent pipe.

Split ring style couplings used for restraint shall be shoulder style. Grooved couplings used for restraint shall be rigid type.

Any fittings used for buried vertical bends and eccentric reducers shall be restrained.

2-16. PROTECTIVE COATINGS AND LININGS. All steel pipe, fittings, specials, wall fittings, and accessories shall be lined, coated, or wrapped as specified herein.

2-16.01. Type of Coating and Lining. Surface preparation shall be in accordance with the pipe manufacturer's and coating and lining manufacturer's instructions. Types of protective coating and lining shall be as follows:

Exterior Surfaces in Interior Locations	Shop-applied universal primer.
Exterior Surfaces Underground, Including those Encased in Concrete	Liquid epoxy, ANSI/AWWA C210 or polyurethane, ANSI/AWWA C222. The governing standards shall be as modified herein. POW piping - Polyurethane, ANSI/AWWA C222: Carboline 777 Polyclad (40 mils DFT)
Exterior Surfaces in Contact with Potable Water or Submerged in Water Treatment Process Waters	Cement mortar, ANSI/AWWA C205, Liquid epoxy, ANSI/AWWA C210, polyurethane, ANSI/AWWA C222
Interior Surfaces	Unless otherwise indicated - Cement mortar - shop applied, ANSI/AWWA C205.The governing standards shall be as modified herein. POW piping - Liquid epoxy, ANSI/AWWA C210 or polyurethane, ANSI/AWWA C222. One of the

		following: Carboline Carboguard 891 (16 mils DFT) Sherwin Williams Macropoxy 646 (16 mils DFT) Carboline 767 Polyclad (25 mils DFT) Raven Aquatapoxy A-6 (25 mils DFT) Sherwin Williams Polycote 115 (PW) (25 mils DFT)
Pipe Joints		
	Couplings	Shop coating as specified for each type of coupling. Field coating as specified for ends of sections in the Joint Holdbacks and Coatings and Linings paragraph and the Corrosion Protection paragraph for buried couplings.
	Ends of Sections	As specified in the Joint Holdbacks and Coatings and Linings paragraph.
	Machined Surfaces	Rust-preventive compound.
Blind Flanges		Shop coat with 20 mil dry film thickness of liquid epoxy in accordance with ANSI/AWWA C210.

2-16.02. Modifications to the Governing Standards.

2-16.02.01. Cement Mortar Lining. Cement mortar lining for all pipe shall be shop applied Except as modified herein, shop-applied mortar linings shall comply with ANSI/AWWA C205.

Specials. Wire fabric reinforcement shall be used in the lining of fittings and specials in accordance with ANSI/AWWA C205.

Adjacent to Valves. If the specified nominal pipe size is the actual outside diameter, cement mortar lining installed in steel pipe adjacent to butterfly valves shall be tapered so that the lining material will not interfere with the valve disc during valve operation.

2-16.02.02. Tape Coating. Except as modified or supplemented herein, tape coating shall be shop applied and comply with ANSI/AWWA C214 for straight pipe sections, and ANSI/AWWA C209 for fittings and specials. The tape coating system shall consist of a primer layer, an inner layer of tape for corrosion protection, and two outer layers of tape for mechanical protection. The total thickness of the tape coating system shall be at least 80 mils. The outer layer of tape shall be white with ultraviolet light stabilizers.

2-17. MARKING. In addition to the pipe markings required by ANSI/AWWA C200, each pipe section, fitting, and special shall be clearly marked to indicate the service, the wall thickness, and the minimum yield strength of the pipe material. Pipe piece identification shall be shown on both the inside and outside of each pipe section, fitting, and special.

2-18. SHOP INSPECTION AND TESTING. Except as otherwise indicated or acceptable to Engineer, all materials and work shall be inspected and tested by the pipe manufacturer in accordance with ANSI/AWWA C200. All costs in connection with such inspection and testing shall be borne by Design-Builder.

Copies of all test reports shall be submitted in accordance with the Submittals Procedures section.

Owner reserves the right to sample and test any pipe after delivery and to reject all pipe represented by any sample which fails to comply with the specified requirements.

Steel greater than or equal to 1/4 inch thickness used in production manufacturing of pipe and specials shall be tested for notch toughness using Charpy V-Notch tests in accordance with ASTM A370 – Test Methods and Definitions for Mechanical Testing of Steel Products. The test acceptance for full size specimens (0.394 in. by 0.394 in. size) shall be 25 foot-pounds at a test temperature of 32 degrees F; tests shall include three impact specimens and shall be conducted in the direction transverse to the final direction of rolling. When full-size specimens are not obtainable, the minimum required Charpy value is permitted to be reduced by multiplying the ratio of the (actual width along the notch / 0.394 in.) x 25 ft-lbs. For sub size specimens the test temperature shall be reduced as follows: Width along the notch > 0.296 in. (no reduction required); 0.295 in. (3/4 size bar): 5 degrees F reduction; 0.236 in.: 15 degrees F reduction. Straight line interpolation for intermediate values shall be used. Tests shall be conducted in accordance with ASTM A20 for two coils of each heat. Only welding consumables that are classified by the applicable AWS filler metal standard (e.g. A5.1, A5.17, A5.18, A5.20) with Charpy impact test requirements at a temperature 32 degrees F or lower are permitted.

2-18.01. Owner's Inspection at the Shop. If Owner elects to inspect any work or materials, as permitted under Section 5.1 of ANSI/AWWA C200, all costs in connection with the services of Owner's inspector will be paid for by Owner.

A fabrication schedule shall be prepared at least 30 days prior to fabrication activities. The Design-Builder shall notify the Owner's Representative at least 5 days prior to any change in the revised and current schedule. If the Owner's representatives make an inspection and the manufacturer is not performing the work as indicated in the revised and current schedule for that date, the expense shall be the sole responsibility of the Design-Builder.

Additional weld test specimens shall be furnished to Owner's inspector for testing by an independent testing laboratory whenever, in the judgment of Owner's inspector, a satisfactory weld is not being made. Test specimens shall also be furnished when Owner's inspector desires. The entire cost of obtaining, inspecting, and testing of such additional specimen plates, welds, or materials will be borne by Owner. If any specimen is found not to conform to the specified requirements, the materials represented by the specimen will be rejected. The expense of all subsequent tests due to failure of original specimens to comply with the specifications shall be the responsibility of Design-Builder.

In addition to making or witnessing specified tests and submitting any required reports to Owner, Owner's inspector will submit written reports to Design-Builder concerning all materials rejected, noting the reason for each rejection.

Inspection by Owner's inspector, or Owner's option not to provide inspections, shall not relieve Design-Builder of his responsibility to provide materials and to perform the work in accordance with the Contract Documents.

The Owner reserves the right to sample and test any pipe after delivery and to reject all pipe represented by any sample which fails to meet with the specified requirements.

PART 3 - EXECUTION

3-1. INSPECTION. Pipe and fittings shall be carefully examined for cracks and other defects immediately before installation. Pipe ends shall be examined with particular care. All defective pipe and fittings shall be removed from the Site.

All shop-applied exterior tape or other dielectric coatings on pipe, fittings, or specials shall be electrically inspected for holidays and other defects, and repaired if necessary. All electrical inspection shall be made in accordance with the standard to which the coating was applied.

Inspection and repair of linings and coatings shall be performed by and at the expense of Design-Builder, after receipt of the pipe, fittings, or specials on the Site and before installation. Electrical inspection of exterior tape or other dielectric coatings after installation of the pipe, fitting, or special in the trench shall be made where, in the opinion of Engineer, the coating may have been damaged by handling during installation.

3-1.01. Confined Space Entry Supervision. Design-Builder shall provide above ground confined space entry supervision whenever Engineer is required to enter the pipe to verify Design-Builder's deflection measurements, inspect joints, or any other time the Engineer is required to enter the pipe.

3-2. PROTECTION AND CLEANING. The interior of all pipe and fittings shall be thoroughly cleaned of all foreign material prior to installation and shall be kept clean until the work has been accepted. Before jointing, all joint contact surfaces shall be wiped clean.

Precautions shall be taken to prevent foreign material from entering the pipe during installation and until the work has been accepted.

Whenever pipe laying is stopped, the open end of the pipe shall be closed to prevent entry of dirt, mud, rodents, and other material. All water in the trench shall be removed prior to removing the closure.

3-3. ALIGNMENT AND GRADE. Buried pipe shall be laid to the lines and grades as specified and indicated on the Drawings. Pipelines or runs intended to be straight shall be laid straight. Curves in stab joint pipe may be formed by opening the joint. Maximum joint openings and deflections shall be as recommended by the pipe manufacturer. For welded lap joints, deflections up to 4-1/2 degrees may be made by shop-mitering the bell end of one pipe. For welded butt joints, deflections up to 22-1/2 degrees may be made by shop-mitering the ends of two adjacent sections of pipe by equal amounts. Deflections greater than 22-1/2 degrees shall be made by use of fabricated bends.

Where deflections would exceed the pipe manufacturer's recommendations, either shorter pipe sections or fittings shall be installed where needed to conform to the alignment or grade indicated on the Drawings and as acceptable to the Engineer.

High points which allow air to collect in pipelines will not be permitted unless an air release valve is indicated on the Drawings at that location.

Unless otherwise specified or acceptable to Engineer, laser beam equipment, surveying instruments, or other suitable means shall be used to maintain alignment and grade. At least one elevation reading shall be taken on each length of pipe. If laser beam equipment is used, periodic elevation

measurements shall be made with surveying instruments to verify accuracy of grades. If such measurements indicate thermal deflection of the laser beam due to differences between the ground temperature and the air temperature within the pipe, precautions shall be taken to prevent or minimize further thermal deflections.

Additional requirements for alignment and grade are covered in the Project Requirements and Trenching and Backfilling sections and on the Drawings.

3-3.01. Tolerances. Each section of pipe shall be laid to the alignment and grade indicated on the Drawings and pipe laying schedule with pipe ends within the following tolerances;

+/- 0.10 foot in grade at any point
+/- 0.20 foot in alignment at any point

In addition, piping shall be visually straight or on a smooth curve between the points of deflection or curvature indicated on the Drawings. Stricter tolerances than specified above shall be used as necessary to maintain minimum cover, to maintain required clearances, to maintain the correct slope to avoid high or low points along the pipeline other than at locations indicated on the Drawings, or to meet other restrictions as required or directed by the Design-Builder.

3-3.02. Anotated Pipe Laying Schedule. The pipe laying schedule shall be annotated during the progress of the Work to show all changes made during construction for record documentation. Upon completion of the installation of the piping, the annotated pipe laying schedule shall be submitted to Engineer in accordance with the Submittals Procedures section.

3-4. INSTALLATION.

3-4.01. Buried Piping. Field installation of buried steel water piping shall be in accordance with ANSI/AWWA C604 unless otherwise specified or indicated on the Drawings.

For buried piping, all trenching, embedment, and backfilling shall conform to the Trenching and Backfilling section and the details indicated on the Drawings. Pipe embedment and backfilling shall closely follow the installation and jointing of steel pipe in the trench to prevent floatation of the pipe by water and minimize longitudinal movement caused by thermal expansion or contraction of the pipe. Pipe shall be protected from floatation during installation when subjected to groundwater or flood conditions.

Each joint, including restrained joints, shall be checked by Design-Builder as recommended by the pipe manufacturer to verify that the joint and the restraints are installed properly.

For restrained joint pipe, not more than 160 feet of pipe shall be exposed ahead of the backfilling in any section of trench. The backfill adjacent to field joints may be temporarily omitted to provide adequate space for field coating the joints. Closure welds on restrained joint pipe shall be made during the cool part of the day.

3-4.02. Pipe Deflection. All buried pipe larger than 30 inches in diameter shall be tested for excessive deflection.

3-4.02.01. Test Section. Not used.

3-4.02.02. Deflection Measurements. Pipe deflection for all buried pipe shall be determined by measuring initial pipe vertical and horizontal inside diameters before the backfill load is supported by the pipe and a second vertical and horizontal inside diameters at least 24 hours after the backfill load is supported by the pipe. Initial and second measurements shall be made for at least two locations on each piece of pipe and approximately equally spaced along the pipe. The points of initial deflection measurements shall be marked so that final deflection measurements are at the same points. The tolerance for deflection measurements shall be 1/8 inch. The percent deflection shall be the largest difference between the initial and second measurements at each point divided by the nominal pipe diameter. Pipe embedment and backfill not exceeding one foot above the top of pipe shall be in place during initial measurements. Struts that allow access may remain in place during initial measurements but shall be removed after initial measurements. Pipe deflection will be measured and documented by Design-Builder and verified by Engineer for each piece of pipe. Engineer shall be notified in advance of when deflection measurements are made. The deflection documentation shall be submitted daily unless otherwise acceptable to the Engineer.

3-4.02.03. Allowable Deflection. The allowable deflection shall be the calculated design percent of nominal diameter with a deflection lag factor of 1.0 and excluding live load, for the depth of the installed pipe to the nearest foot. Pipe exceeding the allowable deflection shall be uncovered and the embedment and backfill replaced as needed to prevent excessive deflection. After replacing embedment and backfill, the pipe shall be retested. Pipe damaged by over deflection or otherwise shall be satisfactorily repaired or removed and replaced with new pipe.

3-4.03. Flanged Joints. Flange faces shall be flat and perpendicular to the pipe centerline. The rust-preventive coating on the flange faces shall be soluble and shall be removed before the joint is made.

Care shall be taken in bolting flanged joints to avoid restraint on the opposite end of the pipe or fitting, which would prevent uniform gasket compression or would cause unnecessary stress in the flanges. The pipe or fitting shall be free to move

in any direction while the flange bolts are being tightened. Bolts shall be tightened gradually in a crisscross pattern at a uniform rate, to ensure uniform compression of the gasket around the entire flange. All flange joint bolting procedures shall be in accordance with the pipe manufacturer's recommendations.

Care shall be taken when connecting piping to pumping equipment to ensure that piping stresses are not transmitted to the pump flanges. All connecting piping shall be permanently supported to obtain accurate matching of bolt holes and uniform contact over the entire surface of flanges is obtained before any bolts are installed in the flanges.

Pump connection piping shall be free to move parallel to its longitudinal center line while the bolts are being tightened. Each pump shall be leveled, aligned, and wedged into position which will fit the connecting piping, but shall not be grouted until the initial fitting and alignment of the pipe so that the pump may be shifted on its foundation if necessary to properly install the connecting piping. Each pump shall, however, be grouted before final bolting of the connecting piping.

After final alignment and bolting, the pump connections shall be tested for applied piping stresses by loosening the flange bolts which, if the piping is properly installed, should result in no movement of the piping relative to the pump or opening of the pump connection joints. If any movement is observed, the piping shall be loosened and re-aligned as needed and then the flanges bolted back together. The flange bolts then shall be loosened and the process repeated until no movement is observed.

3-4.04. Insulated Flanged Joints. Insulated flanged joints shall be installed where indicated on the Drawings. In addition to one full-faced insulating gasket, each flange insulating assembly shall consist of one full-length sleeve, two insulating washers, and two backing washers for each flange bolt. The insulating gasket ID shall be 1/8 inch less than the ID of the flange in which it is installed. The insulated flanged joint accessories shall be installed in accordance with the instructions and recommendations of the insulating kit manufacturer.

3-4.05. Stab Joints. Gasket installation and other jointing procedures shall conform to the instructions and recommendations of the pipe manufacturer. All joint surfaces shall be lubricated with heavy vegetable soap solution immediately before making the joint. The lubricant shall be suitable for use in potable water, shall be stored in closed containers, and shall be kept clean. Measurements shall be taken at the joints after installation to ensure that the specified clearances have not been exceeded.

3-4.06. Welded Joints. All welds shall be sound and free from embedded scale or slag and shall be watertight. Butt welds shall have tensile strength across the weld not less than that of the thinner of the connected sections., Butt welds shall

be used for all welded joints in pipe assemblies and in the fabrication of bends and other specials. Field-welded joints, where permitted, shall be either butt-welded or lap-welded Lap-welded joints shall have full fillet welds. Any weld that undercuts the parent metal shall be cut out, filled, and ground smooth.

Field welding of joints shall conform to ANSI/AWWA C206 and M11. Where acceptable to the Engineer, single field-welded butt joints with outside backing rings may be used for pipe larger than 30 inches in diameter. Backing rings will not be permitted for 30 inch and smaller pipe. Butt straps shall be welded on both the inside and outside of the pipe and at each end of the pipe and strap to avoid stress multiplication.

Field-welded lap joints may have only a single fillet weld on the inside of the pipe joint as detailed in Figure)3-40 05 24(B), except where double-welded joints as detailed in Figure 3-40 05 24(B) are indicated on the Drawings or specified. The interior joint may be welded after the exterior joint has been coated with a shrinkable wrapped sleeve or other specified coating and backfilled with at least 3 feet [900 mm] of backfill material. The field welding shall be performed so that the interior lining, the exterior coating, and the field applied joint coating are not damaged.

A field test, including excavation of a welded joint for inspections, shall be performed to verify that the interior lining, the exterior coating, and the field applied joint coating are not damaged by the interior welding at the start of the project. The field test shall be repeated if welding procedures are modified.

Provisions shall be made to minimize stresses in welded steel pipe to account for temperature changes and to avoid the accumulation of expansion and contraction during installation and after the pipe is in service as recommended by the pipe manufacturer and in accordance with ANSI/AWWA M11 and C604. The allowable temperature range of the pipe during welding shall be established by the pipe design and monitored during installation as recommended by the pipe manufacturer.

3-4.06.01. Standard Inspection and Testing. Standard shop inspection and testing shall be in accordance with the shop inspection and testing provisions specified herein.

Field weld test specimens shall be furnished to Engineer for testing by an independent testing laboratory whenever, in the judgment of Engineer, a satisfactory weld is not being made. Test specimens shall also be furnished when Engineer desires. All costs for this testing will be paid by Owner.

3-4.07. Couplings. Surfaces of pipe ends and couplings in contact with the sealing gasket shall be clean and free from foreign material when the coupling is installed on the pipe. Wrenches used in bolting couplings shall be of a type and

size recommended by the coupling manufacturer. All bolts shall be tightened by approximately the same amount, with all parts of the coupling square and symmetrical with the pipe. Following installation, the exterior coating of each coupling shall be touched up or re-primed.

Where restraint is required, Design-Builder shall verify that tie bolts have been stressed to assure the pipe will not creep when pressurized. When split ring, fixed type couplings are installed, piping shall be in a fully-extended position to engage the restraint rings at the pipe ends.

3-4.07.01. Flanged Coupling Adapters. Flanged coupling adapters shall be installed in accordance with the coupling manufacturer's recommendations. After the pipe is in place and all bolts have been properly tightened, the location of holes for the anchor studs shall be determined and the pipe shall be field drilled. Holes for anchor studs shall extend completely through the pipe wall. Hole diameter shall be not more than 1/8 inch [3 mm] larger than the diameter of the stud projection. Unless otherwise indicated on the Drawings, all 12 inches [300 mm] and smaller flange coupling adapters shall be restrained and all 14 inches [350 mm] and larger flange coupling adapters may only be used in unrestrained applications.

3-4.07.02. Dismantling Joints. Dismantling joints shall be installed in accordance with the coupling manufacturer's recommendations. Unless otherwise indicated on the Drawings, dismantling joints shall be restrained.

3-4.07.03. Mechanical Couplings. Mechanical couplings shall be installed in accordance with the coupling manufacturer's recommendations. A space of at least 1/4 inch, but not more than 1 inch, shall be left between the pipe ends. Pipe and coupling surfaces in contact with gaskets shall be clean and free from dirt and other foreign matter during assembly. All assembly bolts shall be uniformly tightened so that the coupling is free from leaks, and all parts of the coupling are square and symmetrical with the pipe. Following installation of the coupling, damaged areas of shop coatings on the pipe and coupling shall be repaired to the satisfaction of Engineer.

3-4.07.04. Grooved-End Joints. Grooved-end joints with rigid type grooving shall be installed in accordance with the coupling manufacturer's recommendations. Completed joints shall be rigid and shall allow no angular deflection or longitudinal movement. Except for closure pieces, field grooving of pipe will not be acceptable.

Grooved-end couplings shall not be used in the following applications: chemical services, except lime slurry piping; flammable liquid or flammable gas piping, compressed air or compressed gas piping operating at pressures above 25 psi; toxic gas piping; hot liquid with operating temperatures above 120º F; or steam piping.

3-5. WALL SLEEVES AND WALL PIPES. Wall sleeves and wall pipes shall be installed as indicated on the Drawings and shall be installed where steel pipe passes through concrete or masonry walls, unless otherwise noted.

Where harness lugs are attached to wall sleeves, the sleeves shall be carefully aligned to permit installation of the tie rods. In flange and mechanical joint wall sleeves and wall pipe, holes in the mechanical joint bells and flanges shall straddle the top (or side for vertical piping) center line. The top (or side) center line shall be marked on each flange and mechanical joint piece at the fabricating shop.

Where specified or indicated on the Drawings for sleeves detailed, one or two sets of modular casing seals shall be installed at the face of walls to seal against soil or provide a dust or water tight seal. Design-Builder shall coordinate the diameter of wall sleeve with the modular casing seal manufacturer. When soil may be present at wall sleeves, a set of modular casing seals shall be installed at each face of the wall. Modular casing seals shall not be used in submerged conditions unless the hydrostatic pressure is less than 20 feet and piping is less than 24 inches size.

3-6. REDUCERS. Reducers shall be eccentric or concentric as indicated on the Drawings. Reducers of eccentric pattern shall be installed with the straight side on top, so that no air traps are formed.

3-7. BLOWOFFS. Blowoffs shall be located and arranged as indicated on the Drawings.

3-8. ACCESS MANHOLES. Not used.

3-9. GAS AND OIL-RESISTANT GASKETS. Gas and oil-resistant gaskets shall be installed where specified, indicated on the Drawings, or directed by Engineer where jointing gaskets may be subject to permeation when piping passes through areas where soil may be contaminated with gas or petroleum (oil) products or organic solvents or their vapors.

3-10. PIPE ANCHORS, BLOCKING, CONCRETE ENCASEMENT, HANGERS, AND SUPPORTS. Pipe anchors, blocking, hangers, and supports shall be installed where and as specified and indicated on Drawings and shall be fabricated in accordance with thethe details indicated on the Drawings, and shall be furnished and installed complete with all concrete bases, anchor bolts and nuts, plates, rods, and other accessories required for proper support of the piping. All piping shall be rigidly supported and anchored so that there is no movement or visible sagging between supports. Unless otherwise permitted, lugs for lateral or longitudinal anchorage shall be shop welded to the pipe.

Concrete reaction anchorage, blocking, encasements, and supports shall be installed as indicated on the Drawings. Concrete and reinforcing steel for anchorages, blocking, encasements, and supports shall conform to the Cast-in-Place Concrete section. All pipe to be encased shall be suitably supported and blocked in proper position, and shall be anchored to prevent floatation. A pipe joint shall be provided within 12 inches of each end of the concrete encasement.

The concrete blocking size shall be of the dimensions indicated on the Drawings, shall extend from the fitting to solid undisturbed earth, and shall be installed so that all joints are accessible for repair. If adequate support against undisturbed earth cannot be obtained, restrained joints shall be installed to provide the necessary support.

Reaction blocking, anchorages, or other supports for fittings installed in fills or other unstable ground, installed above grade, or exposed within structures, shall be provided as indicated on the Drawings.

All ferrous metal clamps, rods, bolts, and other components of reaction anchorages or joint harness, subject to submergence or in contact with earth or other fill material and not encased in concrete, shall be protected from corrosion as specified in the Corrosion Protection paragraph of this section.

3-11. JOINT HOLDBACKS AND COATINGS AND LININGS.

3-11.01. Shop Holdbacks and Coatings and Linings and Field Repair. Entry into the pipe or pipeline for application of interior linings to unlined ends shall be from open ends or through access manholes. Pour holes, where allowed by the Engineer of Record, shall consist of 4-inch standard weight black steel pipe welded to the pipe to be lined and covered with a bolted blind flange.

Holdbacks, coatings and linings for pipe ends at joints shall conform to the following:

For Field-Welded Joints		
	Cement Mortar	Hold back coating and lining 4 to 6 inches from joint. Field repair in accordance with ANSI/AWWA C205 as modified herein.
	Tape Coating	Hold back coating at least 4 to 6 inches from joint. Field repair in accordance with ANSI/AWWA C214 and ANSI/AWWA C604 using Heat Shrinkage Wrap ANSI/AWWA C216, 80 mils. Type I for pipe and fitting joints.

For Flanged Joints		Extend lining to ends of pipe. Field coat buried exterior surfaces as specified in the Corrosion Protection paragraph for flanges.
For Stab Joints		
	Cement Mortar	Hold back the coating on spigots and the lining in bells from joints as submitted by the pipe manufacturer and accepted by Engineer. Field repair in accordance with ANSI/AWWA C205 as modified herein.
	Liquid Epoxy	Epoxy shop coating shall extend to ends of pipe. Epoxy shop lining shall extend to ends of pipe. If cement-mortar or tape coating is used, epoxy shop lining shall be extended around the end of pipe to a point 4 inches past the sealing point of the rubber gasket.
	Tape Coating	Hold back the coating on spigots as as submitted by the pipe manufacturer and accepted by Engineer. Field repair in accordance with ANSI/AWWA C214 and ANSI/AWWA C604 using Heat Shrinkage Wrap ANSI/AWWA C216, 80 mils, Type I for pipe and fitting joints.
For Mechanically Coupled Joints		
	Cement Mortar	Hold back coating 16 inches (or greater if required to clear harness lugs) from joints. Shop coat exposed surfaces with liquid epoxy to end of pipe in accordance with ANSI/AWWA C210 Epoxy. Lining shall extend to end of pipe. Field coat buried exterior surfaces as specified in the Corrosion Protection paragraph for mechanical couplings.
	Liquid Epoxy	Epoxy shop coating shall extend to ends of pipe; epoxy shop lining shall extend to ends of pipe; in accordance with ANSI/AWWA C210 . Field coat buried exterior surfaces as specified in the Corrosion Protection paragraph for mechanical couplings.

	Polyurethane	Polyurathane shop coating shall extend to ends of pipe; Polyurathane shop lining shall extend to ends of pipe; in accordance with ANSI/AWWA C222. Field coat buried exterior surfaces as specified in the Corrosion Protection paragraph for mechanical couplings.
	Tape Coating	Hold back coating 16 inches (or greater if required to clear harness lugs) from joints. Shop coat exposed surfaces with liquid epoxy to end of pipe in accordance with ANSI/AWWA C210 Epoxy. Field coat buried exterior surfaces as specified in the Corrosion Protection paragraph for mechanical couplings
For Other Type of Joints and Exposed Buried Surfaces		Other types of joints and exposed buried surfaces that cannot be shop coated with the primary coating and lining system shall be shop coated and lined with 20 mil dry film thickness of liquid epoxy in accordance with ANSI/AWWA C210 Epoxy.

3-11.02. Modifications to the Governing Standards.

3-11.02.01. Field Repair of Cement Mortar Lining. Field repair of interior joint surfaces shall be done in accordance with ANSI/AWWA C205, except that an epoxy bonding agent and latex admixture shall be used in conjunction with the sand and cement mortar. The addition of lime or pozzolan will not be permitted.

The exposed steel shall be thoroughly cleaned and all grease shall be removed. A coat of epoxy bonding agent shall be applied over the area to be lined in accordance with the coating manufacturer's recommendations. A soupy mixture of cement and water shall be applied over the epoxy after it becomes tacky. Cement mortar to which the latex admixture has been added shall then be packed into the area to be patched and screeded off level with the adjacent cement mortar lining. The patched area shall be given an initial floating with a wood float, followed by a steel trowel finish.

Defective or damaged cement mortar linings shall be removed, the surfaces cleaned, and the lining repaired as specified above for joint repair. Wire fabric reinforcement shall be used in the lining of fittings and specials in conformance with ANSI/AWWA C205.

3-11.02.02. Special Procedure for Exterior Joint Grouting. Each exterior joint recess in cement coated pipe shall be filled with joint grout. A diaper shall be used to prevent foreign material from entering the joint recess before grouting and to serve as a form for the grout. Each diaper shall be of sufficient length to encircle the pipe, leaving enough space between the ends for pouring the grout. Hems shall be stitched into the edges of the diaper to receive steel strapping for attaching the diaper to each side of the pipe joint. The diaper shall have "pouring flap" extensions that fold back while the joint is being poured and that lap over the pouring gap after the diaper is filled with grout. The grout shall be poured or pumped between the diaper and the pipe and shall be allowed to run to the bottom of the pipe on one side until it is observed coming up on the opposite side of the pipe to ensure that the space in the bottom of the joint is filled with grout. Grout can be poured or pumped, topping out on both sides of the pipe, and shall be rodded on the same side of the pipe from which it is pumped or poured, while being poured, using a stiff wire curved to the approximate shape of the pipe to prevent tearing a hole in the diaper. Each joint recess shall be completely filled with grout for the full circumference of the pipe.

Prior to grouting the exterior joints, at least two lengths of pipe shall be in final position, or the pipe shall be backfilled sufficiently to brace and secure it against displacement. Design-Builder shall protect the exterior joint grout against damage during pipe laying or backfilling.

3-12. CORROSION PROTECTION.

3-12.01. Flanged Joints. The flange bolts and nuts on buried flanged joints shall be protected by wrapping them with wax tap in accordance with ANSI/AWWA C217. A primer shall be applied prior to applying the wax tape. The application of the wax tape shall be as recommended by the wax tape manufacturer.

Following application of the wax tape protection, the entire flanged joint shall be encapsulated with a shrink sleeve. The shrink sleeve shall extend a minimum of 6 inches onto the shop coated pipe on each side of the flange. A primer shall be applied to the piping on each side of the flange prior to installing the shrink sleeve. The installation of the shrink sleeve shall be in accordance with ANSI/AWWA C216 and as recommended by the shrink sleeve manufacturer. There shall be no bare or unprotected ferrous metal surfaces.

Corrosion protection of buried insulated flanges shall be as specified herein unless otherwise shown on the drawings

3-12.02. Valves. Buried valve flanges shall be protected as specified herein for buried flange joints.The corrosion protection for the entire remaining buried valve and actuator to the wrench nut shall be wax tape or shrink sleeve.

3-12.03. Mechanical Couplings. The coupling and its tie bolts and nuts on all buried mechanical couplings shall be coated with two coats, 20 mils minimum, of medium consistency coal tar.

After the protective coating has been applied to the coupling and tie bolts, the entire mechanical coupling shall be encapsulated with a shrink sleeve. The shrink sleeve shall extend a minimum of 6 inches onto the shop coated pipe on each side of the coupling, including covering all epoxy coated steel. A primer shall be applied to the piping on each side of the coupling prior to installing the shrink sleeve. The application of the shrink sleeve shall be in accordance with ANSI/AWWA C216 and as recommended by the shrink sleeve manufacturer. There shall be no bare or unprotected ferrous metal surfaces.

3-12.04. Restrained Mechanical Couplings. Buried mechanical couplings shall be protected with two coats of medium consistency coal tar and shrink sleeve as specified herein for buried mechanical couplings.

The tie rods and bolts of the harness rings or lugs of the restrained coupling assembly shall be protected by wrapping them with wax tape in accordance with ANSI/AWWA C217. A primer shall be applied prior to applying the wax tape. The application of the wax tape shall be as recommended by the wax tape manufacturer.

Following the application of the wax tape, the entire restrained mechanical coupling assembly, including coupling, tie bolts and nuts, pipe, and harness rings or lugs, shall be encapsulated with an underlying sleeve covered by a shrink sleeve. The underlying sleeve shall extend a minimum of 6 inches onto the pipe beyond each end of the tie rods. The shrink sleeve shall extend a minimum of 6 inches onto the shop coated pipe beyond each end of the underlying sleeve. A primer shall be applied to the piping on each side of the harness assembly prior to installing the shrink sleeve. The application of the shrink sleeve shall be in accordance with ANSI/AWWA C216 and as recommended by the shrink sleeve manufacturer. There shall be no bare or unprotected ferrous metal surfaces.

3-12.05. Other Assemblies. All ferrous metal clamps, tie rods, bolts, and other components of buried joint harnesses, mechanical joints, wall fittings, or pipe reaction anchorages in contact with earth or other fill material and not encased in concrete, shall be protected by wrapping them with wax tape in accordance with ANSI/AWWA C217. A primer shall be applied prior to applying the wax tape. The application for the wax tape shall be as recommended by the wax tape manufacturer. There shall be no bare or unprotected ferrous metal surfaces.

3-12.06. Surfaces Exposed in Manholes and Vaults. Unless otherwise specified, all uncoated metal surfaces exposed in manholes and vaults shall be cleaned and coated with two coats of medium consistency coal tar. The first coat shall be

dry and hard before the second coat is applied. There shall be no unprotected, bare, or uncoated ferrous metal surfaces.

3-13. CONNECTIONS WITH EXISTING PIPING. Connections between new work and existing piping shall be made using fittings suitable for the conditions encountered. Each connection with an existing pipe shall be made at a time and under conditions which will least interfere with service to customers, and as authorized by Owner.

Facilities shall be provided for dewatering and for disposal of the water removed from the dewatered lines and excavations without damage to adjacent property.

Special care shall be taken to prevent contamination when dewatering, cutting into, and making connections with potable water piping. Trench water, mud, or other contaminating substances shall not be permitted to enter the lines. The interior of all pipe, fittings, and valves installed in such connections shall be thoroughly cleaned and then swabbed with or dipped in a 200mg/L chlorine solution.

3-14. INSTALLATION IN TUNNELS. Not used.

3-15. PROVISIONS FOR CATHODIC PROTECTION. Cathodic protection shall be provided for buried piping as specified in the Cathodic Protection section. Provisions shall be made for cathodic protection of underground steel pipelines. An insulated type joint shall be provided at each connection to a steel water tank, each branch connection to an existing or future water line, each connection between concrete pipe or ductile iron pipe and steel pipe, each connection through a structure wall, and where indicated on the Drawings. An electrical bond shall be provided across all other gasketed pipeline joints. Test lead stations for monitoring electrical currents on the pipeline shall be provided at locations indicated on the Drawings.

3-15.01. Insulated Joints. Insulated flange type joints shall be provided where indicated on the Drawings or specified. After installation, corrosion protection shall be provided for the joint as specified in the Corrosion Protection paragraph.

3-15.02. Electrical Bond Across Rubber-Gasketed Joints. Two electrical bonding cables shall be bonded to and across each mechanical coupling, stab joint, or other rubber-gasketed stab joint. Before the field joint coating is applied to mechanical couplings, two small areas of metal shall be exposed on the pipe surface each side of the coupling, on the middle ring, and on each follower ring. Before the field joint coating is applied to stab joints, two small areas of metal shall be exposed on each side of the joint. Each area shall be thoroughly cleaned, and two cathodic protection cables shall be bonded to the pipe, one on either side of the joint, and to the middle ring and follower rings for mechanically coupled joints. Each cable shall be bonded by the thermite process. The

completed connections and exposed metal surfaces shall be coated as specified for field repair of coatings in the Corrosion Protection paragraph.

3-15.03. Electrical Bond Across Valves and Flanges. Two electrical bonding cables shall be provided across valves and flanged connections other than insulated flanges. The electrical bond shall be provided as specified for bond across rubber-gasketed joints.

3-15.04. Bonding Cables and Test Lead Wires. Refer to the Cathodic Protection Section.

3-15.05. Test Lead Stations. Test lead stations shall be provided where specified or indicated on the Drawings.

3-16. HOLIDAY TESTING. The Design-Builder will holiday test spray applied-coated steel pipe linings and coatings. After the specified coating has cured per the manufacturer's recommendations, the Design-Builder will test the coated steel surfaces for pinholes and holidays using a high voltage spark tester according to NACE RP0188. Areas which contain visual pinholes and sparking holidays shall be marked, repaired or recoated, and retested in accordance with the coating manufacturer's printed instructions. The electrode movement over the coating surface shall be continuous and shall proceed in a systematic manner, which ensures 100% coverage of the coated surfaces.

1. Coatings with Thickness Exceeding 20 Mils: For surfaces having a total dry film coating thickness exceeding 20 mils, a pulse-type holiday detector such as Elcometer 236 15kV, Tinker & Rasor Model AP-W, D.E. Stearns Co. Model 14/20, or equal shall be used. Holiday testing shall be conducted with a new 12-inch or 18-inch wide wire brush electrode attached to the unit. A silicon rubber electrode shall not be allowed. The unit shall be adjusted to operate at the voltage required to cause a spark jump across an air gap equal to twice the specified coating thickness.
2. Coatings with Thickness Less Than 20 mils: For surfaces having a total dry film coating thickness of 20 mils or less, a low voltage holiday detector shall be used. The unit shall operate at less than 75 volts. For thicknesses between 10 and 20 mils, a non-sudsing type wetting agent, such as Kodak Photo Flo, Wetting Agent as manufactured by Elcometer or equivalent, shall be added to the water prior to wetting the detector sponge. The following products are acceptable:
   a. Tinker-Rasor Model M1
   b. Elcometer 270/4
   c. D.E Sterns Co. Model M1

3-17. PRESSURE AND LEAKAGE TESTS. After installation, pipe and fittings shall be subjected to a pressure test and a leakage test in accordance with the Pipeline Pressure and Leakage Testing section.

All pipe, fittings, valves, pipe joints, and other materials which are found to be defective shall be removed and replaced with new and acceptable materials, and the affected portion of the piping shall be retested by and at the expense of Design-Builder.

All joints shall be watertight and free from visible leaks.

3-18. DISINFECTION. After installation, all potable water pipelines shall be disinfected as specified in the Cleaning and Disinfection of Water Pipelines section.

End of Section

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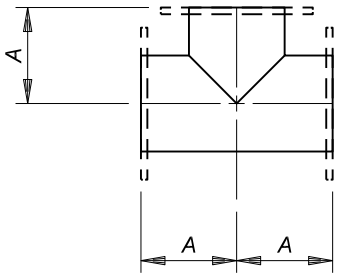

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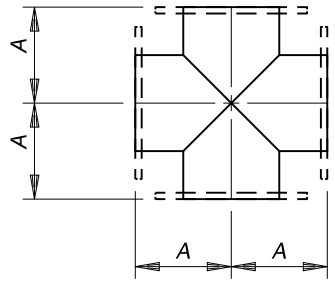

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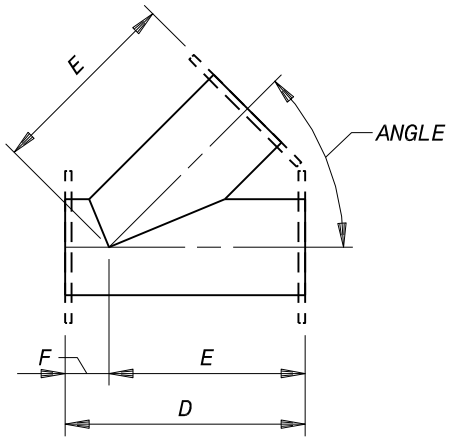
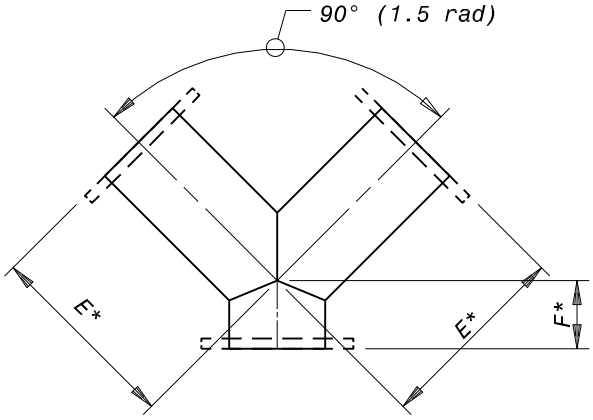
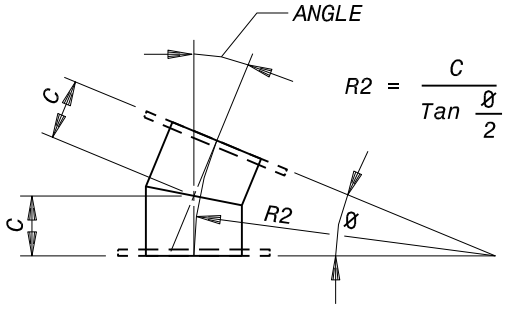


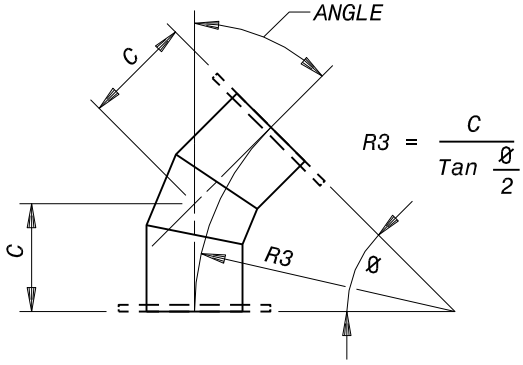
LATERAL 45° (0.7 rad) MIN; 75° (1.3 rad) MAX



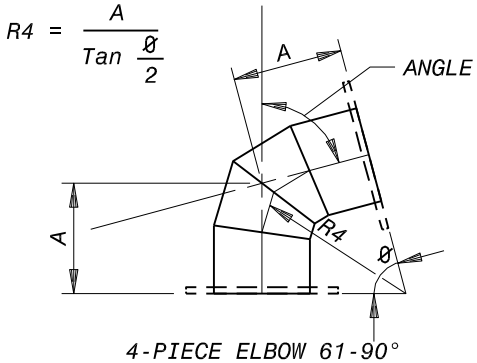
TRUE WYE-90° (1.5 rad)



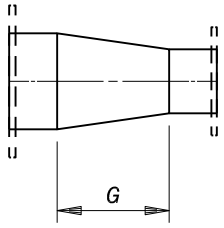
2-PIECE ELBOW
0-30° (0-0.52 rad)



3-PIECE ELBOW 31-60°
(0.54-1.0 rad)



4-PIECE ELBOW 61-90°
(1.1-1.5 rad)



REDUCER

NOTE:
SEE FIGURE 1-02621(B) FOR DIMENSIONS.

STEEL PIPE FITTINGS

BLACK & VEATCH	STEEL PIPE	FIG 1-40 05 24(A)

DIMENSIONS IN INCHES (MILLIMETERS)

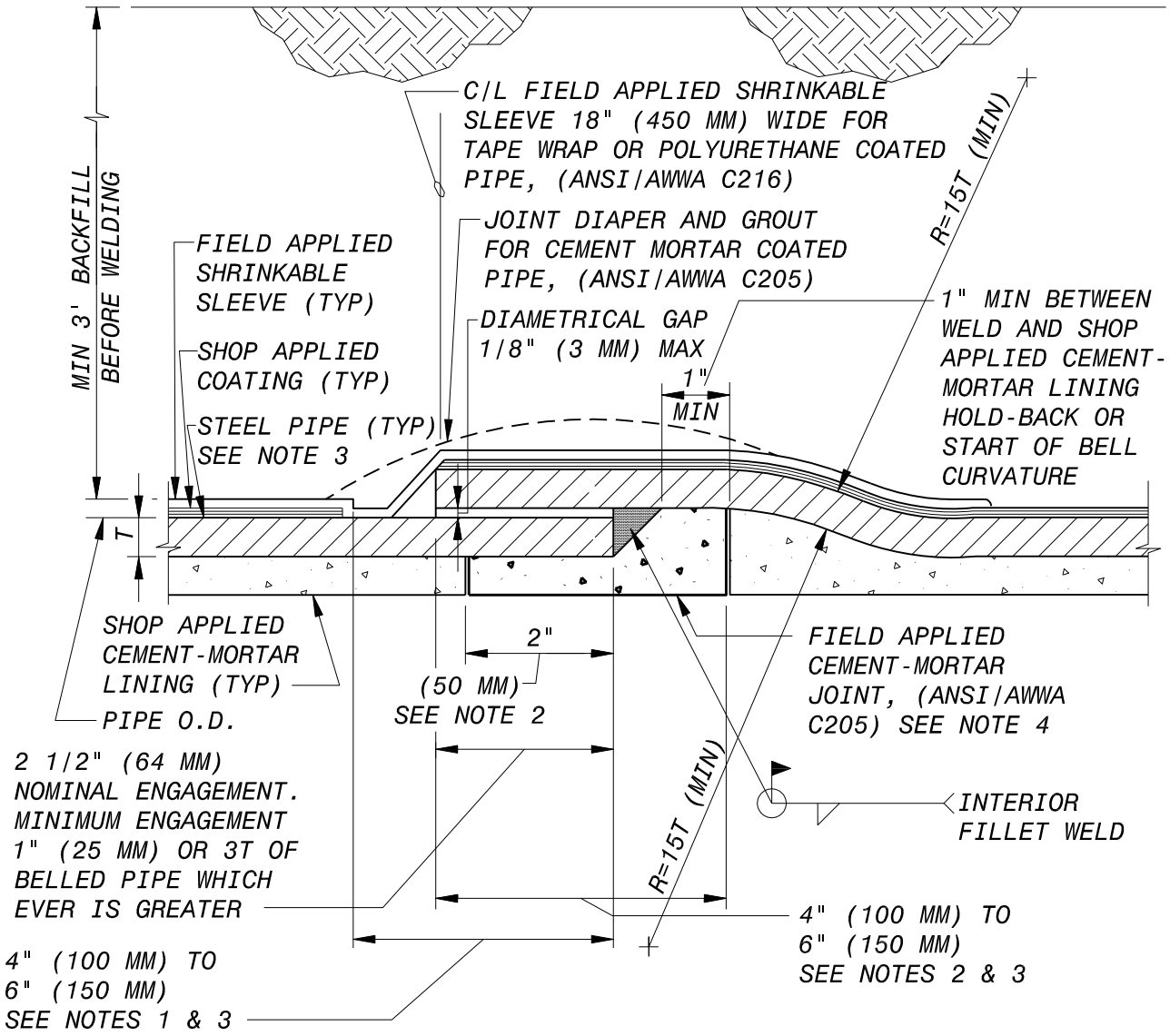
NOMINAL DIA	TEE		CROSS A+A	LATERAL (45–75\) (0.7–1.3 rad)		TRUE WYE (90\) (1.5 rad)		ELBOWS			REDUCER CONE G
	RUN A+A	OUTLET A		RUN D	OUTLET E	E*	F*	2–PIECE (0–30\) (0.0–0.52 rad) C	3–PIECE (31–60\) (0.54–1.0 rad) C	4–PIECE (61–90\) (1.1–1.5 rad) A	
4 (100)	13 (330)	6.5 (165)	13 (330)	15 (381)	12 (305)	6.5 (330)	3 (76)	4 (102)	4 (102)	6.5 (162)	7 (178)
6 (150)	16 (406)	8 (203)	16 (406)	18 (457)	14.5 (368)	8 (203)	3.5 (89)	5 (127)	5 (127)	8 (203)	9 (229)
8 (200)	18 (457)	9 (229)	18 (457)	22 (559)	17.5 (445)	9 (229)	4.5 (114)	5.5 (140)	5.5 (140)	9 (229)	11 (279)
10 (250)	22 (559)	11 (279)	22 (559)	25.5 (648)	20.5 (521)	11 (279)	5 (127)	6.5 (165)	6.5 (165)	11 (279)	12 (305)
12 (300)	24 (610)	12 (305)	24 (610)	30 (762)	24.5 (622)	12 (305)	5.5 (140)	7.5 (191)	7.5 (191)	12 (305)	14 (356)
14 (350)	28 (711)	14 (356)	28 (711)	33 (838)	27 (686)	14 (356)	6 (152)	7.5 (191)	7.5 (191)	14 (356)	16 (406)
16 (400)	30 (762)	15 (381)	30 (762)	36.5 (927)	30 (762)	15 (381)	6.5 (165)	8 (203)	8 (203)	15 (381)	18 (457)
18 (450)	33 (838)	16.5 (419)	33 (838)	39 (991)	32 (813)	16.5 (419)	7 (178)	8.5 (216)	8.5 (216)	16.5 (419)	19 (483)
20 (500)	36 (914)	18 (457)	36 (914)	43 (1092)	35 (889)	18 (457)	8 (203)	9.5 (241)	9.5 (241)	18 (457)	20 (508)
22 (550)	40 (1016)	20 (508)	40 (1016)	46 (1168)	37.5 (953)	22 (559)	9 (229)	10 (254)	10 (254)	20 (508)	22 (559)
24 (600)	44 (1118)	22 (559)	44 (1118)	49.5 (1257)	40.5 (1029)	25 (635)	10 (254)	11 (279)	11 (279)	22 (559)	24 (610)
30 (750)	50 (1270)	25 (635)	50 (1270)	59 (1499)	49 (1245)			15 (381)	15 (381)	25 (635)	30 (762)
36 (900)	56 (1422)	28 (711)	56 (1422)	84 (2134)	60 (1524)			18 (457)	18 (457)	28 (711)	36 (914)
42 (1050)	62 (1575)	31 (787)	62 (1575)	95 (2413)	69 (1753)			21 (533)	21 (533)	31 (787)	42 (1067)
48 (1200)	68 (1727)	34 (864)	68 (1727)	104 (2642)	77 (1956)			24 (610)	24 (610)	34 (864)	48 (1219)
54 (1350)	74 (1880)	37 (940)	74 (1880)					27 (686)	27 (686)	37 (940)	54 (1372)
60 (1500)	80 (2032)	40 (1016)	80 (2032)					30 (762)	30 (762)	40 (1016)	60 (1524)

DIMENSIONS FOR STEEL PIPE FITTINGS

BLACK & VEATCH

STEEL PIPE

FIG 1-40 05 24(B)



SINGLE WELDED BELL/SPIGOT DETAIL (WELD AFTER BACKFILL)

NO SCALE

NOTES:

1. HOLD TAPE MATERIALS BACK 4" (100 MM) TO 6" (150 MM) ON THE SPIGOT OD. LEAVE CUT-BACK BARE STEEL.

2. HOLD CEMENT-MORTAR LINING BACK 4" (100 MM) TO 6" (150 MM) ON BELL ID AND 2" (50 MM) ON SPIGOT ID. LEAVE CUT-BACK BARE STEEL.

3. GRIND SPIRAL WELD BACK 18" (450 MM) ON BELL AND SPIGOT OD. GRIND SPIRAL WELD BACK 4" (100 MM) TO 6" (150 MM) ON BELL ID.

4. FILL JOINT GAP IN LINING BY FIELD APPLIED CEMENT-MORTAR PER ANSI/AWWA C205.

FIELD-WELDED LAP JOINT DETAIL

BLACK & VEATCH	STEEL PIPE	FIG 3-40 05 24(B)

Section 40 05 24.43

MISCELLANEOUS STEEL PIPE, TUBING, AND ACCESSORIES

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of miscellaneous steel pipe, tubing and accessories that for pipe diameters 24 inches and smaller. Pipe and tubing shall be furnished complete with all fittings, flanges, unions, and other accessories specified herein.

Steel pipe for potable and non-potable water conveyance are covered in the Steel Pipe section.

1-2. GENERAL.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-3. SUBMITTALS.

1-3.01. Drawings and Data. Complete specifications, data, and catalog cuts or drawings shall be submitted in accordance with the Submittals Procedures section. Submittals are required for all piping, fittings, gaskets, sleeves, and accessories, and shall include the following data:

Name of Manufacturer
Type and model
Construction materials, thickness, and finishes
Pressure and temperature ratings

Supplier shall submit a written statement from the gasket material manufacturer certifying that the gasket materials are compatible with the joints specified herein and are recommended for the specified field test pressures and service conditions.

1-4. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the general Terms and Conditions. Handling and storage shall be in accordance with manufacturer recommendations and this Section. All materials shall be stored in a sheltered location above the ground, separated by type, and shall be supported to prevent sagging or bending.

1-4.01. Coated Pipe. Handling methods and equipment used shall prevent damage to the protective coating and shall include the use of end hooks, padded calipers, and nylon or similar fabric slings with spreader bars. Bare cables, chains, or metal bars shall not be used. Coated pipe shall be stored off the ground on wide, padded skids. Plastic coated pipe shall be covered or otherwise protected from exposure to sunlight.

PART 2 - PRODUCTS

2-1. GALVANIZED STEEL PIPE.
Galvanized steel pipe materials and service shall be as specified herein.

2-1.01. Material Classification CSG-1.

CSG-1 – Standard Weight Galvanized Steel with Threaded Fittings All pipe sleeves except where plastic sleeves are required.	Pipe Fittings	ASTM A53, Type E, standard weight, Grade A or B; or ASTM A106, of equivalent thickness, galvanized. Cast iron threaded, galvanized. Fittings shall conform to ANSI/ASME B16.4, Class 125.

2-1.02. Material Classification CSG-2.

CSG-2 – Standard Weight Galvanized Steel with Threaded Fittings Grease piping – pumping units. Sump pump discharge piping in interior locations except where buried. Filtrate piping, except where buried. Drain piping from equipment, except where buried.	Pipe Fittings	ASTM A53, Type E, standard weight, Grade A or B; or ASTM A106, of equivalent thickness, galvanized. Malleable iron threaded, galvanized. Fittings shall conform to ANSI/ASME B16.3, Class 150, or Fed Spec WW-P-521, Type II.

2-1.03. Material Classification CSG-3.

CSG-3 – Standard Weight Galvanized Steel with Flanged Fittings. Sump pump discharge piping in interior locations except where buried.	Pipe Fittings	ASTM A53, Type E, standard weight, Grade A or B; or ASTM A106, of equivalent thickness, galvanized. Cast iron flanged, galvanized. Fittings shall conform to ANSI/ASME B16.1, Class 125.

2-1.04. Accessory Materials. Accessory materials for galvanized steel pipe shall be as indicated in the Steel Pipe section of the specification.

2-2. STEEL PIPE. Steel pipe materials and service shall be as specified herein.

2-2.01. Material Classification CS-1. Not used.

2-2.02. Material Classification CS-2.

CS-2 – Standard Weight Steel with Socket Welded Fittings. Sodium hydroxide solution piping, interior locations or outdoors above grade. Compressed air supply piping, 2 inch and smaller up to 250 psig, except where buried. 2 inch [50 mm] and smaller.	Pipe Fittings	ASTM A53/A106, Type S, standard weight, Grade B; Plain ends. Forged steel socket welded. Fitting shall conform to ANSI B16.11, Class 3000; Bonney, Crane, Ladish, or Vogt.

2-2.03. Material Classification CS-3.

CS-3 – Standard Weight Steel with Buttwelded Fittings. Compressed air supply piping up to 250 psig, except where buried. Fuel oil or diesel fuel piping in interior locations or outdoors above grade. 2-1/2 inch and larger.	Pipe Fittings	ASTM A53/A106, Type S, standard weight Grade B; Bevel ends. Buttwelded. Fitting shall conform to ANSI/ASME B16.9, standard weight.

2-2.04. Material Classification CS-4.

CS-4 – Extra Strong Steel with Threaded Fittings. Compressed air supply piping, 251-500 psig, except where buried. Fuel oil or diesel fuel piping in interior locations or outdoors above grade (seal weld). 2 inch and smaller.	Pipe	ASTM A53/A106, Type S, extra strong, Grade B; Threaded ends.
	Fittings	Forged steel, threaded. Fittings shall conform to ANSI B16.11, Class 2000 or 3000; Bonney, Crane, Ladish, or Vogt.

2-2.05. Material Classification CS-5. Not used.

2-2.06. Material Classification CS-6.

CS-6 – Extra Strong Steel with Buttwelded Fittings. Compressed air supply piping, 2-1/2 inches and larger, 251-500 psi except where buried.	Pipe	ASTM A53, Type E, extra strong, Grade B; or ASTM A106, of equivalent thickness. Bevel ends.
	Fittings	Buttwelded. Fittings shall conform to ANSI/ASME B16.9; extra strong.

2-2.07. Material Classification CS-7. Not used.

2-2.08. Material Classification CS-8. Not used.

2-2.09. Material Classification CS-9. Not used.

2-2.10. Material Classification CS-10. Not used.

2-2.11. Material Classification CS-11. Not used.

2-2.12. Material Classification CS-12.

CS-12 – Steel Pipe with PTFE Lining. Sulfuric acid solution piping.	Pipe and Lining	ASTM F423
	Fittings	A587, A106 Grade B, or A53.

2-2.13. Material Classification CS-13. Not used.

2-2.14. Material Classification CS-14. Not used.

2-2.15. Accessory Materials. Accessory materials for the miscellaneous steel pipe and tubing systems shall be as indicated.

Nipples	ASTM A733, seamless, extra strong (Schedule 80); "close" nipples will be permitted only by special authorization in each case.
Unions (Malleable Iron)	Fed Spec WW-U-53l, Class 2; Type B (galvanized) for galvanized pipe or Type A (black) for ungalvanized pipe.
Flanges	
Standard Weight Pipe	ANSI/ASME B16.5, Class 150, flat faced when connected to flat faced flanges; otherwise, raised face.
Extra Strong Pipe	
Chemical Gas Piping	ASTM A105, forged steel, tongue and groove flanged union type, with nonmetallic gasket; rated for a working pressure of 1,500 psi.
Other services	ANSI/ASME B16.5, Class 300, raised face.
Plastic Lined Pipe	Steel, forged or cast, diameter and drilling in accordance with ANSI/ASME B16.5, Class 150 or 300 as required.
Flange Bolts and Nuts	ASTM A193, Grade B7 with ASTM A194 Grade 2H nuts. Length such that, after installation, the bolts will project 1/8 to 3/8 inch beyond outer face of the nut.
Flange Gaskets	
For Process Air Service	
Raised Face Flanges	Non-asbestos inorganic fiber with EPDM binder; dimensions to suit flange contact face, 1/16 inch minimum thickness for plain finished surfaces, 3/32 inch minimum thickness for serrated surfaces, rated for 275°F service; Garlock "IFG 5507".

Flat Faced Flanges	Premium Grade, EPDM, full face, 1/8 inch thick, rated for 275°F service; Garlock "8314".
For Oil Service	Non-asbestos filler with neoprene or nitrile binder; dimensions to suit flange contact face; 1/16 inch minimum thickness for plain finished surfaces, 3/32 inch minimum thickness for serrated surfaces.
For Heating Water Service	Non-asbestos inorganic fiber with nitrile binder; dimensions to suit flange contact face, 1/16 inch minimum thickness for plain finished surfaces, 3/32 inch minimum thickness for serrated surfaces; Garlock "IFG 5500".
For Water Service	ASTM D1330, Grade I, red rubber, ring type, 1/8 inch thick.
For Chemical Service	Suitable for chemical.
For Other Services	
Flat Faced Flanges	Non-asbestos filler with neoprene or nitrile binder; dimensions to suit flange contact face; 1/16 inch minimum thickness for plain finished surfaces, 3/32 inch minimum thickness for serrated surfaces.
Raised Face Flanges	Continuous stainless steel ribbon wound into a spiral with non-asbestos filler between adjacent coils with a carbon steel gauge ring. Compressed gasket thickness shall be 0.095 inch ±0.005 inch.
Grooved Couplings	
Rigid	AWWA C606; Gustin-Bacon "No. 120 Rigid" or Victaulic "07 Zero-Flex".
Standard	AWWA C606; Gustin-Bacon "No. 100 Standard" or Victaulic "Style 77".
Mechanical Couplings	Dresser "Style 38" or Smith-Blair "Type 411 Flexible Coupling"; without pipe stop.

Expansion Joints

Process air

Expansion joints shall be the elastomeric, arched type and shall be Mercer “Type 450” with “Type 500” retaining rings and Kevlar reinforcement, or equal.

The number of arches shall be as indicated on the Drawings. The connection shall be suitable for a maximum pressure of 15 psig and maximum temperature of 250 F . Expansion joints shall have the following ratings:

Number of Arches:	1
Spring rate:	___ lbs/inch
Movement:	___ inch
Number of Arches:	2
Spring rate:	___ lbs/inch
Movement:	___ inch
Number of Arches:	3
Spring rate:	___ lbs/inch
Movement:	___ inch

Heating water, chilled water, and other services not specified.

Flexonics "Model H Expansion Compensators" for 3 inch or smaller; Flexonics "Mid-Corr, Series MCB" with flanged ends and stainless steel bellows for 4 inch or larger. Expansion joints shall be suitable for working pressures up to 150 psig.

Material Classification

CS-14: Double wall pipe with leak detection.

Joining

Carrier pipe shall be joined by socket welding. Containment pipe shall be joined by split sleeve of the same diameter as containment pipe with minimum 60 mil thick polyethylene jacket.

End Seal

End seals shall be furnished at all terminal ends. The end seal shall be sealed to the containment pipe.

Leak Detection

Microprocessor based monitoring unit, for continuous monitoring by cable of a single line for water and hydrocarbon.

Control Panel	Modified NEMA Type 12 enclosure, with Status and Alarm Data Model "PAL-AT20C". Power supply to the unit will be 120 volt, 1 phase, 60 Hz. Unit shall be UL listed with alarm horn and shall locate leaks and not depend on battery back-up functions. System conditions shall be stored in memory in the event of power failure and shall automatically resume monitoring without reset once power is available. Monitoring unit shall be able to differentiate between water left in pipe during installation and an actual growing leak. Panel shall also be able to detect a break in sensor cable and its location.
Cable	Cable shall be located in the interstitial space between the carrier and containment pipe, shall detect both water and hydrocarbon, and shall be capable of being dried in place without being replaced after exposure to any fluid Type "AGW-Gold". Coaxial cable shall interface monitoring control panel with sensor cable by utilizing waterproof junction box for protecting connection.

2-3. COATINGS. Standard weight steel pipe shall not be used in buried locations. Coatings for hot piping shall be as specified.

Extra strong steel pipe shall not be used in buried locations.

All surfaces to be tape-wrapped in the shop shall be thoroughly cleaned and primed in accordance with the tape manufacturer's recommendations immediately before wrapping. The tape shall be applied by two-ply (half-lap) wrapping or as needed to provide a total installed tape thickness of at least 60 mils.

Shop applied coatings shall be as follows:

External Coatings

Plastic	Liberty Coating Company “Pritec" or Bredero-Shaw “Entec". The products of other manufacturers will not be acceptable.

Tape Wrap	ANSI/AWWA C209, except single ply tape thickness shall not be less than 30 mils [760 µm]; Protecto Wrap "200" or Tapecoat "CT".
High temperature epoxy for aeration and process air piping	Shop or field applied high solids epoxy; suitable for protection at continuous pipe wall temperatures up to 300 F. Coating shall be abrasion resistant. The finished coating shall have a minimum total film thickness of 10 mils. The surface shall be prepared in accordance with SSPC-SP7 as a minimum unless otherwise recommended by the coating manufacturer. The coating shall be Carboline “Thermaline 450”, Ameron “Amerlock 400 with Amercoat 880 Additive”, or approved equal.

PART 3 - EXECUTION

3-1. INSTALLATION. Materials furnished under this section will be installed in accordance with the Miscellaneous Piping and Accessories Installation section.

End of Section

Section 40 05 31.12

POLYVINYL CHLORIDE (PVC) PRESSURE PIPE

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing and installation of 4 through 36 inch buried polyvinyl chloride (PVC) pressure pipe for potable water service, fire water service, recycled water service, and plant process piping. PVC pressure pipe shall be furnished complete with all fittings, jointing materials, anchors, blocking, encasement, and other necessary appurtenances.

Pressure and watertightness tests, cleaning, and disinfection, are covered in other sections. Pipe trenching, bedding, and backfill are covered in the Trenching and Backfilling section.

Pipe shall be furnished where indicated in the pipeline schedule or where indicated on the Drawings.

1-1.01. Pipe Manufacturer's Experience and Field Services. Not used.

1-2. SPARE MATERIALS. Not used.

1-3. GOVERNING STANDARDS. Except as modified or supplemented herein, all PVC pressure pipe shall conform to the applicable requirements of ANSI/AWWA C900.

The supplementary information required in the governing standards is as follows:

Affidavit of Compliance	Required.
Plant Inspection	Not required.
Special Markings	Not required.
Special Preparation for Shipment	Not required.
Certification	Required.

1-4. SUBMITTALS. Drawings and data shall be submitted in accordance with the Submittals Procedures section. Drawings and data shall include, but shall not be limited to, the following:

Gasket material.

Pipe length.

Pipe Dimension Ratio.

Manufacturer's hydrostatic proof test results for each length of pipe in each lot from which pipe shall be provided for the Project, and results from dimension measurements, flattening tests, and extrusion quality tests performed in accordance with the governing standard, for each lot from which pipe is provided for the Project. Test results shall include a summary of the number of lengths in each lot that fail the tests and the total number of lengths in each lot. The submittal shall also include a listing of the number of lengths of pipe provided from each lot.

Affidavit of Compliance (ANSI/AWWA C900, Sec. 6.3).

Certification (ANSI/AWWA C900, Sec. 4.2.4).

Certificate of Compliance with NSF Standard No. 61.

1-4.01. Emergency Repair Manual. Not used.

1-5. MATERIALS TESTING. Not used.

1-6. DELIVERY, STORAGE AND HANDLING. Shipping shall be in accordance with the general Terms and Conditions. Handling and storage shall be in accordance with manufacturer recommendations and this Section.

Pipe, fittings, and accessories shall be handled in accordance with Chapter 6 of AWWA Manual M23, to ensure installation in sound, undamaged condition. Pipe shall not be stored uncovered in direct sunlight.

PART 2 - PRODUCTS

2-1. DIMENSIONS. The dimension ratios (DRs: outside diameter to wall thickness) of PVC pressure pipe shall be as indicated on the Drawings or the Pipe Schedule.

2-2. MATERIALS.

Pipe	ANSI/AWWA C900; cast iron pipe OD, Certa-Lok with spline, dimension ratio as specified herein.
Fittings	PVC. Ductile iron fittings are not acceptable except where shown on Drawings. Tapping saddles/sleeves shall be sized for PVC pipe.

Joints	
PVC to PVC	ANSI/AWWA C900 Certa-Lok with spline.
PVC to Cast Iron	Not Used.
Tapping Saddles	Ductile iron, with galvanized steel straps and synthetic rubber sealing gasket, 250 psi [1.7 MPa] pressure rating.
Restrained Joints	Certa-Lok with spline.
Tapping Sleeves	Ductile iron, 250 psi [1.7 MPa] pressure rating.
Polyethylene Encasement	Tube or sheet, ANSI/AWWA C105/A21.5.
Joint Tape	Self-sticking, PVC or polyethylene, 10 mils [250 µm] thick; Chase "Chasekote 750", Kendall "Polyken 900", or 3M "Scotchrap 50".
Coal Tar Epoxy	High-build coal tar epoxy; Ameron "Amercoat 78HB Coal Tar Epoxy", Carboline "Bitumastic 300 M", Tnemec "46H-413 Hi-Build Tneme-Tar", or Sherwin-Williams "Hi-Mil Sher-Tar Epoxy".
Conductive Tracer	Detection tape, 3 inches wide; aluminum foil core, 0.5 mil thick, encased in a protective inert plastic jacket; 5,000 psi min tensile strength; 2.5 lbs per inch per 1,000 feet min mass; color coded in accordance with APWA Uniform Color Code; Lineguard "Type III", or Reef Industries "Terra Tape D".

Manufacturing quality control shall be maintained by frequent, regularly scheduled sampling and testing. Testing shall comply with the governing standards.

2-3. SHOP COATING AND LINING. Not used.

PART 3 - EXECUTION

3-1. INSPECTION. Pipe and fittings shall be carefully examined for cracks and other defects immediately before installation; spigot ends and bells shall be examined with particular care. All defective pipe and fittings shall be removed from the site of the work.

3-2. LAYING PIPE. Pipe shall be protected from lateral displacement by pipe embedment material installed as specified in the Trenching and Backfilling section. Pipe shall not be laid in water or other unsuitable conditions.

Pipe shall be laid with bell ends facing the direction of laying, except when reverse laying is specifically permitted.

Foreign matter shall be prevented from entering the pipe during installation.

Whenever pipe laying is stopped, the open end of the line shall be sealed with a watertight plug. All water shall be removed from the trench prior to removing the plug.

A conductive tracer shall be buried above PVC pipe, not more than 18 inches below the ground surface.

3-2.01. Cleaning. The interior of all pipe and fittings shall be thoroughly cleaned before installation and shall be kept clean until the work has been accepted.

3-2.02. Alignment. Piping shall be laid to the lines and grades indicated on the Drawings. Pipelines or runs intended to be straight shall be laid straight. Deflections from a straight line or grade shall not exceed the maximum deflections specified by the manufacturer.

Unless otherwise specified or indicated on the Drawings, either shorter pipe sections or fittings shall be installed as required to maintain the indicated alignment or grade.

3-3. CUTTING PIPE. Cutting shall comply with the pipe manufacturer's recommendations and with Chapter 7 of AWWA Manual M23. Cuts shall be smooth, straight, and at right angles to the pipe axis. After cutting, the end of the pipe shall be dressed to remove all roughness and sharp corners and shall be beveled in accordance with the manufacturer's instructions.

3-4. JOINTS. Joints shall be Certa-Lok spline type unless otherwise indicated on the Drawings.

3-4.01. Gasketed Push-on Type Joints. Not used.

3-4.02. Mechanical Joints. Mechanical joints shall be carefully assembled in accordance with the manufacturer's recommendations. If effective sealing is not obtained, the joint shall be disassembled, thoroughly cleaned, and reassembled. Over-tightening of bolts to compensate for poor installation practice will not be permitted.

3-5. POLYETHYLENE ENCASEMENT. Not used.

3-6. CONNECTIONS WITH EXISTING PIPING. Connections with existing pipes shall be made using fittings suitable for the conditions encountered. Each connection with an existing pipe shall be made at a time and under conditions which will least interfere with service to customers, and as authorized by Owner. Facilities shall be provided for proper dewatering and for disposal of water removed from the dewatered lines and excavations without damage to adjacent property.

Special care shall be taken to prevent contamination of potable water lines when dewatering, cutting into, and making connections with existing pipe. No trench water, mud, or other contaminating substances shall be permitted to enter the lines. The interior of all pipe, fittings, and valves installed in such connections shall be thoroughly cleaned and then swabbed with, or dipped in, a 200 mg/L chlorine solution.

3-7. SERVICE CONNECTIONS. Tapping saddles or tapping sleeves shall be used for all service connections 2 inches and smaller. Direct tapping of PVC pipe will not be permitted. Fittings shall be used for service connections larger than 2 inches.

3-8. CONCRETE ENCASEMENT. Concrete encasement shall be installed as indicated on the Drawings. Concrete and reinforcing steel shall be as specified in the Cast-in-Place Concrete section. All pipe to be encased shall be suitably supported and blocked in proper position and shall be anchored against flotation.

3-9. RESTRAINED JOINTS. All bell-and-spigot or all-bell tees, Y-branches, bends deflecting 11-1/4 degrees or more, valves, and plugs which are installed in piping subjected to internal hydrostatic heads in excess of 30 feet [9 m] shall be provided with suitable restraint.

Concrete blocking shall not be used unless indicated on the Drawings.

All steel clamps, rods, bolts, and other metal accessories used in tapping saddles or reaction anchorages subject to submergence or in contact with earth or other fill material, and not encased in concrete, shall be protected from corrosion by two coats of medium consistency coal tar applied to clean, dry metal surfaces. The first coat shall be dry and hard before the second coat is applied.

3-10. PRESSURE AND LEAKAGE TESTS. After installation, PVC piping shall be hydrostatically tested for defective workmanship and materials as specified in the Pipeline Pressure and Leakage Testing section.

3-11. LEAKAGE. All PVC piping shall be watertight and free from leaks. Each leak which is discovered within the correction period stipulated in the General Conditions shall be repaired.

3-12. CLEANING AND DISINFECTION. After installation, PVC piping shall be cleaned and disinfected as specified in the Cleaning and Disinfection of Water Pipelines section.

End of Section

Section 40 05 31.16

POLYVINYL CHLORIDE (PVC) SEWER PIPE

PART 1 - GENERAL

1-1. SCOPE. This section covers furnishing polyvinyl chloride (PVC) gravity sewer pipe and fittings, complete with all jointing materials and appurtenances. Ribbed pipe or open profile pipe will not be acceptable.

Pipe trenching, bedding, and backfilling are covered in the Trenching and Backfilling section.

1-2. SUBMITTALS. Drawings and data shall be submitted in accordance with the Submittals Procedures section. Drawings and data shall include, but shall not be limited to, the following:

Details of joints.

Gasket material.

Pipe length.

Certification in accordance with ASTM D3034, Section 11; ASTM F679, Section 10; ASTM F1803, Section 12.

1-3. DELIVERY, STORAGE AND HANDLING. Shipping shall be in accordance with the general Terms and Conditions. Handling and storage shall be in accordance with the manufacturer recommendations and this Section.

Pipe, fittings, and accessories shall be handled in accordance with Chapter 6 of AWWA Manual M23, to ensure installation in sound, undamaged condition. Pipe shall not be stored uncovered in direct sunlight.

PART 2 - PRODUCTS

2-1. MATERIALS.

Pipe and Fittings.

Solid wall 4 through 15 inches.	ASTM D3034, Minimum SDR 35, Minimum Cell Classification 12354.
18 through 48 inches.	ASTM F1803, or ASTM F679, Minimum Pipe Stiffness of 46 psi, Minimum Cell Classification 12354.

Jointing Materials.	
Bell-and-Spigot Joints.	ASTM D3212, integral bell push-on type elastomeric gasket joints.
Gaskets.	ASTM F477, synthetic rubber. Natural rubber will not be acceptable.
Field-Cut Joints and Connections to Other Piping Materials.	Fernco "Flexible Couplings" or Mission "Eastern Standard Band-Seal Couplings" with stainless steel shear rings.
For Grouted Connections to Cast-in-Place Concrete Manholes	Rubber ring water stop.
Conductive Tracer	Detection tape, 3 inches [75 mm] wide; aluminum foil core, 0.5 mil [13 µm] thick, encased in a protective inert plastic jacket; 5,000 psi [35 MPa] min tensile strength; 2.5 lbs per inch per 1,000 feet [45 g/mm per 300 mm] min mass; color coded in accordance with APWA Uniform Color Code; Lineguard "Type III", or Reef Industries "Terra Tape D".

PART 3 - EXECUTION

3-1. INSTALLATION AND TESTING. Pipe shall be installed and tested in accordance with the Sewer Pipe Installation and Testing section.

A conductive tracer shall be buried above PVC pipe, not more than 18 inches below the ground surface.

End of Section

Section 40 05 32

MISCELLANEOUS PLASTIC PIPE, TUBING, AND ACCESSORIES

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of miscellaneous plastic pipe, tubing, and accessories. Pipe and tubing shall be furnished complete with all fittings, flanges, unions, jointing materials and other necessary appurtenances.

1-1.01. See Scope of Supply Section for requirements.

1-2. SUBMITTALS.

1-2.01. Drawings and Data. Complete specifications, data and catalog cuts or drawings shall be submitted in accordance with the Submittals Procedures section. Submittals are required for all piping, fittings, gaskets, sleeves, and accessories, and shall include the following data:

Name of Manufacturer
Type and model
Construction materials, thickness, and finishes
Pressure and temperature ratings

Contractor shall obtain and submit a written statement from the gasket material manufacturer certifying that the gasket materials are compatible with the joints specified herein and are recommended for the specified field test pressures and service conditions.

1-3. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the general Terms and Conditions. All materials shall be stored in a sheltered location above the ground, separated by type, and shall be supported to prevent sagging or bending.

Pipe, tubing, and fittings shall be stored between 40°F and 90°F [4°C and 32°C].

PART 2 - PRODUCTS

2-1. FRP PIPE. Not used.

2-2. PVC PIPE MATERIALS.

PVC pipe materials and services shall be as specified herein.

2-2.01. Material Classification PVC-1.

PVC-1 – Schedule 40 PVC Pipe with Solvent Welded Joints. Foul air piping. Drain piping. Irrigation system supply mains and lateral piping. Other piping shown on Drawings.	Pipe Fittings	ASTM D1785, Cell Classification 12454, bearing NSF seal, Schedule 40. ASTM D2466, Cell Classification 12454, bearing NSF seal.

2-2.02. Material Classification PVC-2.

PVC-2 – Schedule 80 PVC Pipe with Solvent Welded Joints. Drain piping. Filter backwash piping. Indirect potable reuse water piping. Microfiltration filtrate piping. Non-potable water piping. Overflow piping. Plant outfall water piping. Polymer piping. Reclaimed water piping. Reverse osmosis feed, permeate, concentrate, and forward flush piping. Ultraviolent treatment effluent piping. Waste activated sludge piping Other piping shown on Drawings.	Pipe Fittings	ASTM D1785, Cell Classification 12454, bearing NSF seal, Schedule 80. ASTM D2467, Cell Classification 12454, bearing NSF seal. Flanges or unions shall be provided where needed to facilitate disassembly of equipment or valves. Flanges or unions shall be joined to the pipe by a solvent weld. When acceptable to Design-Builder, threaded joints may be used instead of solvent welded joints in exposed interior locations for the purpose of facilitating assembly. The use of threaded joints in this system shall be held to a minimum.

2-2.03. Material Classification PVC-3. Not used.

2-2.04. Material Classification PVC-4.

PVC-4 – PVC DWV Pipe (Single Wall) with Solvent Welded Joints. Chemical resistant waste and vent piping for plumbing systems.	Pipe Fittings	ASTM D1785, cell classification 12454, bearing NSF seal. ASTM D2665 and ASTM D3311, cell classification 12454, bearing NSF seal.

2-2.05. Material Classification PVC-5.

PVC-5 – PVC DWV Pipe (Double Wall Containment) with Solvent Welded Joints. Chemical resistant waste and vent piping for plumbing systems.	Pipe Fittings	George Fischer Sloane "+GF+Contain-It"; with manufacturer's standard spacers, fittings, and suitable chemical service solvent or equal. ASTM D2665 and ASTM D3311, cell classification 12454, bearing NSF seal.

2-2.06. Material Classification PVC-6.

PVC-6 – PVC Underdrain Pipe Deep structures underdrains	Pipe Fittings	ASTM F758, perforated wall, Cell Classification 12454 or 12364, Type PS 46. ASTM D3034, Cell Classification 12454, wall thickness SDR 35, with elastomeric gasket joints.

2-2.07. Material Classification PVC-7.

PVC-7 – Double-Contained Chemical Feed Pipe. Various	System Primary Pipe Containment Pipe Interstitial Supporting Devices	Prefabricated system consisting of primary pipe supported within secondary containment piping. Material and fittings shall be as specified for single-contained piping for the respective chemical. ASTM D1785, Cell Classification 12454, bearing NSF seal, Schedule 80. Polypropylene spider clips or C-type, within the secondary containment pipe.

2-2.08. Material Classification PVC-8.

PVC-8 – Flexible PVC Tubing with Nylon Braiding.	Tubing Fittings	Kentak Products Company, “K-6100”. Connections shall be accomplished with hose barbs constructed of a suitable material and hose clamps constructed of stainless steel.

2-2.09. Accessory Materials. Accessory materials for the PVC Pipe systems shall be as indicated.

Flanges	Diameter and drilling shall conform to ANSI/ASME B16.5, Class 150. Schedule 80 for DWV systems.
Flange Bolts and Nuts	ASTM A307, Grade B, length such that, after installation, the bolts will project 1/8 to 3/8 inch beyond outer face of the nut. Stainless steel for DWV and chemical feed systems, galvanized steel for all other systems.
Flat Washers	ANSI B18.22.1, plain. Same material as bolts and nuts.
Flange Gaskets	Full face, 1/8 inch thick, chemical-resistant elastomeric material suitable for the specified service.
Expansion Joints	Edlon "Thermo-molded TFE" or Resistoflex "Style R6905" molded expansion joint.

2-3. CPVC PIPE. CPVC pipe materials and services shall be as specified herein.

2-3.01. Material Classification CPVC-1.

CPVC-1 – Schedule 40 CPVC Pipe with Solvent Welded Joints. Carrier piping for DB-01 and DB-02.	Pipe	ASTM F441, Cell Classification 23447, bearing NSF seal, Schedule 80.
	Fittings	ASTM F439, Cell Classification 23447, bearing NSF seal. Flanges or unions shall be provided where needed to facilitate disassembly of equipment or valves. Flanges or unions shall be joined to the pipe by a solvent weld.

2-3.02. Material Classification CPVC-2.

CPVC-2 – Schedule 80 CPVC Pipe with Solvent Welded Joints. Antiscalant piping. Sodium bisulfate piping. Sodium hydroxide solution piping, buried or submerged. Sulfuric acid piping. Reverse osmosis permeate and CIP return and supply piping. Other piping shown on Drawings	Pipe Fittings	ASTM F441, Cell Classification 23447, bearing NSF seal, Schedule 80. ASTM F439, Cell Classification 23447, bearing NSF seal. Flanges or unions shall be provided where needed to facilitate disassembly of equipment or valves. Flanges or unions shall be joined to the pipe by a solvent weld.

2-3.02. Accessory Materials. Accessory materials for the CPVC Pipe systems shall be as indicated.

Flanges	Diameter and drilling shall conform to ANSI/ASME B16.5, Class 150.
Flange Bolts and Nuts	ASTM A307, Grade B, length such that, after installation, the bolts will project 1/8 to 3/8 inch beyond outer face of the nut. Stainless steel for chemical feed systems, galvanized steel for all other systems.
Flat Washers	ANSI B18.22.1, plain. Same material as bolts and nuts.
Flange Gaskets	Full face, 1/8 inch thick, chemical-resistant elastomeric material suitable for the specified service.
Expansion Joints	Edlon "Thermo-molded TFE" or Resistoflex "Style R6905" molded expansion joint.

2-4. PE PIPE. PE pipe materials and services shall be as specified herein.

2-4.01. Material Classification PE-1.

PE-1 – Polyethylene Pipe with Socket Fusion Joints. Natural gas, buried. 2 inch [50 mm] and smaller	Pipe Fittings	ASTM D3350, Cell Classification PE445574C. ASTM D2513, IPS, SDR11"Yellowstripe 8300" or equal ASTM D3350, Cell Classification PE PE445574C. ASTM D2683, socket type, with wall thickness same as for pipe.

2-4.02. Material Classification PE-2.

PE-2 – Polyethylene Pipe with Butt Fusion Joints. Natural gas, buried. 3 inch [75 mm] and larger	Pipe Fittings	ASTM D3350, Cell Classification PE445574C. ASTM D2513, IPS, SDR11 "Yellowstripe 8300" or equal. ASTM D3350, Cell Classification PE PE445574C. ASTM D3261, butt heat fusion type, with wall thickness same as for pipe.

2-4.03. Material Classification PE-3. Not used.

2-4.04. Material Classification PE-4. Not used.

2-4.05. Material Classification PE-5. Not used.

2-4.06. Material Classification PE-6.

PE-6 – Polyethylene Tubing in carrier pipe. Antiscalant Citric Acid Sodium Hydroxide Sodium Bisulfate Other piping shown on Drawings	Tubing and Fittings	1/8 through 3/4 inch [3 through 19 mm] OD, 1/16-inch wall thickness, 130°F maximum operating temperature with compression fittings.

2-4.07. Accessory Materials. Accessory materials for the PE Pipe systems shall be as indicated.

Flanges	Schedule 80 PVC; diameter and drilling shall conform to ANSI/ASME B16.5, Class 150.

Flange Bolts and Nuts	ANSI B18.2.1, ASTM A193, AISI Type 304, heavy hex head, length such that after installation the bolts will project 1/8 to 3/8 inch beyond outer face of the nut. ASTM A194, AISI Type, ANSI/ASME B18.2.2, heavy hex pattern.
Fittings and Flange Adapters	Molded or manufactured from the pipe; cell classification of material and pressure rating same as for pipe.

2-5. POLYPROPYLENE PIPE.

2-5.01. Material Classification PP-1. Not used.

2-5.02. Material Classification PP-2. Not used.

2-5.03. Material Classification PP-3. Not used.

2-6. PVDF PIPE. Not used.

2-7. REINFORCED PLASTIC TUBING. Not used.

2.8. FLEXIBLE PFA TUBING. Not used.

2.9 TEFLON (PFA) HOSE. PFA hose materials and services shall be as specified herein.

2-9.01. Material Classification TEFL-1.

TEFL-1 – Teflon Hose in carrier pipe. Sodium Hypochlorite Sulfuric Acid Other piping shown on Drawings	Hose	Polypropylene braided, convoluted PFA Teflon Hose; PureFlex Inc "ProFlex", or preapproved equal.
	Fittings	Connections shall be accomplished using ProFlex Style 11 or equal fittings constructed of solid Kynar and installed at the factory. Splices and hose fittings shall be factory installed. Tubing connections to hard pipe shall be flange type or as recommended by the tubing manufacturer with wetted parts suitable for the chemical.

		Where barbed fittings are required the clamps shall be of stainless steel with blow-off proof crimping collar. Field connections shall be accomplished using ProFlex Style 03 or equal fittings constructed of solid Kynar.

PART 3 - EXECUTION

3-1. INSTALLATION. Materials furnished under this section will be installed in accordance with the Miscellaneous Piping and Accessories Installation section.

End of Section

Section 40 05 33.11

HIGH DENSITY POLYETHYLENE (HDPE) PRESSURE PIPE

PART 1 - GENERAL

1-1. SCOPE. This section covers furnishing and installation of 4 inch through 36 inch buried solid wall high density polyethylene (HDPE) pressure pipe. HDPE pressure pipe shall be furnished and installed complete with all fittings, jointing materials, anchors, blocking, encasement, and other necessary appurtenances.

Pressure and leakage tests, disinfection , and cleaning are covered in other sections. Pipe trenching, bedding, and backfill are covered in the Trenching and Backfilling section.

Polyethylene pipe for gas service shall be in accordance with SoCalGas standards and the Miscellaneous Plastic Pipe, Tubing, and Accessories Section.

1-2. GOVERNING STANDARDS. Except as modified or supplemented herein, all HDPE pressure pipe shall conform to the applicable requirements of ANSI/AWWA C906, latest edition.

The supplementary information required in the foreword of the governing standard is as follows:

Affidavit of Compliance (Sec. 6.3)	Required.
Plant Inspection by Purchaser (Sec. 5.7)	Not required.
Markings (Sec. 6.1)	Required.
Shipping (Sec. 6.2)	Required.
Verification (Sec. 5)	Required.

1-3. SUBMITTALS. Drawings and data shall be submitted in accordance with the Submittals Procedures section. Drawings and data shall include, but shall not be limited to, the following:

Details of joints and connections.
Pipe section length.
Pipe Dimension Ratio.
Certification of compliance with NSF Standard No. 61 (for potable water system, and IPR pipe if required).
Affidavit of Compliance (ANSI/AWWA C906, Sec. 6.3).
Verification, including Quality Assurance Testing (ANSI/AWWA C906, Sec. 5).

1-4. QUALITY ASSURANCE.

1-4.01. Qualifications. The pipe manufacturer shall provide the services of an experienced, competent, and authorized representative to visit the site of the work to advise and consult with Design-Builder during joining and installation of the pipe. The manufacturer's representative shall not directly supervise Design-Builder's personnel, and Design-Builder shall remain responsible for the pipeline work.

1-4.02. Fusion. Fusion joints shall be made by qualified fusion technicians who shall demonstrate fusion experience on projects completed within a year of the Bid date which included similar or larger installation lengths, similar pipe sizes (+/- 2 pipe sizes) and similar DRs (+/- 2 DRs).

1-5. STORAGE AND HANDLING. Storage and handling shall meet the requirements of the general Terms and Conditions section, and shall be in accordance with Chapter 7, Transportation, Handling and Storage of Pipe and Fittings of AWWA Manual M55, to ensure installation in sound, undamaged conditions. Pipe shall not be stored uncovered in direct sunlight.

PART 2 - PRODUCTS

2-1. PERFORMANCE AND DESIGN REQUIREMENTS.

2-1.01. Dimensions. Dimensions shall be as specified in the materials paragraph.

2-2. MATERIALS.

Pipe	ANSI/ AWWA C906; material designation (ASTM D3350) PE4710, minimum cell classification 445474C with oxidative resistance classification CC3, IPS (Iron Pipe Size). Pressure class and wall thicknessas specified in the Pipeline Schedule. Thermal butt fusion joints, ASTM D3261. Wastewater – Green striped. Water – Green striped. Reuse – Purple striped.
Joints	Butt fusion joints, ASTM D3261; manufactured by injection molding; pressure class of the pipe or greater.

Fittings	
Electrofusion Type	ASTM F1055 having pressure class equivalent to the pipe or greater as required.
Molded or Fabricated Type	Meet applicable AWWA C906 requirements; pressure class and cell class equivalent to the pipe or greater as required.
Other Types	Subject to review by the Engineer.
Tapping Saddles	Ductile iron, with galvanized steel straps and synthetic rubber sealing gasket, 250 psi pressure rating.
Tapping Sleeves	Ductile iron, 250 psi pressure rating.
Coal Tar Epoxy	High-build coal tar epoxy; Ameron "Amercoat 78HB Coal Tar Epoxy", Carboline "Bitumastic 300 M", Tnemec "46H-413 Hi-Build Tneme-Tar", or Sherwin-Williams "Hi-Mil Sher-Tar Epoxy".
Conductive Tracer	Detection tape, 3 inches [75 mm] wide; aluminum foil core, 0.5 mil [13 µm] thick, encased in a protective inert plastic jacket; 5,000 psi [35 Mpa] min tensile strength; 2.5 lb/inch per 1,000 feet [45 g/mm per 300 mm] min weight; color coded in accordance with APWA Uniform Color Code; Allen Systems "Detectatape", Lineguard "Type lll", or Reff Industries "Terra Tape D".

PART 3 - EXECUTION

3-1. INSPECTION. Pipe and fittings shall be carefully examined for cracks and other defects immediately before installation, with special attention to pipe ends. All defective pipe and fittings shall be removed from the site of the work.

3-2. INSTALLATION.

3-2.01. Laying Pipe. Pipe shall be protected from lateral displacement by pipe embedment material installed as specified in the Trenching and Backfilling section. Pipe shall not be laid in water or under unsuitable weather or trench conditions, and shall be protected against entry of foreign matter.

During freezing weather, particular care shall be taken in handling and laying pipe to prevent damage by impact.

Pipe shall be protected from extended exposure to sunlight, shall be kept as cool as possible during installation, and shall be covered with backfill immediately after installation.

Conductive tracer shall be buried above the center line of all HDPE pipe, not more than 18 inches below the ground surface unless otherwise directed by Engineer.

3-2.02. Cleaning. The interior of all pipe and fittings shall be thoroughly cleaned before installation and shall be kept clean until the work has been accepted.

3-2.03. Alignment. Piping shall be laid to the lines and grades indicated on the drawings. Pipelines or runs intended to be straight shall be laid straight. Deflections from a straight line or grade shall not exceed the maximum deflection specified by the manufacturer.

Unless otherwise specified or indicated on the drawings, and subject to acceptance of the Engineer, either shorter pipe sections or fittings shall be installed as required to maintain the indicated pipeline alignment or grade.

3-2.04. Cutting Pipe. Cutting shall be in accordance with the pipe manufacturer's recommendations. Cuts shall be smooth, straight, and at right angle to the pipe axis. After cutting, the end of the pipe shall be dressed to remove all roughness and sharp corners and shall be beveled in accordance with the manufacturer's instructions.

3-2.05. Jointing. Jointing of pipe and fittings shall be performed in accordance with the instructions and recommendations of the pipe manufacturer and in accordance with ASTM F2620 and PPI TR 33. Sections of HDPE pipe shall be joined above ground into continuous lengths by the thermal butt fusion method.

Saddle fusion shall be performed in accordance with ASTM D2657 or `PPI TR 41 and the fitting manufacturer’s recommendations.

Where required, electrofusion shall be performed in accordance with ASTM F1290, PPI TN 34, and the manufacturer recommended procedure.

Socket fusion and extrusion welding or hot gas welding will not be acceptable.

All joining procedures shall be acceptable to Engineer.

3-2.06. Connections with Existing Piping.

Connections between new work and existing piping or work by Others shall be made using suitable fittings. Each connection with an existing pipe shall be made at a time and under conditions which will least interfere with service to customers, and as authorized by Owner. Facilities shall be provided for proper dewatering and for disposal of all water removed from the dewatered lines and excavations without damage to adjacent property.

Special care shall be taken to prevent contamination of potable water lines when dewatering, cutting into, and making connections with existing pipe. Trench water, mud, and other contaminating substances shall be kept out of the lines. The interior of all pipe, fittings, and valves installed in connections to existing piping shall be thoroughly cleaned and then swabbed in accordance with the requirements of AWWA C651.

3-2.07. Service Connections. Not used.

3-2.08. Concrete Encasement. Concrete encasement shall be installed as indicated on the drawings. Concrete and reinforcing steel shall be as specified in the Cast-in-Place Concrete section. All pipes to be encased shall be suitably supported and blocked in proper position and shall be anchored against flotation.

3-2.09. Reaction Anchorage and Blocking. Reaction blocking, anchorages, or other supports for fittings installed in fill or in other unstable ground shall be provided as indicated on the drawings or as directed by Engineer. Concrete blocking shall extend from the supported fitting to solid undisturbed earth and shall be installed so that all joints are accessible for repair. The dimensions of concrete reaction blocking shall be as indicated on the drawings or as directed by Engineer.

3-2.10. Protective Coating. All steel clamps, rods, bolts, and other metal components of tapping saddles or reaction anchorages subject to submergence or in contact with earth or other fill material, and not encased in concrete, shall be protected from corrosion by petrolatum wax tape and primer in accordance with ANSI/AWWA C217 as specified in the Ductile Iron Pipe section.

3-3. FIELD QUALITY CONTROL.

3-3.01. Hydrostatic Tests. After installation, HDPE piping shall be hydrostatically tested for defective workmanship and materials as specified in the Pipeline Pressure and Leakage Testing section.

3-3.02. Leakage. All HDPE piping shall be watertight and free from leaks.

3-4. CLEANING. After installation, HDPE piping shall be cleaned as specified in the Cleaning and Disinfection of Water Pipelines section.

End of Section

Section 40 05 41

MISCELLANEOUS PIPING AND PIPE ACCESSORIES

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of miscellaneous piping and pipe accessories. Miscellaneous piping shall be furnished complete with all fittings, flanges, unions, and other accessories specified herein.

1-2. SUBMITTALS.

1-2.01. Drawings and Data. Complete specifications, data and catalog cuts or drawings shall be submitted in accordance with the Submittals Procedures section and the Schedule of Submittals. Submittals are required for all piping, fittings, gaskets, sleeves, and accessories, and shall include the following data:

Name of Manufacturer
Type and model
Construction materials, thickness, and finishes
Pressure and temperature ratings

1-3. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the general Terms and Conditions. All materials shall be stored in a sheltered location above the ground, separated by type, and shall be supported to prevent sagging or bending.

PART 2 - PRODUCTS

2-1. MATERIALS. Miscellaneous piping materials shall be as specified herein.

2-1.01. Material Classification BR-1.

BR-1 – Regular Weight Brass Pipe Gauge piping for hot/cold water. Gauge piping for seal water. Gauge piping for compressed air.	Pipe Fittings	ASTM B43, red brass, seamless, regular weight. ANSI/ASME B16.15, Class 125.

2-1.02. Material Classification BR-2. Not used.

2-1.03. Material Classification HS-1.

HS-1 – Hose with Insert Type Couplings Flexible connections in chemical piping. Overflow lines from chlorine feeders and residual analyzers. Chemical transfer.	Hose Couplings	ID not smaller than nominal size. Boston " Crosslinked Polyethylene Hose" or Gates "Renegade", "Mustang 45 HW" or "Stallion" acid-chemical hose. To be selected for resistance to the service chemical. Rigid PVC or other material suitable for service conditions, with band type stainless steel clamps.

2-1.04. Material Classification HS-2.

HS-2 – Hose with Quick Disconnect Couplings Flexible connections in chemical piping. Overflow lines from chlorine feeders and residual analyzers. Lime slurry. Chemical transfer.	Hose Couplings	ID not smaller than nominal size. Boston "Crosslinked Polyethylene Hose" or Gates "Renegade", "Mustang 45 HW" or "Stallion" acid-chemical hose. To be selected for resistance to the service chemical. Cam-lock type quick connect/disconnect couplers and adapters as manufactured by OPW or PT

2-1.05. Material Classification TG-1. Not used.

2-1.06. Material Classification CRP-1.

CRP-1 – Carpenter 20-Cb3 Pipe with Socket Weld Fittings Sulfuric acid piping Other piping shown on Drawings.	Welded Seamless Fittings	ASTM B464 - UNS NO8020, schedule 40. ASTM B729 - UNS NO8020, schedule 40. Socket weld, Class 3000, ASTM B462 - UNS NO8020. The use of flanged fittings shall be limited to equipment connections.

2-1.07. Accessories. Accessories for the miscellaneous piping systems shall be as indicated.

Unions for brass pipe — Fed Spec A-A-59617, Class 125.

PART 3 - EXECUTION

3-1. INSTALLATION. Materials furnished under this section will be installed in accordance with the Miscellaneous Piping and Accessories Installation section.

End of Section

Section 40 05 56

MISCELLANEOUS VALVES

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of miscellaneous valves as specified herein except where specific requirements are stipulated in other sections.

1-2. GENERAL.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Identification. Valves specified herein shall be tagged in accordance with the Equipment and Valve Identification section.

1-3. SUBMITTALS. Complete drawings, details, and specifications, covering the valves and their appurtenances shall be submitted in accordance with the Submittals Procedures section. Included in the submittal shall be drawings by the valve manufacturer to indicate the position of the valve actuator and valve shaft.

PART 2 - PRODUCTS

2-1. CONSTRUCTION.

2-1.01. Length Tolerance. Unless otherwise specified, the actual length of valves shall be within ±1/16 inch of the specified or theoretical length.

2-1.02. Shop Coatings. All ferrous metal surfaces of valves and accessories, both interior and exterior, shall be shop coated for corrosion protection. The valve manufacturer's standard coating will be acceptable, provided it is functionally equivalent to the specified coating.

Coating Materials

Coal Tar Epoxy	High-build coal tar epoxy; PPG Amercoat "Amercoat 78HB Coal Tar Epoxy", Carboline "Bitumastic 300 M", Tnemec "46H-413 Hi-Build Tneme-Tar", or Sherwin-Williams "Hi-Mil Sher-Tar Epoxy".

Epoxy (for liquid service)	PPG Amercoat "Amerlock 400 High-Solids Epoxy Coating", Carboline "Carboguard 891", Sherwin-Williams “Macropoxy 646NSF” or Tnemec "Series N140 Pota-Pox Plus".
Rust-Preventive Compound	As recommended by the manufacturer.

Surfaces To Be Coated

Unfinished Surfaces	
Interior Surfaces	
Liquid Service	Epoxy enamel.
Exterior Surfaces of Valves to be Buried, Submerged, or Installed in Manholes or Valve Vaults	Coal tar epoxy or Epoxy.
Exterior Surfaces of all Other Valves	Universal primer.
Polished or Machined Surfaces	Rust-preventive compound.
Actuators and Accessories	Universal primer.

2-2. HOSE FAUCETS, HYDRANTS, AND CURB STOPS.

2-2.01. Hose Faucets, VHF-1.

VHF-1 Hose faucet	Type	Faucet, threaded bonnet.
	Body/Bonnet	Brass.
	Trim	
	Seat	Manufacturer’s standard.
	Disc	Manufacturer’s standard.
	Stem	Manufacturer’s standard.
	Stem Seal	Manufacturer’s standard.
	End Connection	Threaded, male NPT x male HPT.
	Temp. Limitations	32°F to 212°F.
	Valve Operator	T-handle.
	Manufacturers	Prier Brass "C - 138NP.75" or Dearborn Brass.

2-2.02. Wall Hydrants, VHF-2.

VHF-2 Wall hydrant	Type	Freezeproof.
	Body/Bonnet	Brass or bronze.
	Trim	
	Seat	Manufacturer's standard.
	Disc	Manufacturer's standard.
	Stem	Manufacturer's standard.
	Stem Seal	Manufacturer's standard.
	End Connection	Threaded, NPT x male HPT.
	Temp. Limitations	32°F to 212°F [0°C to 100°C].
	Valve Operator	Removable key.
	Manufacturers	Smith "5609", Wade " 8600", Woodford "65" or "67, or Zurn "Z-1315".

2-2.03. Wall Hydrants with Vacuum Breaker, VHF-3.

VHF-3 Wall hydrants with vacuum breaker	Type	Freezeproof, with vacuum breaker.
	Body	Brass or bronze.
	Trim	
	Seat	Manufacturer's standard.
	Disc	Manufacturer's standard.
	Stem	Manufacturer's standard.
	Stem Seal	Manufacturer's standard.
	End Connection	Threaded, NPT x male HPT.
	Temp. Limitations	32°F to 212°F.
	Valve Operator	Removable key.
	Manufacturers	Smith "5609", or Wade " 8600".

2-2.04. Box Type Yard Hydrants, VHF-4.

VHF-4 Yard hydrant	Type	Nonfreeze, box type.
	Body	Brass or bronze.
	Trim	
	Seat	Manufacturer's standard.
	Disc	Manufacturer's standard.
	Stem	Manufacturer's standard.
	Stem Seal	Manufacturer's standard.
	Box, Cover, Casing	Bronze.
	End Connection	Threaded, NPT x HPT.
	Temp. Limitations	32°F to 212°F.
	Valve Operator	Removable key.
	Manufacturers	Josam "Series 71600", Smith "5810", or Zurn "Z-1360/1365".

2-2.05. Post Type Yard Hydrants, VHF-5.

VHF-5 Post type yard hydrant	Type	Nonfreeze, post type.
	Body	Brass or bronze.
	Trim	
	Seat	Manufacturer's standard.
	Disc	Manufacturer's standard.
	Stem	Manufacturer's standard.
	Stem Seal	Manufacturer's standard.
	End Connection	Threaded, NPT x HPT.
	Temp. Limitations	32°F to 212°F [0°C to 100°C].
	Valve Operator	Removable key.
	Manufacturers	Smith "5910/5914", Wade "8610", or Zurn "Z-1385/1390".

2-2.06. Curb Stops, VCS-1 Not used.

2-2.07. Fire Hydrants. Fire hydrants shall conform to ANSI/AWWA C502. The information required by Paragraph III. A. of the ANSI/AWWA C502 foreword shall be as indicated below.

Affidavit of compliance	Not required.
Catalog and maintenance data	Required.
Type of shutoff	Compression or gate.
Size of hydrant (valve opening)	5-1/4 inches
Inlet connection	6 inch, locked push-on.
Harnessing lugs	Not required.
Depth of bury	As indicated on the Drawings.
Outlet nozzles	Two 2-1/2 inch hose nozzles and one 4-1/2 inch pumper nozzle, in accordance with City of Morro Bay standard details.
Outlet nozzle threads	See Note 1.
Direction to open	Counterclockwise.
Stem seals	O-ring.
Outlet nozzle cap chains	Required.

Drain outlet	Required.
Operating nut	See Note 2.
Outlet nozzle cap nut	See Note 2.

Notes:

1. Outlet nozzle threads shall be the Owner's standard thread.
2. The operating nut and outlet nozzle cap nut shall be of the Owner's standard shape and size.

2-3. BASIN VALVES.

2-3.01. Basin Floor Pressure Relief Valves Not used.

2-3.02. Basin Wall Pressure Relief Valves. Not used.

2-3.03. Mud Valves. Not used.

2-3.04. Shear Gates. Not used.

2-4. VALVE ACTUATORS. Requirements for valve actuators shall be as specified in the Valve and Gate Actuator section.

2-5. ACCESSORIES. When the Drawings indicate the need for extension stems; position indicator; floor boxes; or operating stands, refer to the Valve and Gate Actuator section.

2-5.01. Valve Boxes. Each buried valve shall be provided with a valve box. Valve boxes shall have cast iron cover and lid with service name cast into the lid. The riser shall be 8-inch C900 PVC, or equal, suitable for the depth of cover indicated on the Drawings.

All metallic parts of valve boxes shall be shop coated with the manufacturer's standard coating and any metallic components shall be protected from soil contact with concrete encasement or as otherwise allowed by Design-Builder.

Valve boxes which are to be provided with position indicators shall have top sections and covers designed for proper installation of the position indicator and accessories.

PART 3 - EXECUTION

3-1. INSTALLATION. Materials furnished under this section shall be installed in accordance with the Valve Installation section.

End of Section

Section 40 06 20

SCHEDULES FOR LIQUIDS PROCESS PIPING

1. SCOPE. This section consists of a schedule of 4 inch and larger pipelines indicating the type of pipe to be used. Pipe materials, installation, testing, and disinfection, when specified, are covered in other sections.

Piping smaller than 4 inches is covered in the various miscellaneous piping sections. Piping for plumbing, heating and air conditioning systems is covered in other sections. Piping to be furnished with equipment is covered in the applicable equipment section.

2. ALTERNATIVE PIPE TYPES. Where more than one type of pipe is indicated in the schedule, the type of pipe material to be installed may be selected by Contractor. The details on the drawings cover only one type of pipe for each line. If a different material is selected, all details of connections, jointing, wall fittings, support, anchorage, and harnesses shall be modified as necessary to produce an equivalent design acceptable to Engineer of record

3. WALL FITTINGS. A wall pipe or sleeve will be required for all pipe passing through concrete or masonry block walls. Wall fittings and sleeves shall be as indicated on the drawings and as specified in the applicable piping section.

4. SCHEDULE INDEX. Pipe material abbreviations and their applicable specification section number are as indicated:

Abbreviation	Pipe Material	Section No.
RCP	Concrete culvert pipe	33 42 16
CI	Cast iron soil pipe	22 13 16
CPVC	CPVC	40 05 32
CS	Miscellaneous steel pipe	40 05 24.43
CSG	Galvanized steel pipe	40 05 24.43
CU	Copper tubing	40 05 17
DIP	Ductile iron pipe	40 05 19
HDPE	HDPE pressure pipe	40 05 33.11
HS	Hose	40 05 41

Abbreviation	Pipe Material	Section No.
PE	Polyethylene	40 05 32
PP	Polypropylene	40 05 32
PVC	PVC	40 05 32
PVCPP	PVC pressure pipe	40 05 31.12
PVCSP	PVC sewer pipe	40 05 31.16
PVDF	PVDF	40 05 32
RPT	Reinforced plastic tubing	40 05 32
SP	Steel pipe	40 05 24
SS	Stainless steel pipe	40 05 23

5. SCHEDULE. Pipe materials shall conform to Schedule 40 06 20 -S01. All pipelines indicated on the drawings and all pipelines required for proper operation of the equipment furnished shall be provided whether listed in the schedule or not.

End of Section

Ductile Iron Pipe Schedule
400519 S01

Size, inches	System	Name/Function	Material(s)	Specification	Exposure	Lining	Test Pressure (psi)
3	D	Process Drain	DIP	400519	I	Cement Mortar	150
					O	Cement Mortar	150
	DRN	Process Drain	DIP	400519	I	Cement Mortar	150
					O	Cement Mortar	150
	PRW	Plant Recycled Water	DIP	400519	O	Cement Mortar	150
	WAS	Waste Activated Sludge -WAS	DIP	400519	O	Ceramic Epoxy	150
	WWS	Wastewater - Screened	DIP	400519	O	Cement Mortar	150
4	AWS	Aerated WAS - Sludge Holding Tanks	DIP	400519	O	Ceramic Epoxy	150
	DRN	Process Drain	DIP	400519	I	Cement Mortar	150
					O	Cement Mortar	150
	FBW	Filtered Backwash - FBW	DIP	400519	O	Ceramic Epoxy	150
	FSW	Filter Solids Waste	DIP	400519	O	Ceramic Epoxy	150
	PRW	Plant Recycled Water	DIP	400519	O	Cement Mortar	150
	WWR	Wastewater - Raw	DIP	400519	I	Cement Mortar	150
	WWS	Wastewater - Screened	DIP	400519	O	Cement Mortar	150
6	AWS	Aerated WAS - Dewatering Sludge Feed Pumps	DIP	400519	O	Ceramic Epoxy	150
	DRN	Process Drain	DIP	400519	I	Cement Mortar	150
					O	Cement Mortar	150
	FBW	Filtered Backwash - FBW	DIP	400519	O	Ceramic Epoxy	150
	FIW	Filter Inlet Water	DIP	400519	B	Ceramic Epoxy	150
	FSW	Filter Solids Waste	DIP	400519	O	Ceramic Epoxy	150
	IPR	Indirect Potable Reuse Water - IPR	DIP	400519	O	Cement Mortar	150
	WAS	Waste Activated Sludge -WAS	DIP	400519	O	Ceramic Epoxy	150
	WWS	Wastewater - Screened	DIP	400519	B	Cement Mortar	150
					O	Cement Mortar	150
8	DRN	Process Drain	DIP	400519	I	Cement Mortar	150
					O	Cement Mortar	150
	FSCM	Filter Scum	DIP	400519	B	Ceramic Epoxy	150
					O	Ceramic Epoxy	150
	IPR	Indirect Potable Reuse Water - IPR	DIP	400519	O	Cement Mortar	150
	WWR	Wastewater - Raw	DIP	400519	O	Cement Mortar	150
	WWS	Wastewater - Screened	DIP	400519	O	Cement Mortar	150
10	IPR	Indirect Potable Reuse Water - IPR	DIP	400519	O	Cement Mortar	150
	POW	Plant Outfall Water - POW	DIP	400519	O	Cement Mortar	150
12	IPR	Indirect Potable Reuse Water - IPR	DIP	400519	O	Cement Mortar	150
				400533.11	B	Cement Mortar	150
	MFF	Microfiltration Filtrate - MFF	DIP	400519	O	Ceramic Epoxy	150
	POW	Plant Outfall Water - POW	DIP	400519	O	Cement Mortar	150
	WWR	Wastewater - Raw	DIP	400519	B	Cement Mortar	150
					O	Cement Mortar	150
	WWS	Wastewater - Screened	DIP	400519	B	Cement Mortar	150
					O	Cement Mortar	150
14	FOW	Filtered Outfall Water - FOW	DIP	400519	O	Cement Mortar	150

Ductile Iron Pipe Schedule
400519 S01

14	**POW**	Plant Outfall Water - POW	**DIP**	400519	**O**	Cement Mortar	150
	WWS	Wastewater - Screened	**DIP**	400519	**B**	Cement Mortar	150
					O	Cement Mortar	150
16	**WWR**	Wastewater - WWR	**DIP**	400519	**B**	Cement Mortar	150
					O	Cement Mortar	150
18	**FOW**	Filtered Outfall Water - FOW	**DIP**	400519	**O**	Cement Mortar	150
	POW	Plant Outfall Water - POW	**DIP**	400519	**O**	Cement Mortar	150
	WWS	Wastewater - Screened	**DIP**	400519	**O**	Cement Mortar	150
20	**FIW**	Filter Inlet Water	**DIP**	400519	**B**	Cement Mortar	150
					O	Cement Mortar	150
	FOW	Filtered Outfall Water - FOW	**DIP**	400519	**B**	Cement Mortar	150
					O	Cement Mortar	150
	OF	Overflow	**DIP**	400519	**O**	Cement Mortar	150
	POW	Plant Outfall Water - POW	**DIP**	400519	**B**	Cement Mortar	150
					O	Cement Mortar	150
24	**FOW**	Filtered Outfall Water - FOW	**DIP**	400519	**O**	Cement Mortar	150
	ML	Mixed Liquor	**DIP**	400519	**O**	Cement Mortar	150
30	**RAS**	Return Activated Sludge	**DIP**	400519	**B**	Ceramic Epoxy	150
	WWS	Wastewater - Screened	**DIP**	400519	**B**	Cement Mortar	150
36	**ML**	Mixed Liquor	**DIP**	400519	**B**	Cement Mortar	150
					O	Cement Mortar	150

Stainless Steel Pipe and Alloy Pipe, Tubing, and Accessories Schedule

40 05 23 - S01

Size, inches	System	Name/Function	Exposure	Material(s)	Specification	Test Pressure (psi)
1	**MFF**	Microfiltration Filtrate - MFF	**O**	SS-04	**400523**	150
3	**AS**	Air-Scour - Membrane Basins	**O**	SS-02	**400523**	150
4	**ROC**	Reverse Osmosis Concentrate- ROC	**I**	SS-05	**400523**	150
	ROF	Reverse Osmosis Feed- ROF	**I**	SS-05	**400523**	150
6	**AA**	Air-Aeration Process Air	**O**	SS-02	**400523**	150
		Air-Aeration Sludge Tanks	**O**	SS-02	**400523**	150
	CIPS	CIP Solution Supply	**I**	SS-05	**400523**	150
	MFF	Microfiltration Filtrate - MFF	**I**	SS-04	**400523**	150
	ROC	Reverse Osmosis Concentrate- ROC	**I**	SS-05	**400523**	150
	ROF	Reverse Osmosis Feed- ROF	**I**	SS-05	**400523**	150
8	**AA**	Air-Aeration Process Air	**O**	SS-02	**400523**	150
	AS	Air-Scour - Membrane Basins	**O**	SS-02	**400523**	150
	MFF	Microfiltration Filtrate - MFF	**O**	SS-04	**400523**	150
10	**AA**	Air-Aeration Process Air	**O**	SS-02	**400523**	150
	MFF	Microfiltration Filtrate - MFF	**O**	SS-04	**400523**	150

Steel Pipe Schedule
400524 S01

Size, inches	System	Name/Function	Material(s)	Exposure	Specification	Input Steel min wall thickness, in	Test Pressure (psi)
14	**RAS**	Return Activated Sludge	**SP**	O	**400524**	(blank)	150
20	**POW**	Plant Outfall Water - POW	**SP**	O	**400524**	(blank)	150
24	**ML**	Mixed Liquor	**SP**	O	**400524**	(blank)	150
36	**POW**	Plant Outfall Water - POW	**SP**	B	**400524**	0.25	150
48	**POW**	Plant Outfall Water - POW	**SP**	B	**400524**	0.3125	150
78	**POW**	Plant Outfall Water - POW	**SP**	B	**400524**	0.5	150

Miscellaneous Plastic Pipe, Tubing, and Accessories Schedule
400532 S01

Size, inches	System	Name/Function	Material(s)	Specification	Exposure	Test Pressure (psi)
0.5	ANTI	Antiscalant -RO Influent Feed Point	PE	400532	B	125
	CA	Citric Acid - RO CIP Feed Point	PE	400532	B	125
	NACL	Sodium Hypochlorite Feed Lines	TEFL	400532	B	125
	NAOH	Sodium Hydroxide Feed points	PE	400532	B	125
	NHS	Sodium Bisulfate	CPVC-02	400532	O	125
		Sodium Bisulfate - NHS	PE-06	400532	B	125
	SA	Sulfuric Acid -RO Influent Feed Point	TEFL	400532	B	150
		Sulfuric Acid -UV AOP Influent Feed Point	TEFL	400532	B	150
0.75	CA	Citric Acid - MBR Cleaning Feed Point	PE	400532	B	125
	NACL	Sodium Hypochlorite	TEFL	400532	B	125
	NAOH	Sodium Hydroxide -RO CIP Feed Point	PE	400532	B	125
1	ANTI	Antiscalant -RO Influent Feed Point	PE-06	400532	I	125
			PVC-02	400532	I	125
	DRN	Process Drain	CPVC-02	400532	I	150
					O	150
	MFF	Microfiltration Filtrate - MFF	PVC-02	400532	O	150
	NHS	Sodium Bisulfate	CPVC-02, P	400532	I	125
	NPW	Non-potable water	PVC-02	400532	O	150
	POLF	Polymer	PVC-02	400532	O	125
	PRW	Plant Recycled Water	PVC-02	400532	O	150
		Reclaimed Water - PRW	PVC-02	400532	B	150
	ROP	Reverse Osmosis Permeate- ROP	PVC-02	400532	I	150
	SA	Sulfuric Acid -UV AOP Influent Feed Point	CPVC-02	400532	I	150
2	Carrier	Chemical Bank	CPVC	400532	B	150
	CIPS	CIP Solution Supply	CPVC-01	400532	I	150
	DRN	Process Drain	PVC-01	400532	O	150
			PVC-02	400532	B	150
	FA	Foul Air	PVC-01	400532	O	150
	FBW	Filtered Backwash - FBW	PVC-02	400532	O	150
	PRW	Plant Recycled Water	PVC-02	400532	O	150
		Reclaimed Water - PRW	PVC-02	400532	B	150
	PW	Water Potable Water - PW	PVC-02	400532	B	150
	ROP	Reverse Osmosis Permeate- ROP	CPVC-02	400532	I	150
2.5	PRW	Reclaimed Water - PRW	PVC-02	400532	B	150

Miscellaneous Plastic Pipe, Tubing, and Accessories Schedule
400532 S01

3	**CIP**	Neutralization Tank Drain	**CPVC-02**	400532	**I**	150
	CIPS	CIP Solution Supply	**CPVC-02**	400532	**I**	150
	D	Process Drain	**PVC-02**	400532	**I**	150
					O	150
	POLF	Polymer	**PVC-02**	400532	**O**	125
	PRW	Plant Recycled Water	**PVC-02**	400532	**B**	150
	PW	Water Potable Water - PW	**PVC-02**	400532	**B**	150
	ROP	Reverse Osmosis Permeate- ROP	**PVC-02**	400532	**I**	150
	WAS	Waste Activated Sludge -WAS	**PVC-02**	400532	**B**	150
4	**CIPR**	CIP Solution Return	**CPVC-02**	400532	**I**	150
	CIPS	CIP Solution Supply	**CPVC-02**	400532	**I**	150
	DRN	Drain	**PVC-02**	400532	**B**	150
	FF	RO Forward Flush	**PVC-02**	400532	**I**	150
	MFF	Microfiltration Filtrate - MFF	**PVC-02**	400532	**O**	150
	OF	Overflow	**CPVC-02**	400532	**I**	150
	PCR	Reverse Osmosis Permeate	**CPVC-02**	400532	**I**	150
	PRW	Reclaimed Water - RCW	**PVC-02**	400532	**B**	150
	PW	Water Potable Water - PW	**PVC-02**	400532	**B**	150
	ROC	Reverse Osmosis Concentrate - ROC	**PVC-02**	400532	**B**	150
	ROP	Reverse Osmosis Permeate- ROP	**CPVC-02**	400532	**I**	150
			PVC-02	400532	**I**	150
6	**CIPR**	CIP Solution Return	**CPVC-02**	400532	**I**	150
	FBW	Filtered Backwash - FBW	**PVC-02**	400532	**B**	150
	FSW	Filter Solids Waste	**PVC-02**	400532	**B**	150
	OF	Overflow	**PVC-02**	400532	**(blank)**	150
	PW	Water Potable Water - PW	**PVC-02**	400532	**B**	150
	ROF	Reverse Osmosis Feed- ROF	**PVC-02**	400532	**I**	150
	WWS	Wastewater - Screened	**PVC-02**	400532	**B**	150
8	**FA**	Foul Air	**PVC-01**	400532	**O**	150
	MFF	Microfiltration Filtrate - MFF	**PVC-02**	400532	**B**	130
	PW	Water Potable Water - PW	**HDPE**	400532	**B**	150
	ROF	Reverse Osmosis Feed- ROF	**PVC-02**	400532	**B**	130
					I	150
					O	150
	ROP	Reverse Osmosis Permeate- ROP	**PVC-02**	400532	**I**	150

Miscellaneous Plastic Pipe, Tubing, and Accessories Schedule
400532 S01

8	**ROP**	Reverse Osmosis Permeate- ROP off spec water	**PVC-02**	400532	**B**	130
	UVE	Ultraviolet Treatment Effluent - UVE	**PVC-02**	400532	**B**	130
					O	150
10	**FA**	Foul Air	**PVC-01**	400532	**O**	150
	IPR	Indirect Potable Reuse Water - IPR	**PVC-02**	400532	**O**	150
	ROC	Reverse Osmosis Concentrate- ROC	**PVC-02**	400532	**I**	150
	ROF	RO Feed	**PVC-02**	400532	**(blank)**	150
	UVE	Ultraviolet Treatment Effluent - UVE	**PVC-02**	400532	**O**	150
12	**MFF**	Microfiltration Filtrate - MFF	**PVC-02**	400532	**B**	100
					O	150
	ROF	Reverse Osmosis Feed- ROF	**PVC-02**	400532	**I**	150
					O	150
14	**FA**	Foul Air	**PVC-01**	400532	**O**	150
	ROC	Reverse Osmosis Concentrate- ROC	**PVC-02**	400532	**I**	150
18	**MFF**	Microfiltration Filtrate - MFF	**PVC-02**	400532	**O**	150
1-2	**CA**	Citric Acid - Miscellaneous	**CPVC-02, D**	400532	**I**	125
1-3	**NACL**	Sodium Hypochlorite	**CPVC-01, D**	400532	**B**	125
					I	125
	NAOH	Sodium Hydroxide -Feed	**CS-02, CS-0**	400524.43,	**B**	125
					I	125

HDPE Schedule
400533.11 S01

Size, inches	System	Name/Function	Material(s)	Specification	Input HDPE DR (max)	Test Pressure (psi)
6	**FPW**	Fire Protection Water	**HDPE**	400533.11	**11**	150
8	**PW**	Water Potable Water - PW	**HDPE**	400532	**11**	150
12	**IPR**	Indirect Potable Reuse Water - IPR	**HDPE**	400533.11	**17**	95
	MFF	Microfiltration Filtrate - MFF	**HDPE**	400533.11	**17**	45
14	**ROC**	Reverse Osmosis Concentrate- ROC	**HDPE**	400533.11	**21**	75
	WWR	Wastewater - Raw	**HDPE**	400533.11	**11**	125
18	**FPW**	Water - Fire - FPW	**HDPE**	400533.11	**11**	150
	MFF	Microfiltration Filtrate - MFF	**HDPE**	400533.11	**17**	50
	PW	Water Potable Water - PW	**HDPE**	400533.11	**11**	150
	WWR	Wastewater - WWR	**HDPE**	400533.11	**11**	125
20	**FIW**	Filter Inlet Water	**HDPE**	400533.11	**17**	45
	FOW	Filtered Outfall Water - FOW	**HDPE**	400533.11	**32.5**	45
	POW	Plant Outfall Water - POW	**HDPE**	400533.11	**17**	75
24	**POW**	Plant Outfall Water - POW	**HDPE**	400533.11	**17**	75
30	**RAS**	Return Activated Sludge	**HDPE**	400533.11	**26**	50
	WWS	Wastewater - Screened	**HDPE**	400533.11	**17**	50