



Monterey One Water

Providing Cooperative Water Solutions

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October 22, 2024

United States Environmental Protection Agency
Attn: Sayana Murakami (Murakami.Sayana@epa.gov)
1200 Pennsylvania Avenue NW
WJC-E 7334A
Washington, DC 20460

RE: AIS/BABA Availability Waiver Request

Dear Ms. Murakami,

On behalf of Monterey One Water, please find enclosed our AIS/BABA Waiver Request Form and associated documentation for your consideration. As outlined in the waiver request, we seek a waiver from the American Iron and Steel requirements for a select number of valves to avoid scheduling delays associated with our Pure Water Monterey Groundwater Replenishment Project.

If any additional information is needed, please reach out to me at (831)915-6630 or alison@my1water.org or to our construction manager, Melanie Carrido (melanie.carrido@mwhconstructors.com).

Thank you for your assistance.

Sincerely,

Alison M. Imamura

Digitally signed by Alison M. Imamura
DN: G=Alison M. Imamura, C=US United States,
E=alison@my1water.org, OU=Engineering,
O=Monterey One Water, L=US United States,
CN=Alison M. Imamura
Reason: I am the author of this document
Date: 2024.10.22 10:18:50-07'00'

Alison Imamura, PE, AICP
Principal Engineer

Cc (via email):

Mak Kavita, Project Engineer - mak.kavita@epa.gov
David Lindow, PE, Program Manager, Monterey One Water
Yohana Vargas, Contracts Administrator, Monterey One Water
Mike McCullough, Director of External Affairs, Monterey One Water
Melanie Carrido, PE, Construction Manager, MWH Constructors
James Mitchell, Assistant Resident Engineer, MWH Constructors

This waiver request applies only to the project in the subject line. All supporting correspondence and/or documentation from contractors, suppliers or manufacturers included as a part of this waiver request was done so by the WIFIA borrower to provide an appropriate level of detail and context for the submission. There may be documents with project diagrams, schedules, and supplier correspondence in formats that do not meet the Federal accessibility requirements for publication on the Agency's website. Hence, these exhibits have been omitted from this waiver publication. They are available upon request by emailing WIFIAWaiver@epa.gov.

Product Name	Brief Description	Unit Cost of Non-Domestic Product	Unit Cost of Domestic Product	Quantity Needed	Date Product Needed
8" Bray 43 SST Butterfly Valve	ANSI 300 Lugged Ends, 316 SS Body, 316 SS Disc, 17-4 SS Stem, RPTFE w/ Silicone Energizer Seat, 720 PSI CWP	\$5,400	\$12,130	10	10/30/24
8" Bray 31 SST Butterfly Valve	Lugged Ends, Ductile Iron Body, 316 Stainless Steel Disc, 316 Stainless Steel Stem, EPDM Seat, 175 PSI CWP Handwheel Operator for Above Ground Service w/ Limit Switch, (2) Switches, NEMA 4X Enclosure with Dome Indicator	\$3,118	\$5,870	5	10/22/24
10" Bray 31 SST Butterfly Valve	Lugged Ends, Ductile Iron Body, 316 Stainless Steel Disc, 316 Stainless Steel Stem, EPDM Seat, 175 PSI CWP Handwheel Operator for Above Ground Service w/ Limit Switch, (2) Switches, NEMA 4X Enclosure with Dome Indicator	\$3,168	\$7,100	5	10/22/24
12" Bray 31 SST Butterfly Valve	Lugged Ends, Ductile Iron Body, 316 Stainless Steel Disc, 316 Stainless Steel Stem, EPDM Seat, 175 PSI CWP Handwheel Operator for Above Ground Service w/ Limit Switch, (2) Switches, NEMA 4X Enclosure with Dome Indicator	\$4,822	\$11,230	5	10/22/24

SECTION 43 20 00

PIPING, VALVES AND ACCESSORIES

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes: Provide all piping, including fittings, valves, supports, and accessories as shown on the Drawings, described in the Specifications and as required to completely interconnect all equipment with piping for complete and operable systems, including equipment drains.

1.02 REFERENCES

- A. Air-Conditioning and Refrigeration Institute (ARI)
- B. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
- C. ASTM International (ASTM)
- D. American Society of Mechanical Engineers (ASME)
- E. American National Standards Institute (ANSI)
- F. American Water Works Association (AWWA)
- G. American Welding Society (AWS)
- H. Cast Iron Soil Pipe Institute (CISPI)
- I. U.S. Department of Transportation (DOT)
- J. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)
- K. National Fire Protection Association (NFPA)
- L. National Sanitation Foundation (NSF)

1.03 SUBMITTALS

- A. Shop Drawings:
 - 1. Verify by excavation, inspection and measurement all installation conditions, including existing utilities and structures, for all pipe before preparation of Shop Drawings. Submit field measurements and photos with Shop Drawings where exposed conditions are significantly different than indicated on the Drawings. See also Section 31 00 00.
 - 2. Layouts and Schematics: Submit detailed installation drawings of all piping. Schematics may be submitted for piping 4 inches and smaller. The Drawings and schematics shall include: pipe support locations and types, fittings, valves, other appurtenances. (Product Review)
 - 3. Submit data to show that the following items conform to the Specification requirements:
 - a. Pipe, fittings and accessories (Product Review).
 - b. Fabricated pipe supports and other pipe supports (Product Review).
 - c. Pipe couplings and flexible pipe pieces (Product Review).

- d. Valves and accessories (Product Review).
- e. Thermal insulation (Product Review).
- 4. Pipe, fittings and joint fabrication details for welded steel pipe (Product Review).
- 5. Submit reinforcement calculations for welded steel pipe to demonstrate compliance with AWWA M11.
- 6. Submit procedures for welding field joints of welded steel and stainless steel pipe and welder qualifications (Product Review).
- 7. Submit procedures for shop welding joints of welded stainless steel and Alloy 20 pipe and welder qualifications (Product Review).
- 8. Submit procedures for butt wrapping FRP pipe joints and personnel qualifications (Product Review).
- 9. Submit procedures for thermal butt fusing polypropylene and PVDF pipe and personnel qualifications (Product Review).
- 10. Submit samples of gaskets and other materials where required by the detailed specifications.
- 11. Submit certified test reports as required herein and by the referenced standard specifications (Product Information).
- 12. All items utilized on systems supplying or producing drinking water or on reclaimed water systems, including, but not limited to, pipe and valve linings, solvent cements, welding materials, gaskets and gasket lubricants, and additives in concrete or cement mortar shall comply with the Safe Drinking Water Act and NSF requirements for use in water systems in accordance with Section 64591 of the California Water Works Standards. Submit proof of NSF certification for each item.
- 13. Samples: Solder and flux for copper pipe.
- 14. Gaskets for PVC Type V-4 Pipe.
- B. Manuals: Furnish manufacturer's installation and operation manuals, bulletins, and spare parts lists for the following items:
 - 1. Valves 4 inches and larger and all actuated valves.
 - 2. Air valves.
 - 3. Pneumatic/motorized actuators, including positioners and I/P converters. Include the actuator manuals for the valves requiring them.
 - 4. Strainers, motorized or automatic washing.
 - 5. Filters.
 - 6. Pressure regulators.
 - 7. Rotameters.
- C. Affidavits: Furnish affidavits from the manufacturers for the following equipment:
 - 1. Valves, motorized or pneumatically operated.
 - 2. All motorized or calibrated equipment.
- D. Field test reports as required in Part 3.

1.04 QUALITY ASSURANCE

- A. Materials and equipment furnished under this Section shall be of manufacturers who have been regularly engaged in the design and manufacture of the materials and equipment for a period of at least five (5) years. Demonstrate to the satisfaction of the Engineer that the quality is equal to the materials and equipment made by the manufacturers specifically named herein, if an alternate manufacturer is proposed.

- B. Welder Qualifications: All proposed welders shall submit qualification records for the processes to be used. For the stainless steel and Alloy 20 piping, the Contractor shall conform to the following additional requirements.
1. All welders and welding operators shall be qualified at the Contractor's sole expense by an ASME-approved testing laboratory before performing any welding under this section. Qualification tests shall be in accordance with Section IX, Article III of the ASME Boiler and Pressure Vessel Code. Welders and welding operators shall be qualified for making groove welds in Alloy 20, Type 304L and 316L stainless steel pipe in position 6g for each welding process to be used.
 2. Prior to the start of the work, Contractor shall submit a list of the welders he proposes using and the type of welding for which each has been qualified.
 3. Qualification tests may be waived if evidence of prior qualification is deemed suitable by the Engineer. The Contractor shall retest any welders at any time Engineer considers the quality of the welder's work substandard. When Engineer requests the retest of a previously qualified welder, the labor costs for the retest will be at the Engineer's expense if the welder successfully passes the test. If the welder fails the retest, all cost shall be at the Contractor's expense.
- C. Factory Quality Control: The Contractor shall test all products as noted herein and by the reference specifications.
1. All stainless steel piping welded in the shop shall be subject to visual inspection by the Engineer.
 2. Fabricated stainless steel pipe assemblies shall be inspected at the Contractor or fabricator's facility by a representative of the Engineer.
 3. An initial inspection shall be conducted once initial fabrication work has begun, prior to completion of 10 percent of the welds. The Contractor shall make available a borescope for use by the Engineer's representative in visually checking the completed welds. Deviations from the Drawings and/or requirements specified herein shall be grounds for rejection and rework.
 4. A final inspection shall be conducted on all the finished assemblies, following fabrication but prior to electro-polishing. The Contractor shall make available a borescope for use by the Engineer's representative in visually checking the completed welds. Deviations from the Drawings and/or requirements specified herein shall be grounds for rejection and rework. The manufacturer must receive written acceptance of the finished assemblies prior to shipment to the site.
- D. Field Quality Control:
1. The Owner will:
 - a. Inspect field welds and test the welds if it is deemed necessary.
 - b. Perform bacteriological analysis for pipelines to be disinfected.
 2. The Contractor shall:
 - a. Perform leakage tests.
 - b. Be responsible for the costs of additional inspection and retesting by the Owner resulting from noncompliance.

1.05 POTHOLING (CHECK ON LOCATIONS)

- A. Do not prepare any shop drawings for, or make final order for, or design any pipe materials for any particular section of pipeline until all utilities in that section of

pipeline have been exposed, as specified in Section 31 00 00 and until such time as no interferences are found between said existing utilities and the proposed pipeline alignment. If interferences are found in any particular section of pipeline, do not prepare any shop drawings for, or make final order for, or design any pipe materials for that particular section of pipeline until the pipeline alignment has been modified by the Engineer to eliminate all such interferences.

1.06 CONSTRUCTION SCHEDULING/SEQUENCING

- A. Construction under this Contract may involve expansion and/or modification of an existing piping system which must continue to provide service to all buildings during construction.
- B. Connections and utilities changes must be programmed to provide the least possible interruptions of service. Prior to any shutdown, all materials, fittings, supports, equipment and tools shall be on the site and all necessary labor scheduled prior to starting any connection work. The Contractor shall notify the Engineer in writing at least 7 days in advance of any required shutdowns so that affected customers may be notified. In general, shutdowns shall not exceed 4 hours in duration unless specifically authorized or indicated in the suggested construction sequence. If a shutdown of more than 4 hours is required, the Contractor shall first install temporary service connections to all affected houses and other buildings. All temporary piping shall be disinfected before being put into service (water and recycled water piping systems only).
- C. All work under this Contract shall be conducted in a manner which will minimize shutdowns, open roadways, or traffic obstructions caused by the construction. Shutdowns causing damage to adjacent public and private property shall not be permitted, and any damage resulting shall be the sole responsibility of the Contractor.
- D. Planned utility service shutdowns shall be accomplished during periods of minimum use. In some cases, this will require night or weekend work, which shall be at no additional cost to the Owner. The Contractor shall program his work so that service will be restored in the minimum possible time, and shall cooperate with the Owner in reducing shutdowns of the utility system to a minimum. No utility interruption will be permitted without the prior approval of the Engineer.

1.07 PIPING SYSTEMS

- A. The various piping systems are identified by a multi-letter code on the Drawings. Each system shall be constructed using the materials indicated on the Process and Instrumentation Diagrams (P&IDs) next to the piping system code. Refer to the Drawing sheet G1.12 - Piping Schedule for additional piping systems, information and requirements. Piping materials are identified by both material abbreviation and type designation in the Schedule unless otherwise noted, and most valves and accessories are identified by a valve and accessory system unless otherwise noted.

1.08 APPURTENANCES

- A. Furnish and install all necessary guides, inserts, anchors and assembly bolts, washers and nuts, hangers, supports, gaskets, couplings and flanges; all other appurtenant items shown on the Drawings, specified or required for the proper

installation and operation of the piping; devices included in or on the piping equipment; and piping accessories.

1.09 PIPE SUPPORTS

A. General:

1. Piping 6 Inches and Larger: Pipe supports are shown on the Drawings for piping 6 inches and larger in diameter, where the piping is shown on layout drawings. Each pipe support used is designed to resist seismic loading except where the support is of the sliding type for thermal expansion. Other supports are provided to resist axial seismic loading of pipes designed for thermal expansion. Pipe supports that are considered seismic resistant are so noted on the pipe support detail sheets on the Drawings. The location and types of supports and braces are indicative and may be modified by the Contractor to suit field conditions, provided the modified support system conforms to the design criteria stated herein, and receives the favorable review of the Engineer. Where piping is shown schematically only, it shall be the Contractor's responsibility to support all such piping in accordance with the design criteria stated herein and using support details shown on the Drawings. Pipe supports have been designed assuming flanged joints on ductile iron pipe and steel pipe, unless otherwise indicated on the Drawings. If groove type mechanical couplings are used as an alternative, provide additional supports where required, particularly to resist rotation. Shop drawings of these additional supports shall be favorably reviewed by the Engineer prior to installation.
2. Piping Less Than 6 Inches: Pipe supports are generally not shown for piping less than 6 inches in diameter. Where supports are not shown, it shall be the Contractor's responsibility to support all such piping in accordance with the design criteria stated hereinafter and the support details shown on the Drawings. Piping 2-½ inches and larger and all piping for hazardous chemicals shall be supported with pipe supports designed to resist seismic loads. Hazardous chemical piping includes fuel, natural gas, sodium hypochlorite, hydrogen peroxide, oxygen, ozone, sodium bisulfite, sulfuric acid (concentrated and solution), calcium hydroxide, compressed air, sodium hydroxide, ammonium sulfate, ferric chloride and threshold inhibitor. Piping smaller than 2-½ inches with non-hazardous contents may be supported with non-seismic resistant supports.
3. Where not detailed or otherwise indicated, pipe support types and spacing shall be in accordance with the Manufacturer's Standardization Society (MSS) Standard Practice No. SP-58 and No. SP-69, except as superseded by the requirements of these Specifications. Hangers and supports used as components of a fire protection system shall comply with NFPA Standard No. 13 and be listed and labeled by UL and FM.

B. Pipe Support System Design:

1. Design Loads: Pipe suspension shall be such as to prevent excessive stress or excessive variation in supporting force while system is in operation. Pipe supports shall support the sum of the weight of the pipe, fittings, appurtenances, and contents. In addition, the pipe shall be anchored to resist internal pressure forces tending to separate any unrestrained joint at pressures 1-½ times the maximum working pressure for the applicable service.

2. Seismic Loads: See Section 01 35 00.
3. Location: All piping shall be supported in a manner that will prevent undue strain on any valve, fitting, or piece of equipment. In addition, pipe supports shall be provided at changes in direction or elevation, adjacent to flexible couplings, at all non-rigid joints, at hose bibbs, and where otherwise shown. Where piping connects to equipment, it shall be supported by a pipe support and not by the equipment.
 - a. Maximum support spacing shall conform to the following table:

Pipe Size Inches	Pipe Material	Maximum Spacing Feet
1-inch and smaller	Iron or Steel	6
	Copper	4-1/2
	Plastic	continuous
	Tubing	continuous
1-¼-inch to 2-inch	Iron or Steel	8
	Copper or Plastic	5
2-½-inch to 4-inch	Iron or Steel	10
	Copper or Plastic	6
6-inch to 8-inch	Iron or Steel	12
	Plastic	8
10-inch and larger	Iron or Steel	15

- b. Piping penetrations through concrete walls and slabs are considered to resist seismic loading, provided penetrations for pipes 3 inches in diameter and larger are complete with a wall flange.
 - c. Branch piping is not considered to provide resistance to seismic forces.
4. Anchors: Anchors for connecting pipe supports to concrete shall be in accordance with Section 05 09 00.
5. Thermal Expansion Allowance:
 - a. Provide one (1) rigid pipe support for each straight run of pipe and between each pair of flexible couplings, flexible connectors, or expansion loops for pipes listed below. Provide other supports at the required spacing that allow sliding or rolling, as noted, along the pipe axis:
 - 1) PVC pipe larger than 1-inch in diameter (sliding inside PVC sleeve).
 - 2) Building heating hot water (rolling).
 - 3) Domestic hot water (rolling).
 - 4) Liquid Oxygen.
 - 5) Aeration Air, Airwash Air, Compressed Air.
 - b. Provide vertical support only, that is, no lateral support, within 4 feet of an angle or tee for pipes listed above.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Pipe and valve sizes are nominal inside diameter unless otherwise noted.
- B. Construct vents of materials specified for the pipe system for which they serve.

- C. All materials delivered to the job site shall be new, free from defects, and marked to identify the material, class, and other appropriate data such as thickness for piping.
- D. Acceptance of materials shall be subject to strength and quality testing in addition to inspection of the completed product. Acceptance of installed piping systems shall be based on inspection and leakage tests as specified hereinafter.
- E. Cutoff Flanges: Provide at all pipe or sleeve penetrations where cast into wall for pipes 4 inches and greater in nominal diameter, and at all penetrations of 3-inch and smaller nominal diameter pipe in wet or potentially wet locations as indicated on the Drawings. Cutoff flange outside diameter shall be at least a standard connection flange's outside diameter except that for pipe 30-inch-diameter and larger, nominal size, cutoff flange outside diameter may be 6 inches greater than outside pipe diameter. Cutoff flange shall be at least ¼-inch thick and shall be continuously welded (or cast) onto the pipe.

2.02 GENERAL MATERIAL REQUIREMENTS

- A. Gaskets: Except where specified otherwise, gaskets shall be SBR rubber, or NBR (Nitril or Buna-N) if in contact with hydrocarbons.
 - 1. Use PTFE (Teflon) for ozone, oxygen, hypochlorite, and hydrogen peroxide service.
 - 2. Use Viton for sulfuric acid and aeration air service.
 - 3. Use PTFE for MF and RO compressed air service.
 - 4. Use peroxide-cured EPDM with resistance to sodium hypochlorite for the following process stream identifications:
 - a. SE
 - b. MFF
 - c. MFE
 - d. BWS
 - e. BWB
 - f. CIPS
 - g. CIPR
 - h. ROP
 - i. ROF (on low pressure lines, test pressure <200 psig)
 - j. ROC (on low pressure lines, test pressure < 200 psig)
 - k. UVF
 - l. UVP
 - m. DPW
 - n. PW
 - o. (NH₄)₂SO₄
 - p. TI
 - q. NaOH
 - r. SBS
 - s. FC
 - t. CaOH₂
 - u. FF
 - v. CF
 - w. CR
 - x. FLW
 - y. REC

5. For ROF and ROC piping with test pressure > 200 psig, provide gaskets manufactured with spiral wound 316L stainless steel with chlorocarb (non-asbestos) filler and 316 stainless steel inner ring and outer centering ring. The spiral wound component shall be wound from metal preformed in a chevron configuration. Gaskets shall be Spiraseal Style WR as manufactured by Lamons or equal.
- B. Bolts and Tie Rods: Unless specified otherwise herein, flange bolts and nuts, coupling bolts and nuts, tie rods, and other hardware shall be as follows:
 1. Exposed, General Service: Electroplated zinc or cadmium steel.
 2. Exposed, Ozone, MF and RO Service: Type 316 stainless steel. Includes the following services: OSE, OZ, MFE, CIPS, CIPR, ROP, ROF, ROC, TI, NaOH, FF, CF, CR, REC, FLW, and SA.
 3. Submerged: Type 316 stainless steel, minimum tensile strength: 60,000 psi.
 4. Concrete Encased: Steel.
 5. Buried: Type 304 stainless steel or fluoropolymer-coated carbon steel, minimum tensile strength: 60,000 psi.
 6. Apply an anti-gauling compound to the threads of stainless steel bolts.
 - C. Flexible Sealant: Flexible sealant for pipe joints, where shown on the Drawings, shall be a two-component polysulfide, non-sag; Sikaflex 2C, Dualthane, or equal.
 - D. Fusion Epoxy Coating: AWWA C213; except application shall be by fluid bed only unless the greatest dimension of the article to be coated exceeds 10 feet, in which case electrostatic spray or flocking application may be used.

2.03 PIPING MATERIALS

- A. Pipe and Fitting Designation: Piping materials are identified by a "Type" designation in these Specifications. The "Type" designation identifies not only the pipe itself but the associated fittings and appurtenances and the installation and test procedures described for that "Type." The designation of a particular type shall indicate a complete installation including fittings, joints, cleaning and testing. The pipe and fitting materials for each type designation shall be as specified herein and summarized in the Pipe Type Schedule below.
- B. Piping Schedule: Piping systems and their corresponding piping and valve systems are listed on the Drawings.
- C. Pipe Type Schedule: Pipe material, joints, and fittings shall be as summarized below. A detailed specification of each pipe type follows. (The detailed specification supersedes the Schedule in case of any conflicts.)

Pipe Type		Pipe Description	Field Joints	Fittings
C20,	W-3	Alloy 20 Stainless Steel Pipe	Welded, Flanged, Threaded	Alloy 20 Stainless Steel
CISP,	N-3	Cast Iron Soil Pipe	B&S or Mech. Coupling	CI
CPVC,	V-9	Chlorinated PVC Pipe	Solvent Weld, Flanged, Threaded	CPVC
CU,	T-1	Copper Pipe	Solder or Flare	Wrought Copper or Bronze

Pipe Type		Pipe Description	Field Joints	Fittings
CUT,	T-2	Copper Tubing	Compression or Solder	Wrought Copper
DI (Buried),	N-1	Ductile Iron Bell & Spigot Pipe	B&S	DI
DI (Flanged),	N-2	Ductile Iron Flanged Pipe	Flange or Mech. Groove Coupling	DI
FRP,	O	Fiberglass Reinforced Plastic Pipe	Butt Wrapped, Flanged	Fiberglass
GS,	Y-1	Galvanized Steel Pipe, Schedule 40	Thread	Galvanized Malleable Iron or Cast Iron
HDPE,	U-1	High Density Polyethylene Pipe, Water	Heat Weld, Flanged	Polyethylene
PFA,	V-11	PTFE Tubing	Flared	PVDF Flare
PP-1,	P-1	Polypropylene Pipe, Drain and Waste Service	Hot Weld or Mechanical	Polypropylene
PP-2,	P-2	Polypropylene Pipe, Unpigmented Chemical Service	Fusion Weld, Threaded, Flanged	Polypropylene, Unpigmented
PVC-1,	V-1	PVC Pipe, Schedule 40, 80	Threaded, Flanged or Solvent Weld	PVC, Schedule 40, 80
PVC-4,	V-4	PVC Pipe, Pressure	B&S	CI or DI
PVC-6,	V-6	PVC Pipe, Drain, Waste and Vent	B&S	PVC
PVDF,	V-10	PVDF Pipe	Butt Fusion, Flanged or Threaded	PVDF
SS,	W-1	Stainless Steel Pipe	Flanged, Grooved or Butt Weld	Stainless Steel
SST,	W-2	Stainless Steel Tubing	Compression or Welded	Stainless Steel
STL,	M-2	Welded Steel Pipe	Weld (flanged or coupling where shown)	Welded Steel

D. C20, Type W-3 Pipe

1. Pipe: Stainless steel alloy, ASTM B464 (UNS Designation N08020), Schedule 40S.
2. Fittings: Butt Welding Type, where future disassembly is not required. Stainless steel alloy, ASTM B462 (UNS Designation N08020) in accordance with ASTM B366, Type WP20CBW, with schedule to match connected piping.
3. Branch Connections: Tees or reducing tees in conformance with requirements for "Fittings" above.
4. Shop Fabricated Joint Assemblies: Butt-welded without exception.
 - a. All welding shall be carried out in the shop and shall be in accordance with the latest editions of Section IX of the ASME Boiler and Pressure Vessel Code and ASME Code for Pressure Piping, ASME B31.3 (severe cyclic), as applicable.

- b. All welds shall have 100 percent penetration. The internal weld bead shall be small, smooth and continuous with no crevices, pits or other voids. The external weld bead shall be well rounded, smooth and continuous with no anomalies.
 - c. All welded connections shall be parallel and perpendicular to the extent that the piping appears to be correct to the naked eye.
 - d. Pipe edges shall be prepared by machine cutting or shaping using an aluminum oxide blade. Beveled ends shall conform to the requirements of ANSI B16.9.
 - e. Clean weld joints and weld joint areas both before and after welding in accordance with ASTM A380 using stainless steel wire brushes or stainless steel wool.
 - f. Alignment: Align ends to be joined within commercial tolerances on diameter, wall thickness, and out-of-roundness. Root opening at the joint shall be as stated in the procedure specification.
 - g. Welding: The direct current, straight polarity, gas tungsten-arc (GTAW) process shall be used for all welding. Welding may be by manual GTAW or automatic (orbital) GTAW processes. The inside of the pipe shall be purged with Argon gas during welding and while the weld is cooling to prevent oxidation of the weld.
 - h. Tack Welds: All tack welds shall be made by a qualified welder. All tack welds shall be made with welding rod the same as that used for the succeeding root pass. Tack welds shall be small enough to be readily fused into the bead of the root pass. Thoroughly clean tack welds with a stainless steel wire brush prior to the root pass to prevent pinholing or excessive porosity. Tack welds which have cracked shall be completely removed prior to making the root pass. Surface defects which will affect the soundness of the weld shall be removed, visually inspected, and re-welded.
 - i. Finished welds shall conform to requirements under Chapter V of ASME B31.3 (severe cyclic), as applicable.
5. Connections Requiring Field Assembly:
- a. Threaded: For connections to instrument taps only.
 - b. Union Fittings: Where noted or shown.
 - c. Flanged: For connections to flanged devices, or where otherwise noted or shown.
 - 1) Type: Factory-made wrought fittings, lap-joint stub end in conformance with ASTM B366, Type WP20CB; schedule to match pipe.
 - 2) Dimensions: To match connected piping, faced and drilled ANSI Class 150.
 - 3) Gaskets: Gaskets shall be Viton, full face, meeting ASTM D 2000 - Standard Classification System for Rubber Products in Automotive Applications, HK 710, with a hardness of 65 – 75 durometer. Minimum tensile strength shall be 1200 psi, and rated for a maximum operating temperature not less than 400–degree F. Gasket surfaces shall have a matte finish with the name of the manufacturer and model number indelibly imprinted thereon. Gaskets shall be Garlock Rubber Technologies Style 9520 or equal.

- d. Bolting: Flanged Joints: Type 316 stainless steel. ASTM A193, Grade B8M hex head bolts and washers; Grade B8M hex head nuts.
 - 6. Accessories:
 - a. Thread Lubricant: Teflon tape.
 - b. Welding Rod and Bare Electrodes: AWS 5.9, ER 320LR.
 - 7. Finishing:
 - a. Pickle all stainless steel pipe, fittings, and finished assemblies following fabrication to remove all mill scale, weld inclusions and color in accordance with ASTM A380.
 - b. Electropolish the outer surface of all components until a homogeneous, polished appearance is attained.
- E. CISP, Type N-3 Pipe:
 - 1. Pipe and Fittings: Bell and spigot service weight cast iron soil pipe or no-hub cast-iron soil pipe. (No-hub pipe may not be used under structures.)
 - a. Bell and Spigot: ASTM A74.
 - b. No-Hub: Cast Iron Soil Pipe Institute Standard No. 301.
 - 2. Bell and Spigot Gaskets: Sewage and oil resistant, ASTM C564.
 - 3. No-Hub Couplings: Cast Iron Soil Pipe Institute Standard No. 301.
- F. CPVC, Type V-9 Pipe:
 - 1. Pipe: Schedule 80 chlorinated polyvinyl chloride (CPVC), ASTM F441. Pipe shall bear the National Sanitation Foundation (NSF) label.
 - 2. Fittings: CPVC fittings and specials for CPVC pipe shall be Schedule 80. Schedule 80 fittings shall be solvent welded fittings and shall conform to ASTM F439 for CPVC.
- G. CUP, Type T-1 Pipe:
 - 1. Pipe: Copper, ASTM B88.
 - a. Buried: Type K (soft drawn).
 - b. Exposed: Type L (hard drawn).
 - 2. Joints:
 - a. Buried: Soldered or flared.
 - b. Exposed: Soldered.
 - 3. Solder: ASTM B32, Alloy Grade S_N 94, S_N 95 or S_N 96. Solder and flux shall contain less than 0.2% lead.
 - 4. Fittings:
 - a. Soldered: Wrought copper, ASTM B75 for materials and ANSI B16.22 for dimensions; or cast bronze, ASTM B62 for materials and ANSI B16.18 for dimensions.
 - b. Flared: AWWA C800 and ANSI B16.26.
- H. CUT, Type T-2 Pipe (Tubing):
 - 1. Tubing and Fittings:
 - a. Tube: Copper, Type DHP, Alloy No. 122, soft annealed, bright seamless, ASTM B68 and B75.
 - 1) Dimensions: ¼-inch outside diameter x 0.030-inch wall, 3/8-inch outside diameter x 0.032-inch wall, ½-inch outside diameter x 0.035-inch wall.
 - b. Joints: Flared compression or soldered.
 - c. Fittings:
 - 1) Soldered: Seamless wrought copper, ASTM B75.
 - 2) Compression: Brass, Imperial; Swagelok; or equal.

2. Jackets: Polyvinyl chloride, flame retardant, ASTM D1047.
 3. Armor: Flexible, interlocking galvanized steel.
 4. Single Armored Tube: Tube as specified above with inner and outer jackets and armor. Parker TAT, equivalent product by Okonite; or equal.
 5. Bundled Armored Tube: Tubes as specified above, with two spares. Each tube shall be marked with a code for identification at 2-inch intervals. Each bundle shall include two 22 AWG insulated communication wires. Tube bundle shall be wrapped with polyester tape, inner jacket, armor, and outer jacket. Parker Multitube, CTAT; equivalent product by Okonite; or equal.
- I. DI Buried, Type N-1 Pipe:
1. Pipe: Ductile iron bell and spigot pipe, AWWA C151.
 - a. Minimum Pressure Class: 350
 2. Joints: Push-on or mechanical, AWWA C111 as modified, except where flanged joints are shown on the Drawings or where making connections to valves. PW service requires push-on and not mechanical joints.
 - a. Gaskets: SBR or NBR (Nitril or Buna-N) unless otherwise called for in paragraph 2.02 A above.
 - b. Restrained joints: Unless noted otherwise on the Drawings, provide restrained joints for pipe and fittings capable of deflection after restraint is installed. Joints shall not separate under an internal pressure of 350 psi. For push-on joints use TR FLEX or Field Lok 350 by United States Pipe & Foundry Company; Flex Ring by American Cast Iron Pipe Company; or equal. For mechanical joints use Megalug restraints by EBAA Iron, or equal.
 - c. Buried Tee-Head Bolts and Nuts for Mechanical Joints: Fluoropolymer coated carbon steel.
 - d. Buried bolts and nuts for flanged joints shall be Fluoropolymer coated carbon steel.
 - e. Provide insulating flanges for buried ductile iron to steel connections.
 3. Fittings: Ductile iron with push-on joints, or mechanical joints, AWWA C110 and AWWA C153.
 - a. Special Fittings: Special fittings not available in ductile iron or cast iron pipe may be fabricated of welded steel pipe (STL) with a design pressure of 350 psi. Line and coat with fusion epoxy. Design and wall thickness shall be submitted to the Engineer for review.
 4. Lining:
 - a. Cement-lined (DIC): Standard thickness cement mortar lining for pipe and fittings, AWWA C104, except where noted otherwise in the Drawings or in the Piping Schedule. Cement mortar linings shall be seal coated.
 - b. Epoxy-lined (DIE): Pipe and fittings shall be fusion epoxy lined per AWWA C116.
 5. Coating: Buried pipe shall receive asphalt coating per AWWA C151. Exposed or submerged pipe requiring protective coating per Section 09 96 00 shall be shipped bare or shall be factory primed compatible with selected field paint system.
 6. Protection for buried pipe: Polyethylene encasement, black, AWWA C105. Single-wrap pipe, double-wrap flanged fittings, mechanical joints, or other appurtenances with significantly different outside diameters from the pipe.

Tape to seal seams and overlaps at least 4 mils thick and at least 2 inches wide.

7. Pipe Taps:

- a. Threaded metal pipe branch lines up to 1 inch in diameter from ductile iron pipe may be made with direct threaded taps, provided the ductile iron wall thickness is in excess of the minimum shown in Tables A.1 and A.2 of AWWA C151 for four full threads. Bosses may be used at the taps to provide the required pipe wall thickness, or use service saddles or reducing flanges on tees.
- b. Service Saddles:
 - 1) Materials: Ductile iron saddle with electro-galvanized straps and hardware for above ground and bronze or 304 stainless steel for buried, and nitrile or neoprene gaskets.
 - 2) Type: For ductile iron pipe 4 inches and less, single strap saddles may be used. For pipe greater than 4-inch, double-strap saddles shall be used.
 - 3) Manufacturers: Smith-Blair Model 311 or 313; equivalent by Mueller; or equal.

8. Field Closure Connections for Restrained Joints: Pipe cut in the field where necessary and when favorably reviewed by the Engineer shall be connected by one of the following methods.

- a. Series 3800 Mega-Coupling by EBAA Iron, Inc.; or equal.
- b. Mechanical joint sleeve with two Series 1100 Metalug restraints by EBAA Iron, Inc.; or equal.

J. DI Flanged (or Grooved), Type N-2 Pipe:

1. Pipe: Flanged or grooved end ductile iron.
 - a. Flanged Pipe: AWWA C115 including Appendix A, minimum thickness Class 53.
 - b. Grooved End Pipe: AWWA C151 with grooves in accordance with AWWA C606, Table 3, for rigid joints. Provide minimum thickness classes in accordance with AWWA C606.
2. Joints: Where flanges are shown on the Drawings, provide mechanical rigid grooved couplings up to 24-inch or flanges, at the Contractor's option, except where grooved couplings are required in the Drawings. (See paragraph 1.09 A.1 for special requirements for pipe supports with grooved couplings.) Provide flanges where required to connect to valves, equipment or certain pipe supports.
3. Flanges: Ductile iron, plain faced, AWWA C115. Submit certification that flanges comply with AWWA C115. Provide insulating flanges with two cathodic test stations for buried ductile iron to steel connections.
4. Mechanical Grooved Couplings: AWWA C606, minimum pressure rating of 150 psi.
5. Fittings:
 - a. Flanged: Ductile iron, AWWA C110 or AWWA C153.
 - b. Grooved End: Ductile iron, AWWA C110 for materials, dimensions and pressure ratings. Grooves shall be in accordance with AWWA C606, Table 3, for rigid joints.
 - c. Special Fittings: Special fittings not available in ductile iron may be fabricated of fusion epoxy lined and coated welded steel pipe with a

- design pressure of 450 psi. Submit design and wall thickness to the Engineer for review.
- d. Buried bolts and nuts for flanged and grooved end joints shall be fluoropolymer-coated carbon steel.
6. Lining:
- a. Cement-lined (DIC): Standard thickness cement mortar lining for pipe and fittings, AWWA C104, except where noted otherwise in the Drawings or in the Piping Schedule. Cement mortar lining shall be seal coated.
 - b. Epoxy-lined (DIE): Fusion epoxy lining and coating, where required in the Drawings or Piping Schedule, shall be applied in accordance with paragraph 2.02 D.
7. Coating: Buried pipe shall receive asphalt coating per AWWA C115. Exposed or submerged pipe requiring protective coating per Section 09 96 00 shall be shipped bare or shall be factory primed compatible with selected field paint system.
8. Protection for buried pipe: Polyethylene encasement, black, AWWA C105. Single-wrap pipe, double-wrap flanged fittings, mechanical joints, or other appurtenances with significantly different outside diameters from the pipe. Tape to seal seams and over laps at least 2 inches wide.
9. Gaskets:
- a. Flanged: Full face, 1/8-inch-thick SBR rubber or NBR (Nitril or Buna-N), AWWA C115, Appendix A unless otherwise called for in paragraph 2.02 A above.
 - b. Mechanical Grooved Coupling: SBR rubber or NBR (Nitril or Buna-N), AWWA C606 unless otherwise called for in paragraph 2.02 A above.
10. Flange Bolts: AWWA C115, Appendix A unless stainless steel is required in paragraph 2.02.
11. Pipe Taps:
- a. Threaded metal pipe branch lines up to 1 inch in diameter from ductile iron pipe may be made with direct threaded taps, provided the ductile iron wall thickness is in excess of the minimum shown in Tables A.1 and A.2 of AWWA C151 for four full threads. Bosses may be used at the taps to provide the required pipe wall thickness, or use service saddles or reducing flanges on tees.
 - b. Service Saddles:
 - 1) Materials: Ductile iron saddle with electro-galvanized straps and hardware for aboveground and bronze or 304 stainless steel for buried, and nitrile or neoprene gaskets.
 - 2) Type: For ductile iron pipe 4 inches and less, single strap saddles may be used. For pipe greater than 4-inch, double strap saddles shall be used.
 - 3) Manufacturers: Smith-Blair Model 311 or 313; equivalent by Mueller; or equal.
12. Field Closure Connections for Restrained Joints: Pipe cut in the field where necessary and when favorably reviewed by the Engineer shall be connected by one of the following methods:
- a. Series 3800 Mega-Coupling by EBAA Iron, Inc.; or equal.
 - b. Mechanical Joint Sleeve with two Series 1100 Megalug Restraints by EBAA Iron, Inc.; or equal.

K. FRP, Type O Pipe:

1. Pipe: The pipe and fittings shall be manufactured from vinyl ester resin by either:
 - a. Centrifugal Casting - ASTM D2997, RTRP, Type II, Grade 2, Class B.
 - b. Filament Winding - ASTM D2996, RTRP, Type I, Grade 2, Class B or E.
 - c. Filament Winding – ASTM D2996, RTRP-12EE1-211, Cyclic Test Method.
 - d. Filament Winding – ASTM D2996, RTRP-12EU1-211, Static Test Method.
 - e. All pipe and fittings shall be as manufactured by Ameron; Ershigs; Fibercast; or equal.
 - f. The pipe shall have a reinforced wall made up of not less than 45% by weight glass roving for pipe sizes up through 14-in. For sizes greater than 14-in, the weight percent of glass shall be not less than 65%. The roving length shall be at least the circumference of the pipe outside diameter. The reinforced wall thickness shall be determined per ASTM D 3567.
 - g. All pipe shall have a resin rich corrosion barrier. Pure resin corrosion barriers shall be 80 mil minimum. Barriers with up to 35% glass and filler by weight shall be 100 mil minimum. Barrier glass and filler content shall not exceed 35% by weight as determined per ASTM D 2584.
 - h. Resin used in the laminate shall be premium corrosion resistant vinyl ester resin. Resin shall be Hetron 922 by Ashland Chemical Company or equal.
 - i. Minimum Pipe Performance Standards

Nominal Pipe Size (inches)	Pipe Internal Pressure Rating	Pipe External Pressure Rating	Pipe Unsupported Span Rating
Temperature	@ 75°F	@ 75°F	@ 175°F
Note #	1	2	3
Units	PSI	PSI	FEET
1	700	1,900	9
1.5	650	950	10
2	650	850	12
3	650	500	14
4	650	350	16
6	500	150	18
8	400	60	20
10	300	30	20
12	250	20	20
14	250	15	20
16	150	2.9	11
18	150	2.7	12
20	150	1.5	12
24	150	1.3	13
30	150	2.3	15

Notes:

1. The internal pressure rating is to be the lesser value as calculated from thin wall vessel equations using 1/3 the ultimate hoop tensile stress as determined per ASTM D 1599 and 1/6 the ultimate tensile stress as determined per ASTM D 2105.
2. External pressure rating to be the failure pressure as determined per ASTM D 2994.
3. Unsupported span length to be calculated for maximum deflection using 3 span continuous beam equations. The beam bending modulus of elasticity is to be determined per ASTM D 790.

2. Joints:

- a. Pipe joints shall be flanged to the greatest extent possible. Equipment and valve connections shall be flanged. Flanges shall be full face type with the bolt pattern conforming to ANSI Class 150 standard. Flanges shall be fiberglass reinforced plastic wound integral to the pipe or fitting and manufactured using the same materials and methods as the pipe and fittings. Flanges shall be as thick as required for the pressure class of the pipe. Gaskets shall be EPDM and full face type. Bolts, nuts, washers and other fasteners shall be 316 Stainless Steel.
- b. When permitted by the Owner, joints shall be butt-wrapped in accordance with ASME B31.3, Section A328.2, as applicable. All resins, adhesives, and materials used shall be products of the pipe manufacturer. Field tapering or machining will not be allowed.
- c. Use of joining methods, other than flanging and butt wrapping, shall not be allowed.
- d. Performance Requirements:

Nominal Pipe Size (inches)	Fitting Internal Pressure Rating	Fitting Elbow Bending Moment
Temperature	@ 75°F	@ 75°F
Units	PSI	FT-LBS
1	300	400
1.5	300	600
2	200	900
3	150	1900
4	150	2600
6	150	6600
8	150	11000
10	150	18000
12	150	26000
14	150	40000
16	125	2300
18	125	3200
20	100	3600
24	100	6100
30	100	5150

3. Accessories:
 - a. Service saddles shall not be used. Provide reducing nipple with FNPT outlet formed integral with the pipe where required.
 - b. Flexible couplings shall be flanged with two convolution bellows and tie rods. Bellows shall be white Teflon with Monel reinforcing bands. Flanges shall be Type 316L stainless steel, ANSI Class 150. Couplings shall have type 316SS tie rods, rate 150 psig at 180°F. Flexible couplings shall be as manufactured by Technova or equal.
 - c. Gaskets shall be full-faced, ¼-inch thick with a hardness of 50-70 durometer on Shore A scale, EPDM. Provide a filler gasket between flanges with a raised face to protect the FRD flange from the bolting moment.
 - d. Bolts shall be type 316SS, ASTM A193, Grade B8M hex head bolts and washers; Grade B8M hex head nuts. Provide two washers for each bolt. Coordinate bolt length to suit flange thickness.
 - e. Finishing
 - 1) Ultraviolet Protection: Protect pipe and fittings from ultraviolet damage by adding a protective compound to the outer wax coat.
 - 2) Color coding: Add a pigment to the final layer of the exterior surfacing resin to lightly tint the surface. Color selection shall be submitted for approval by the Owner.
- L. GS, Type Y-1 Pipe:
 1. Pipe: Galvanized steel, ASTM A53, Schedule 40.
 2. Fittings:
 - a. Pressure Pipe Service: Galvanized malleable iron, screwed, ASTM A197 for materials, ANSI B16.3 Class 150 for dimensions (rated 300 psig WOG at 150°F).
 - b. Drain Pipe Service: Galvanized cast iron drainage pattern, ANSI B16.12.
 3. Threads: ANSI B2.1.
 4. Unions: Galvanized malleable iron, ASTM A197 for materials and ANSI B16.39 for dimensions, with brass seats.
 5. Thread Compound: Permatex No. 2; Crane equivalent; or equal, or Teflon tape.
- M. HDPE, Type U-1 Pipe:
 1. Pipe: High molecular weight, high density, polyethylene pipe, ASTM D3350.
 - a. Cell Classification: 345464C; color material shall be 345464E.
 - b. Dimension Ratio (DR): 17 maximum.
 - c. Submit manufacturer's certification that pipe and fitting complies with the Specifications.
 2. Joints: Butt fusion, ASTM D2657, except mechanical where required to connect with other pipe, valve or equipment materials.
 - a. Butt Fusion Joints: The tensile strength of the joint at yield shall not be less than the pipe. Joints shall be made with equipment acceptable to the manufacturer. The equipment operators shall have been trained by certified fusion technicians. Submit description of the equipment and methods for favorable review.
 - b. Mechanical Joints: Joint shall consist of a flange adaptor fitting butt-fused to the pipe, a back-up ring of Type 316 stainless steel made to

- ANSI B16.1 dimensional standards (with modified pressure rating), bolts of Type 316 stainless steel, and chloroprene gaskets.
3. Fittings: Molded fittings to ASTM D3261 required where available of the same material as the pipe, with DR no greater than the pipe, and with a pressure rating at least equal to the pipe. Manufacturer shall conduct X-ray inspection on samples from each molded fitting production lot. Fabricated fittings shall comply with AWWA C906 and ASTM F2206 and shall only be used where molded fittings are unavailable. Fitting shall be produced by the same manufacturer as the pipe.
- N. PP-1, Type P-1 Pipe:
1. Pipe and Fittings: Polypropylene acid resistant drain, waste, and vent pipe. Schedule 40, unless indicated otherwise on the Drawings.
 - a. Buried Service: ASTM D4101, PP110B, Cell Classification 63153.
 - b. Non-Buried Service: Flame-resistant, ASTM D4101, PP210B, Cell Classification 53653. Flammability shall be as determined by ASTM Test Method D635 with average burn time less than 5 seconds and average extent of burning less than 13 mm.
 2. Joints:
 - a. Buried Service: Heat-fused.
 - b. Non-Buried Service: Heat-fused or mechanical.
- O. PP-2, Type P-2 Pipe:
1. Pipe and Fittings
 - a. Pipe: Polypropylene, 150 psi rated, unpigmented, Asahi Proline or equal.
 - b. Fittings: Same as pipe.
 2. Joints
 - a. Standard butt fusion, except where connecting to unions, valves, and equipment with threaded connections that may require future disassembly.
 - b. Flanges: Ring type, flat faced flanges with epoxy powder coated ductile iron backing, 150 pound standard.
 3. Thermal Bonding
 - a. All fused connections shall be joined by thermal butt fusion using a Proweld Butt Fusion Machine as manufactured by ASAH/America, or equal as approved by the pipe manufacturer.
- P. PFA, Type V-11 Pipe
1. Materials: Small bore flexible virgin PFA tubing suitable for flaring and available in continuous lengths of 25, 50, 100, 250, and 1,000-ft
 - a. PFA tubing wall thickness as follows:
 - 1) For NS 1/4 inch, 0.047".
 - 2) For NS 3/8 inch, 0.062".
 - 3) For NS 1/2 inch, 0.062".
 - 4) For NS 3/4 inch 0.062".
 - 5) For NS 1 inch, 0.062".
 2. Pressure Rating: Minimum 100 psig at 25 degrees C.
 3. Fittings: PVDF Flare-type (no threads exposed to fluid).
 4. Manufacturers:
 - a. Tubing: Harrington Plastics (supplier) or equal.
 - b. Fittings: FlareLINK by Fit-LINE Inc. or equal.

Q. PVC-1, Type V-1 Pipe:

1. Pipe: Schedule 80 polyvinyl chloride (PVC), gray, normal impact, Type 12454 B, ASTM D1784 and ASTM D1785. Pipe shall bear the National Sanitation Foundation (NSF) label.
2. Joints: Solvent weld, except flanged or threaded permitted where required at equipment connections and where required on the Drawings. Use Military Specification T 27730A tape for threaded joints. Grooved type couplings not allowed on pipe sizes above 1-1/2-in.
3. Fittings: Solvent weld, socket type, of same material as the pipe, Schedule 80, ASTM D2467.
4. Cement: Solvent weld, ASTM D2564, as recommended by the pipe manufacturer for the schedule and size to be joined. For sodium hypochlorite and sodium hydroxide services, use ASTM F-493, IPS724 CPVC by Harrington Plastics; no equal.
5. Pipe Cleaner: As recommended by the pipe manufacturer for the schedule and size to be joined.
6. Double containment of piping is required for all buried PVC pipe and tubing so indicated in the pipe schedule or elsewhere in the Plans and Specifications.
 - a. Size: Provide Schedule 40 PVC containment pipes as follows:

Carrier Pipe	Containment Pipe
½-inch	3-inch
1-inch	3-inch
1-½-inch	4-inch
2-inch	4-inch
3-inch	6-inch
4-inch	6-inch

- b. Joints: Solvent weld except flanged where required. Use two-piece hinged couplings as specified below where necessary. Do not make-up joints until successful completion of leak tests of primary carrier pipe.
 - c. Fittings: Yellow or clear PVC two-piece, hinged, and pre-gasketed (EPDM) containment fittings. Termination couplings shall be hubless type of PVC rubber with 316 stainless steel clamps. Carrier pipe shall be installed concentrically to the containment using three- or four-legged positioning clips. Fittings shall be Contain-It by Georg Fischer; or equal.

R. PVC-4, Type V-4 Pipe:

1. Pipe: Polyvinyl chloride pressure pipe, cast iron pipe outside dimensions. Pipe shall be UL listed or Factory Mutual Approved.
 - a. 4- to 12-inch: AWWA C900.
 - b. 14- to 36-inch: AWWA C905.
2. Dimension Ratio: 25 (Pressure Class 165).
3. Joints:
 - a. Unrestrained Joints: Bell and spigot, gasketed; or twin gasket coupling.
 - b. Restrained Joints: Bell and spigot (push-on) gasketed, or mechanical joints; both using ductile iron clamp-on restraining devices.
 - 1) Restraining Devices: Ductile iron with ductile iron Cor-ten rods and bolts. Pressure rating of at least 150 psi. Series 1500 or

- Series 2800 by EBBA Iron; equivalent by Uni-Flange; or equal for bell and spigot joints. Series 2800PV by EBBA Iron; equivalent by Unif-Flange; or equal for mechanical joints.
- 2) Provide restrained joints for all pipe of this type unless indicated otherwise on the Drawings.
 - 3) Protection for Buried Restraining Devices: Double-wrap with polyethylene encasement, AWWA C105 and tape the edges of the encasement with PVC tape.
 4. Gaskets: SBR rubber or NBR (Nitril or Buna-N) unless otherwise called for in paragraph 2.02 A above.
 5. Fittings: Fusion epoxy lined and coated push-on cast iron or ductile iron AWWA C110 or C153, with hubs cast and/or ground as required for pipe furnished. Fusion epoxy lining and coating shall be in accordance with AWWA C116.
- S. PVC-6, Type V-6 Pipe:
1. Pipe and Fittings: Polyvinyl chloride drain, waste and vent, ASTM D2665. Fitting patterns, ASTM D3311.
 2. Joints: Solvent weld.
 3. Cement: Solvent cement, ASTM D2564, as recommended by the manufacturer.
- T. PVDF, Type V-10 Pipe:
1. Pipe and Fittings
 - a. Pipe: PVDF, 230 psi rated, unpigmented, Asahi Super Proline or equal.
 - b. Fittings: Same as pipe
 2. Joints
 - a. Standard butt fusion, except where connecting to unions, valves, and equipment with threaded connections that may require future disassembly.
 - b. Flanges: Ring type, flat faced flanges with epoxy powder coated ductile iron backing, 150 pound standard.
 3. Thermal Bonding
 - a. All fused connections shall be joined by thermal butt fusion using a Proweld Butt Fusion Machine as manufactured by ASAHI/America, or equal as approved by the pipe manufacturer.
- U. SS, Type W-1 Pipe:
1. Pipe: Pipe shall be stainless steel ASTM A312, welded process, Grade TP316L, unless otherwise specified hereinafter as shown on the Drawings. Schedule as noted or shown. Seamless material may be substituted for welded material but not the reverse. Where not otherwise stated, minimum pipe thickness for un-grooved piping shall be Schedule 10. Where grooved fittings are required, the minimum thickness shall be Schedule 40.
 2. Joints: Butt welded, except where flanged or grooved joints are required adjacent to valves or equipment.
 3. Fittings: Wrought stainless steel, ASTM A774, TP 316L fittings only, ANSI B16.9 for dimensions.
 - a. Stainless steel, ASTM A 403, Grade WP304L or WP316L, Class W with schedule and material to match connected piping unless noted otherwise. For piping and fittings less than or equal to 12-inches, tees

- shall have no welds in the throat area and the crotch shall be reinforced with long radius design to eliminate sharp corners.
- b. Dimensions in accordance with MSS SP-43 and ANSI B16.9. Branch connections may include wrought tees or reducing tees, forged commercial welding branch fittings, extruded reducing branches, or weld-o-lets.
 - c. Forged commercial welding branch fittings with butt welded outlet shall be stainless steel, in conformance with ASTM A182, Grade F316L, with schedule and material to match connected piping. No repair welding shall be performed on forged fittings without prior approval of the Engineer.
 - d. Reducing branches may be formed by an extrusion method (pulled) from pipe. The maximum diameter of any extruded branch connection shall be no more than 75 percent of the nominal diameter of the pipe.
 - e. Weld-o-lets may be used for connections up to 1-inch maximum. Construction shall be to match the connected pipe size and schedule and material with FNPT outlet.
4. Flanges:
- a. For connections to flanged devices, or where otherwise noted or shown.
 - b. Type: For sizes up to 24-in, forged stainless steel, ASTM A182, Grade F316, lap joint flange with stainless steel stub end, ASTM A240, Type 316L, welded grade conforming to MSS-SP43; schedule to match pipe. For sizes over 24-in, provide slip on flanges conforming to ASTM A-182, Grade F316L.
 - c. Dimensions: To match connected piping, rated, faced and drilled ANSI Class 300 or 150 as required to match connected equipment, 1/16-inch raised face, unless otherwise shown or required for connection to equipment.
5. Grooved Fittings
- a. Size: As noted or shown.
 - b. Style: Segmented and bolted.
 - c. 2 pieces on sizes 12 inch and less
 - d. Materials:
 - 1) Housings for groove couplings shall be 316SS conforming to ASTM A 351, A 743 and A 744 Grade CF-8M with
 - 2) Gaskets: EPDM – Food Grade – Peroxide Cured.
 - e. All bolting shall be Type 316 stainless steel with washers the same material as the bolts.
 - f. Manufacturer: Victaulic, Style 77; Piedmont; or equal.
6. Gaskets: Full face gasket per ANSI B16.21, non-asbestos Teflon or PTFE unless otherwise called for in paragraph 2.02 A above.
7. Welder Certification
- a. All welders and welding operators shall be qualified at the Contractor's sole expense by an ASME approved testing laboratory before performing any welding under this section. Qualification tests shall be in accordance with ASME Code for Pressure Piping, B31.3, Chapter 5. Welders and welding operators shall be qualified for making groove welds in Type 316L stainless steel pipe in position 6G for each welding process to be used.

- b. Prior to the start of the work, Contractor shall submit a list of the welders he proposes using and the type of welding for which each has been qualified.
- 8. Welding Requirements
 - a. All welding shall be performed in the shop in accordance with the latest editions of Section IX of the ASME Boiler and Pressure Vessel Code and ASME Code for Pressure Piping, ASME B31.3 (severe cyclic), as applicable.
 - b. All welds shall have 100 percent penetration. The internal weld bead shall be small, smooth and continuous with no crevices, pits or other voids. The external weld bead shall be well rounded, smooth and continuous with no anomalies.
 - c. All welded connections shall be parallel and perpendicular to the extent that the piping appears to be correct to the naked eye.
 - d. Pipe edges shall be prepared by machine cutting or shaping using an aluminum oxide blade. Beveled ends shall conform to the requirements of ANSI B16.9.
 - e. Clean weld joints and weld joint areas both before and after welding in accordance with ASTM A380 using stainless steel wire brushes or stainless steel wool.
 - f. When joining pipes of different wall schedule, taper bore the interior of the larger schedule pipe to match the interior diameter of the connecting pipe with a maximum 1:3 slope.
 - g. The direct current, straight polarity, gas tungsten-arc (GTAW) process shall be used for all welding. Welding may be by manual GTAW or automatic (orbital) GTAW processes.
 - h. The inside of the pipe shall be purged with Argon gas during welding and while the weld is cooling to prevent oxidation of the weld.
 - i. Surface defects, which will affect the soundness of the weld, shall be removed, visually inspected, and re-welded.
- 9. Finishing
 - a. Pickle all stainless steel pipe, fittings, and finished assemblies inside and out following fabrication to remove all mill scale, weld inclusions and color; and passivate inside and out in accordance with ASTM A967.
 - b. Electropolish the outer surface of all interior RO and Ozone System Process piping components until a homogeneous, polished appearance is attained.
- 10. Oxygen and Ozone Service: After shop fabrication, oxygen and ozone piping shall be cleaned of all dirt, oil and grease, mill-scale, and other contaminants. The cleaning, drying, and sealing shall be done by a firm specializing in this process. Immediately after cleaning, open ends shall be sealed with heavy gauge plastic bags and taped. All piping awaiting erection shall be stored indoors in an area that is clean and dry. See Sections 46 31 54 and 46 31 56 for additional requirements for oxygen gas and liquid service.
- 11. Safety Shields: TFE coated fiberglass, OSHA orange border with see-through shield for inspection of leaks. Ramco Vue-Gard; or equal.
- V. SST, Type W-2 Pipe (Tubing):
 - 1. Tube: Stainless Steel, Type 316, 316L, 304, 304L fully annealed ANSI B36.37, ASTM A269, rated 3,000 psi.

- a. Dimensions: ¼-inch outside diameter x 0.035-inch wall;
3/8-inch outside diameter x 0.035-inch wall;
½-inch outside diameter x 0.035-inch wall;
5/8-inch outside diameter x 0.065-inch wall
 2. Joints: Compression or welded.
 3. Fittings: Same material as tube
 - a. Compression: Imperial; Swagelok; or equal.
 - b. Welded fittings and joints, where used, shall be stress relieved.
 4. Jacket: Polyvinylchloride, flame retardant, ASTM D1047.
 5. Armor: Flexible, interlocking galvanized steel.
 6. Single Armored Tube: Tube as specified above with inner and outer jackets and armor. Parker TAT; equivalent product by Okonite; or equal.
 7. Bundled Armored Tubes: Tubes as specified above, with two spares. Each tube shall be marked with a code for identification at 2-inch intervals. Each bundle shall include two 22 AWG insulated communication wires. Tube bundle shall be wrapped with vinyl tape, armor and outer jacket. Parker Multitube CTAT; equivalent product by Okonite; or equal.
- W. STL, Type M-2 Pipe:
1. Pipe: Cement mortar lined steel cylinder pipe, AWWA C200 except as modified herein. Pipe shall be cement mortar coated where buried, and if required elsewhere by the Drawings or Specifications. Steel shall be ASTM A36.
 - a. Dimensions: Nominal inside diameter shall be the minimum net inside clear lined diameter, except that net inside clear lined diameter may be up to ½-inch less than the nominal diameter for nominal diameter 12-inch or less.
 - b. Steel Cylinder Thickness: The pipe manufacturer shall design steel cylinder for pipe and fittings for the cover shown on the Drawings, in accordance with AWWA M-11. The minimum cylinder thickness for pipe with welded joints shall be 12-gauge. Design criteria areas follow:
 - 1) Superimposed external load: AASHTO H20
 - 2) Internal pressure including surge allowance: 350 psi
 - 3) Internal negative pressure: 15 psi
 - 4) Maximum allowable stress: 50% of minimum yield point or 16,500 psi, whichever is less.
 - 5) Maximum deflection permitted: 2%
 - 6) For tapered sections, minimum cylinder and mortar lining thicknesses shall conform to the requirements for the larger pipe diameter.
 - c. Minimum steel cylinder thickness and lining thickness for in-plant piping:

Nominal Size (Inches)	Steel Cylinder Minimum Wall Thickness (inches)	Minimum Lining Thickness (inches)
6 - 8	0.135	3/8
10 - 16	0.188	1/2
18 - 48	0.250	3/4
54 - 60	0.312	3/4

2. Joints: Use welded joints, except flanged or connected with couplings where shown on the Drawings.
 - a. Welded joints shall be butt strap, split butt strap, or lap joint. Butt straps and lap joint details shall be submitted to the Engineer for favorable review. The joint shall be designed to withstand all loads associated with installation and operating conditions. Rolled lap joints are not acceptable. The radius of the bell bends shall be greater than 15 times the cylinder wall thickness. Joint configuration and welding shall conform to the requirements of AWWA M-11 and AWWA C206 except Section 6-2 testing, which are modified herein. The size of fillet welds shall be equal to the thickness of the smaller plate being joined. Butt welds shall be full penetration.
 - b. For pipe less than 24-inch-diameter, the proceeding described in AWWA C205, paragraph 4.7.2.2.2 utilizing a burlap-covered ball shall be used for applying cement mortar lining to the insides of the joints.
 - c. Cement mortar lining shall be patched after joint testing and may be hand applied. Conform to AWWA C205, Appendix A.
 - d. Provide special closure lap joints at approximately 500-foot intervals in accordance with AWWA C206.
3. Fittings: Fittings shall be made of hydrostatically tested cylinders of the same material and minimum thickness as the pipe, except that elbows shall have greater thickness if necessary to compensate for stress concentrations. They shall be as detailed on the Drawings or, if not detailed on the Drawings, shall be designed by the pipe manufacturer by the method stated in the AWWA Pipe Manual M11 as modified herein, subject to the favorable review of the Engineer. Unless otherwise noted or detailed on the Drawings, fitting dimensions shall conform to AWWA C208. Adding pipe to the fittings does not change the requirement that the fittings conform to AWWA C208 dimensionally, nor does it reclassify the pipe portion as part of the fitting. Use 350 psi for the design pressure P.
 - a. Provide reinforcement for fittings (outlets, tees and wyes, etc.) in the form of collars, wrappers or crotch plates, in accordance with the current revision of AWWA M11, Table 13-2. Coat buried fitting reinforcement with cement mortar.
 - b. Crotch plates shall be designed in accordance with AWWA M11, using a minimum plate thickness of 1-inch.
 - c. Elbow dimensions (unless otherwise noted or detailed on the Drawings):
 - 1) Minimum number of pieces for mitered elbows:
 - a) 68° to 90°: Five pieces
 - b) 46° to 67°: Four pieces
 - c) 23° to 45°: Three pieces
 - d) Up to 22½°: Two pieces.
 - 2) Radius, R, to pipe centerline:
 - a) 1.25 pipe diameters for in-plant piping
 - b) 2.5 pipe diameters for transmission lines.
 - 3) Wrought steel elbows complying with ANSI B16.9 and ASTM A234 may be substituted for mitered elbows as long as they meet, as a minimum, the radius, wall thickness and internal diameter requirements of this specification.
 - d. Nozzles 3 inches and less shall be Schedule 40 weld fittings. Wheeling Pipe-O-Lets; Allied Branchlets; or equal. They may be unreinforced.

- e. Flares: Flare diameter shall be equal to the flange O.D. for the same size pipe. Fabricate flares from two sections of truncated cones, one angled 22 ½ degrees from pipe axis, the other 45 degrees. Grind all interior welds and edges perfectly smooth before lining.
- 4. Lining:
 - a. Cement mortar lined (STLC): ¾-inch thick AWWA C205 except as modified herein. Cement shall be Type II. On pipe 27-inch diameter and larger, the lining shall be reinforced using a plain 2 x 4-inch, 13 x 13 gauge welded wire mesh welded to the inside of the pipe, fitting, or steel plate special. If the cement mortar lining is applied by the centrifugal process, the reinforcement may be omitted. Wire reinforcement shall conform to ASTM A185. Paint interior edges and other unlined surfaces in accordance with Section 09 96 00.
 - b. Epoxy lined (STLE): Fusion epoxy lining and coating, where required in the Drawings or Piping Schedule, shall be applied in accordance with paragraph 2.02 D.
- 5. Coating:
 - a. Cement mortar coating: ¾-inch thick over the reinforcement, AWWA C205. Cement shall be Type II. Reinforcement shall be in accordance with AWWA C205.
 - b. Non-cement mortar coating: Pipe without cement mortar coating shall be painted in accordance with Section 09 96 00. Shop prime with products compatible with final coats. Hold back coatings of concrete encased portions of pipes from a point 2 inches within face of concrete encasement.
 - c. On buried piping where the cement mortar coating is held back for flexible couplings or other similar connections, edges shall be ground smooth and the exposed pipe shall be painted in accordance with Section 09 96 00, Protective Coatings, and shall overlap the cement lining and mortar coating. Stripe coat edges between finish coats.
- 6. Flanges and Bolts:
 - a. Steel ring flanges conforming to AWWA C207, Class D with bolt holes drilled in conformance with ANSI B16.1, 125-pound class except as needed to match equipment or other pipeline items. Bolts shall be sized in accordance with ANSI B16.1. Welding shall conform to AWWA C207. The inside diameter of all flanges shall be no more than 3/16-inch greater than the outside diameter of the steel cylinder. Flanges shall be welded to the cylinder without warping and with flange face perpendicular to the longitudinal axis of the cylinder.
 - b. Where ductile pipe joins with steel cylinder pipe, the steel flange is to be modified to be compatible, in pressure rating and configuration, with the ductile iron pipe. Provide insulating flanges for buried ductile iron to steel connections.
 - c. Exposed metal on the flanges shall be coated in accordance with Section 09 96 00. In addition, buried flanges, couplings and other mechanical connections shall be double-wrapped with polyethylene encasement, AWWA C105 and extended to overlap the cement mortar coating with edges of the encasement taped with PVC tape.
- 7. Gaskets: SBR rubber or NBR (Nitril or Buna-N), 1/8-inch thick, unless otherwise called for in paragraph 2.02 A above.

8. Interior Bracing: Each section of pipe 24-inch and larger shall have adequate interior bracing to prevent the pipe from being deformed during handling, transportation, storage, and installation. Bracing shall not be removed until construction operations are complete.
9. Factory Testing: Perform hydrostatic pressure tests of pipe and tests of specials in accordance with Section 5.2 of AWWA C200. Test methods are subject to the favorable review of the Engineer and the tests may be witnessed by the Engineer.
10. Marking: Cylinders and completed pipe and fittings shall be marked in accordance with AWWA C200-97, Section 6.1. The manufacturer shall maintain records that identify the cylinder used for all completed pipe and fittings. All test results and other documentation required to be furnished to the Engineer shall identify the cylinders and completed pipe and fittings by use of this marking system.
11. Interior Moisture Control: Maintain interior moisture and provide plastic sheet end caps during storage and transportation.
12. Protective Coating: Exposed steel at joints, flanges and other locations shall be coated in accordance with Section 09 96 00.

2.04 PIPE COUPLINGS AND FLEXIBLE PIPE PIECES

- A. General: For typical pipe joints refer to pipe material specifications. Other joint devices shall be furnished where called for on the Drawings and as specified below.
- B. Protection for Buried Couplings, Dismantling Joints and Adaptors:
 1. Double-wrap with polyethylene encasement, AWWA C105 and tape the edges of the encasement with PVC tape.
- C. Flexible Couplings and Flange Coupling Adaptors:
 1. Sleeve: Cast iron or fabricated steel.
 2. Followers: Cast iron, ductile iron, or steel.
 3. Sleeve Bolts: ASTM A325, Type 3; malleable iron; or equivalent, except for buried and submerged, which shall be Type 304 stainless steel and Type 316 stainless steel, respectively.
 4. Coating: Fusion epoxy line and coat sleeve and followers.
 5. Pressure Rating: The test pressure of the applicable service or 50 psi, whichever is greater.
 6. Performance: Longitudinal movement and angular deflection capabilities shall meet AWWA C219.
 7. Flanged Coupling Adaptor Flanges: Match mating flanges. If required by connecting valve or other device, provide flanges with inside diameter equal to nominal pipe diameter.
 8. Buried Flexible Coupling Sleeve: Long barrel; Smith-Blair 442, Dresser Style 40; or equal.
 9. Manufacturers:
 - a. Flexible Couplings:
 - 1) Connecting Pipe with Identical Outside Diameters: Smith-Blair 411 or 441; Dresser Style 38 or 138; or equal.
 - 2) Connecting Pipe with Slightly Different Outside Diameters: Smith-Blair 413 or R441; Dresser Style 62; or equal.
 - b. Flange Coupling Adaptors: Smith-Blair 912 or 913; Dresser Style 128-W; or equal.

- c. Restrained Flanged Coupling Adapters: EBBA Iron, Series 2100 MEGAFLANGE, or equal.
- 10. Gaskets: SBR rubber or oil and grease resistant (Nitril or Buna-N) unless otherwise called for in paragraph 2.02 A above.
- 11. Joint Restraint: Provide joint harnesses (tie rod lug or attachment plate assemblies) designed for the test pressure or 50 psi, whichever is greater, across all flexible couplings and flange coupling adaptors, except where specifically indicated otherwise on the Drawings. For steel pipe the joint harness shall conform to the requirements of Chapter 13 of AWWA M-11, Table 13-4 - Tie Bolt Schedule for Harnessed Joints. Anchor studs may be used on flange coupling adapters for pipe up to 12 inches in diameter.
- D. Dismantling Joint:
 - 1. General: The Dismantling Joint shall be a self-contained flanged restrained joint fitting, including both flanged components and sufficient harness bars to withstand the imposed thrust complying with AWWA C219 where applicable. The Dismantling Joint shall be furnished as a complete assembly consisting of spigot piece, flange adapter, tie bars, and gasket. The gasket seal and compression stud and nut arrangement shall be separate and independent of the tie bar restraint system.
 - 2. Performance: No less than 5 inches of longitudinal adjustment and installed with 4 inches of inward adjustment and 1 inch of expansion.
 - 3. Pressure Rating: 150 psi, except PW service requires 250 psi.
 - 4. Spigot Piece and Flange Adapter: Steel.
 - 5. Exterior Fasteners: All exterior fasteners including the bars shall be 316 stainless steel. The bar diameter shall be equal to the corresponding bolt diameter of the mating flange.
 - 6. Flanges: AWWA C207 Class D, except Class E for PW service.
 - 7. Coating: Coated inside and out with a fusion bonded epoxy coating applied to a DFT thickness of 5 to 10 mils. The epoxy shall comply with the requirements of AWWA C550 and AWWA C213. Stainless steel fasteners and tie bars shall not be painted.
 - 8. Gaskets:
 - a. Flanged gaskets shall be full faced gaskets SBR, 1/8-inch thick.
 - b. Wedge gaskets shall be EPDM Grade 199, Buna-S or Buna-N.
 - 9. Manufacturer: The dismantling joint shall be Style 131 as manufactured by Dresser Industries/SVE or equivalent by Romac; or equal.
- E. Mechanical Groove Couplings:
 - 1. Application: Mechanical couplings (segmental clamp joints) shall be used wherever shown on the Drawings. They may be substituted for flanged joints on steel pipe if 16 inches or smaller in diameter and if favorably reviewed by the Engineer and may be substituted for flanges on ductile iron pipe to the extent permitted under the ductile iron pipe specification.
 - 2. Type: AWWA C606, pressure rated at least 300 psi.
 - 3. Joints: Cut groove, except shoulder joints may be used for steel pipe where the wall thickness of the pipe is less than that allowed by Table 4 (AWWA C606). Only Type B, Type C, and Type D special ends are acceptable for shoulder joints.
 - 4. Grooves:
 - a. Ductile Iron Pipe where Mechanical Groove Couplings are shown on the Drawings: Flexible joint, Table 2 (AWWA C606).

- b. Ductile Iron Pipe where Flanges are shown on the Drawings: Rigid joint, Table 3 (AWWA C606).
 - c. Steel Pipe: Table 4 (AWWA C606).
- 5. Gaskets: EPDM, unless otherwise called for in paragraph 2.02 A above.
- F. Flexible Connectors:
 - 1. Up to 12-inch-Diameter:
 - a. Type: Built-up, single arch (unless otherwise shown on Drawings) rubber expansion joints with full rubber flanges and retainer rings.
 - b. Materials: Neoprene cover over nitrile tube, reinforced with nylon or polyester body and galvanized steel retainer rings, except those used on ozone gas piping systems which shall have Hypalon cover over Hypalon tube, and Type 316 stainless steel retainer rings.
 - c. Pressure Rating: 190 psi.
 - d. Manufacturers:
 - 1) Standard: Proco Series 230; Holz Type 200; Garlock Style 200HP; or equal.
 - 2) Concentric Reducers: Proco RC Series; Holz 200TC.
 - 3) Eccentric Reducers: Proco RE Series; Holz 200TE.
 - 4) For connections to plastic piping systems provide connectors with additional flexibility as recommended by the manufacturer. Proco Series 261R; Holz Type 320EZ; or equal.
 - 2. Larger than 12-inch-Diameter:
 - a. Type: Built-up, single arch (unless otherwise shown on Drawings) with full rubber flanges and retaining rings.
 - b. Materials: Neoprene cover over nitrile tube, reinforced with nylon or polyester body and galvanized steel retainer rings. Protect cover with Hypalon paint where exposed outdoors.
 - c. Pressure Rating: 80 psi.
 - d. Manufacturers:
 - 1) Standard: Proco Series 230; Holz Type 200, Garlock Style 200HP, or equal.
 - 2) Concentric Reducers: Proco RC Series; Holz 200TC.
 - 3) Eccentric Reducers: Proco RE Series; Holz 200 TE.
 - 4) For connections to plastic piping systems provide connectors with additional flexibility as recommended by the manufacturer. Proco Series 261R; Holz Type 320EZ; or equal.
 - 3. High Pressure Applications:
 - a. Type: Fixed-flange, bellows type with integral flow liner and limit rod lugs.
 - b. Materials:
 - 1) Flanges: Carbon steel conforming to ASTM A36
 - 2) Bellows: Laminated ASTM A240 Type 304 stainless steel.
 - 3) Flow Liner: ASTM A240 Type 304 stainless steel.
 - 4) Limit Rods: ASTM A307 bolts, A563 nuts.
 - c. Pressure Rating: 300 psi minimum.
 - d. Connections: 300 lb drilled in conformance with ANSI B16.5.
 - e. Manufacturer: Hyspan Model 5501R; Microflex; or equal.
 - 4. Restraint: Provide galvanized steel control rod-compression sleeve assemblies for all flexible spools, except where pipelines cross structural expansion joints or where specifically omitted by note in the Drawings.

Number and size of control rods shall be as required for the test pressure of the pipe system or 50 psi, whichever is greater.

5. Provide full-size intermediate metal pipe flanges where rubber spool connects with wafer style valves, lug style valves, or other pipeline items that do not have full-face metal flanges.

G. Flexible Metal Hose:

1. Braid enclosed corrugated metal hose with factory attached ends with male pipe threads in sizes to 1-½-inch and with flanges for sizes 2-inch and larger. Units shall have minimum live length as recommended by the manufacturer for maximum misalignment of ½-inch unless larger misalignment requirement is shown on the Drawings.
2. Minimum Pressure Ratings:

Service	Minimum Working Pressure (psi)
Compressed Air	300
Water	150

3. Material: AISI Type 316 ELC stainless steel.
4. Manufacturers: Flexonics Series 401; Anaconda Type LW and BW; or equal.

2.05 CONNECTION DEVICES FOR DRAINAGE MANHOLES

- A. Transition Couplings: Transition couplings shall be elastomeric plastic or synthetic rubber-resistant to sewage and grease, chemical and normal sewer gases. Couplings shall be designed to slip over the outside of the pipes being connected with a snug fit. Couplings shall be held in place and sealed with a stainless steel band clamp around each end. Couplings shall be specifically manufactured for making the transition between various types of pipe with different outside diameters. Couplings shall meet the requirements of the Uniform Plumbing Code. Fernco; Indiana Seal; or equal.
- B. Transition Donuts: Transition donuts shall be elastomeric plastic resistant to sewage and grease, chemicals and normal sewer gases. They shall be designed to be inserted into the bells of sewer pipe to adapt the bell to accept the spigot of a smaller size pipe. They shall have reversed fins on the inside and outside to grip the bell and spigot. Transition donuts cast or grouted into concrete pipe or manhole sections shall have an outside diameter at least 2 inches greater than the inside diameter. Fernco; Indiana Sea; or equal.
- C. Manhole Adaptors: Manhole adaptors shall be SBR rubber manhole waterstops for use with PVC sewer pipe, Fernco, or equal.
- D. Flexible Manhole Connectors: ASTM C923.
- E. House sewer service lateral connections between existing pipe and cast iron soil pipe replacement pipe shall be made with rubber couplings and elastomeric bushings sealed with stainless steel banks; Calder couplings as manufactured by Joints, Inc.; Fernco; or equal.
- F. Other Devices: Other equivalent connection devices will be considered provided they are made of elastomers resistant to sewage and grease, chemicals, and normal sewer gases. Metallic parts shall be stainless steel.

2.06 VALVES AND ACCESSORIES

- A. Valve and Accessory System Designation: Most valves and accessories to be furnished and installed are identified by a valve and accessory system designated by a letter symbol in the Pipe Schedule.
- B. General Requirements for Valves:
 - 1. All valves of each type shall be the product of one manufacturer.
 - 2. All exposed valves shall be furnished with operators, handwheels, levers, or other suitable type wrench including handles as specified herein or as shown on the Drawings. Valves 4-inch and larger located more than 7 feet above the floor level shall be furnished with chain operators. Chains shall be galvanized and shall extend to within 3 feet of the floor. Provide hook so that chain may be stored clear of walkways. All buried valves shall be provided with 2-inch-square operating nut and valve boxes.
 - 3. All threaded stem valves shall open by turning the valve stem counter-clockwise.
 - 4. All exposed valves and valve operators shall have a non-bleeding shop coat, unless otherwise specified. Buried valves and operators shall be painted with System 7 as specified in Section 09 96 00.
 - 5. Electric Valve Actuators: See Section 40 92 13.
 - 6. Pneumatic Valve Actuators: See Section 40 92 14.
- C. General Requirements for Accessories: Pressure Gauges: Provide shutoff valves for all pressure gauges. Conform to additional requirements in this Section below.
- D. Valve and Accessory Systems: See Piping Schedule on Sheet G1.12.
 - 1. Valve and Accessory System A:
 - a. Applicable Service Condition: Clean water and air, including BWS, BWW, CLAW, CLCW, CWR, CWS, FFW, FS, MFE, MFF, PUW, PW, SBW, SE, WW and associated samples, DRs and OFs.
 - b. Gate Valves through Size 2-inch (GV-2):
 - 1) Rating: 200 psi WOG.
 - 2) Type: Rising stem, screw in bonnet, solid wedge disc, handwheel operated.
 - 3) Connections: Threaded.
 - 4) Materials: All bronze.
 - 5) Manufacturers: Jenkins Figure 81OJ; Crane No. 428; or equal.
 - c. Gate Valves 2-½-inch through 12-inch (GV-2):
 - 1) Rating: 200 psi WOG.
 - 2) Type: Rising stem, O.S. and Y, solid wedge, handwheel operated.
 - 3) Connections: Flanged, 200 psi WOG.
 - 4) Materials: Cast iron, bronze trimmed.
 - 5) Manufacturers:
 - a) Jenkins Figure 651A; Crane No. 465 1/2; or equal.
 - b) For system pressure above 200 psi, provide Jenkins Figure 20J; Crane 7-1/2 E; or equal.
 - d. Ball Valves (BV-1): See Valve and Accessory System L.
 - e. Ball Valves through size 4-inch in metal piping (BV-3):
 - 1) Rating: 400 psi WOG.
 - 2) Type: Lever.
 - 3) Connections: Threaded.

- 4) Materials: Bronze body, chrome-plated ball, Teflon seats.
- 5) Manufacturers: Apollo 70-100; Watts B-6000; or equal.
- f. Swing Check Valves through size 2-inch (CV-1):
 - 1) Rating: 300 psi WOG.
 - 2) Type: Swing, composition disc.
 - 3) Connections: Threaded.
 - 4) Materials: All bronze, except disc shall be Teflon.
 - 5) Manufacturers: Jenkins 352; Crane 141; or equal.
- g. Swing Check Valves 2-inch through 12-inch (CV-1):
 - 1) Rating: 175 psi
 - 2) Type: Swing, metal seats, outside spring and lever, AWWA C508.
 - 3) Connections: Flanged, 125-pound ANSI.
 - 4) Materials: Cast iron, bronze trim.
 - 5) Manufacturers: M & H Style 259; equivalent by Clow; or equal.
- h. Stainless Steel Check Valves (CV-3): See Valve and Accessory System Q.
- i. Twin Element Check Valves (CV-6):
 - 1) General: Lug type, designed to fit between ANSI flanges. Provide where shown on the Drawings.
 - 2) Design: Valve shall have two movable elements, called doors, which provide a tight shutoff when there is no flow in the pipe. The twin doors shall be spring-loaded by means of a heavy-duty stainless steel torsional spring. The doors shall open when there is flow in the pipe. As the flow is reduced, the doors shall slowly close and shut tight when the flow is reduced to zero velocity. The entire assembly shall be designed to close without slamming.
 - 3) Materials:
 - a) Seat: Buna N rubber, mounted on the body.
 - b) Body: Cast steel, ASTM A216 WCB or ductile iron, ASTM A536.
 - c) Doors: Cast steel, ASTM A216 WCB; or aluminum bronze, ASTM B148 C95200.
 - d) Spring, Hinge Shaft, and Stop Shaft: Type 316 stainless steel.
 - 4) Manufacturers: Duo-Chek, by TRW Mission Manufacturing Company; Double Door Check Valve, by APCO; or equal.
- j. Globe Style Silent Check Valves 3-inch and Larger (CV-8):
 - 1) Rating: 200 psi through 12-inch, 150 psi above 12-inch size.
 - a) Except 300 psi rating for PW service
 - 2) Headloss: Not more than 2.5 ft. at 8 ft./sec. velocity.
 - 3) Type: Center guided plug with spring operated shut-off.
 - 4) Connections: Flanged, 125-pound ANSI, except pressure class 300 for PW service. If connecting flanges are not full-face metal flanges, provide intermediate flanges where required to retain valve seat.
 - 5) Materials: Cast iron, bronze trim, stainless steel spring, except ASTM A536, pressure class 300 for PW service.
 - 6) Manufacturers: APCO Series 600; Valmatic 1800 Series; or equal.

- k. Pressure Gauge Assembly: See Section 40 73 00 - Pressure Measurement.
- l. Strainers (STR-1):
 - 1) Rating: 125 psi.
 - 2) Type: Y-type basket strainers, 20-mesh.
 - 3) Connections: Threaded or flanged.
 - 4) Materials: Iron body, stainless steel screen.
 - 5) Manufacturers: Bailey 100A; Hoffman Series 400, 450; or equal.
 - 6) Installation: Each to be complete with ball valve on blow-off and piping to drain.
- m. Solenoid Valves (SV-1): Valves shall be for 150-psi water pressure, 120-Volt ac service, with a watertight enclosure. Valve body shall be brass, seats Buna-N, with stainless steel plug. Valves shall be normally closed except where noted otherwise. Provide manual override control. Valves shall be ASCO Bulletin 8211; Skinner L or R Series; or equal.
- n. Pressure Reducing Valves:
 - 1) Self-Contained: Watts No. U5B for low flows or 223B for flows to 170 gpm; Cashco Model D for low flows or Model 8310 HP, LP DS for flows to 170 gpm.
 - 2) Provide strainers with stainless steel screens for each pressure reducing valve unless otherwise noted.
 - 3) Sizes, capacities and pressures shall be as noted on the Drawings.
- o. Globe Style Pilot-Controlled Valves (PCV-2):
 - 1) Rating: 175 psi
 - 2) Type: Hydraulic pilot-controlled, globe style for pressure reducing and regulating service.
 - 3) Pressure Rating: 150 psi.
 - 4) Connections: Flanged, 125-pound ANSI.
 - 5) Materials: Iron body with fusion epoxy lining, stainless steel and/or bronze trim, Buna-N elastomers.
 - 6) Manufacturers: Cla-Val; OCV; Watts; Singer; or equal.
- p. Globe Style Pilot-Controlled Valves (PCV-3):
 - 1) Rating: 300 psi
 - 2) Type: Hydraulic pilot-controlled, globe style for pressure reducing and regulating service.
 - 3) Pressure Rating: 300 psi.
 - 4) Connections: Flanged, 300-pound ANSI.
 - 5) Materials: Iron body with fusion epoxy lining, stainless steel trim, Buna-N elastomers.
 - 6) Manufacturers: Cla-Val; OCV; Watts; Singer; or equal.
- q. Globe Style Pilot-Controlled Valves (PCV-7):
 - 1) Type: Hydraulically operated pilot-controlled, globe style for pressure reducing service.
 - 2) Pressure Class: 300 psi.
 - 3) Connections: Flanged, 300-pound ANSI.
 - 4) Materials:
 - a. Valve body and cover: Ductile iron ASTM A536, fusion epoxy lining
 - b. Buna-N elastomers
 - c. Anti-cavitation Trim: stainless steel
 - 5) Orifice Plate:

- a. Provide downstream of valve where show on the Drawings.
- b. Beta Ratio: 0.60
 - 6) Manufacturers: Cla-Val Model 90-01KO; OCV; Watts; Singer; or equal."
- r. Needle Valves (NV-1): See Valve and Accessory System Q.
- s. Rotameters: Rotameters shall be as specified in Section 40 71 00.
- t. Static Mixers: See Section 46 33 40.
- u. Butterfly Valves (BFV-1): See Valve and Accessory System Q.
- v. Butterfly Valves (BFV-4):
 - 1) Standard: AWWA C504, except as modified herein.
 - 2) Type:
 - a) 3-inch through 12-inch: Wafer body, except short body flanged or mechanical joint where shown on the Drawings, or where buried.
 - b) 14-inch through 72-inch: Short body flanged or mechanical joint where shown on the Drawings.
 - c) Geared operator, resilient seated, 90° seating.
 - 3) Pressure Class:
 - a) 3-inch through 12-inch: 150 psi, except 250 psi for PW and PUW service applications.
 - b) 14-inch through 72-inch: 150 psi, except 250 psi for PW and PUW service applications, or unless shown otherwise on the Drawings.
 - c) Valves shall be leak-tight at rated pressure in either direction.
 - 4) Materials:
 - a) Body: Cast Iron; ASTM A126, Class B, or ASTM A48, Class 40, except ASTM A536, pressure class 300 for PW service .
 - b) Disk: Cast or ductile iron with Ni-Chrome or Type 316 stainless steel edge.
 - c) Valve Shaft: Type 304 or Type 316 stainless steel, except for PW and PUW service, material shall be ASTM A Type 630, condition H-1150.
 - d) Seats: Buna-N.
 - 5) Construction:
 - a) Seats: Applied to body. Cartridge type seats with retaining rings are not acceptable.
 - b) Disk to Shaft Connection: Stainless steel taper pins or torque plug.
 - c) Valve Diameter Limitation: Internal diameter of valve at the throat shall be no less than the nominal diameter of the valve less 1-½ inches.
 - d) Bearings shall be self-lubricating and corrosion-resistant.
 - 6) Finish:
 - a) Exposed Exterior: Shop prime compatible with field applied finish coats. Refer to Section 09 96 00.
 - b) Buried Exterior: Shop coat with high-solids epoxy, 12 mils minimum.
 - c) Interior: Shop line with two-component, high solids epoxy, AWWA C550.

- 7) Testing: Test in accordance with AWWA C504, except that leakage test shall be in both directions. Submit certified test results for tests specified in Section 5.2 for valves 24 inches and larger.
- 8) Actuators:
 - a) Type: Manual, except where specified otherwise, or shown otherwise on the Drawings. Provide valve position indicators on all actuators.
 - b) Manual Actuators: Traveling nut, self-locking, or worm gear above 48 inches.
 - (1) Buried: Designed for buried service, watertight up to 10 psi. Provide 2-inch-square standard AWWA operating nut, with extension stem to reach the ground surface as shown on the Drawings, and with a ground level position indicator.
 - (2) Provide three valve operator tee handles to the Owner.
- 9) Manufacturer:

Size Range	Type	First Name	Second Name or Equal
3-inch -12-inch	Wafer	Pratt, MKII	-
3-inch – 20-inch	Flanged	Pratt, 2FII, Pratt HP 250 for PW and PUW service	DeZurik, BAW
24-inch - 72-inch	Flanged	Pratt, XR-70	DeZurik, BAW
Buried 6-inch – 48-inch	Flanged	Pratt Groundhog	DeZurik, BAW

- w. Air Valves:
 - 1) Standard: AWWA C512, except as modified herein.
 - 2) Air Release Valves (ARVs) (ARV-1):
 - a) Function: Releases accumulated air under pressure at pipeline high points.
 - b) Materials: Cast or ductile iron body; stainless steel float.
 - c) Pressure Rating: 150 psi, except 300 psi in PW and PUW service applications.
 - d) Manufacturers: Apco Series 200; equivalent by Valmatic; or equal.
 - 3) Air and Vacuum Valves (AVVs):
 - a) Function: Exhausts large volumes of air during pipeline filling and allows air back in when pipeline pressure drops below atmospheric pressure.
 - b) Provide slow closing Surge Check below air valve consisting of a globe style, sliding disc spring return valve.
 - c) Materials: Cast or ductile iron body; stainless steel float.
 - d) Pressure Rating: 150 psi.
 - e) Manufacturers: Apco Series 140 or 150; equivalent by Valmatic; or equal.
 - 4) Combination Air Valves (CAVs):
 - a) Function: Exhausts large volumes of air during pipeline filling, releases accumulated air under pressure and allows air back in when pipeline pressure drops below atmospheric pressure.

- b) Provide slow closing Surge Check below air valve consisting of a globe style, sliding disc spring return valve.
 - c) Materials: Cast or ductile iron body; stainless steel float.
 - d) Pressure Rating: 150 psi.
 - e) Manufacturers: Apco Series 140C or 150C; equivalent by Valmatic; or equal.
- 2. Valve and Accessory System C:
 - a. Applicable Service Condition: ammonium sulfate, calcium hydroxide, ferric chloride, sodium bisulfite, sodium hydroxide, sodium hypochlorite, CF, CIPA, CIPB, CIPR, CIPS, CIPW, CLW, CR, PCR and REC, as well as associated sample waters, tank OFs and DRs and including DRs from associated spill containment areas .
 - b. Air Release Valves (ARV-2):
 - 1) Type: Plastic combination air release valve.
 - 2) Connection: Threaded.
 - 3) Rating: 150 psi operating pressure.
 - 4) Material: Body and base shall be nylon. Drainage elbow shall be polypropylene. Float shall be foamed polypropylene. Seals shall be EPDM.
 - 5) Manufacturer: A.I.R. Flow Control Accessories model D-040, or equal.
 - c. Ball Valves Through 4-inch Size (BV-2):
 - 1) Rating: 150 psi at 75°F.
 - 2) Type: Double union.
 - 3) Connections: Socket.
 - 4) Materials: PVC body, teflon seats and EPDM O-ring seals, except Viton O-ring seals with chlorine solution.
 - 5) Manufacturers: R&G Sloane, Asahi/America Pro Block, or equal.
 - d. Ball Valve (BV-8): Use BV-2 with vent hole drilled in upstream side of valve to allow degassing.
 - e. Check Valves Double Union Type (CV-4):
 - 1) Rating: 150 psi at 75°F.
 - 2) Type: Ball for horizontal or vertical service.
 - 3) Connections: Union ends for socket weld.
 - 4) Materials: PVC body, Viton O-ring seals and seats except provide EPDM for caustic service.
 - 5) Manufacturers: Chemtrol True Union BC, Plastiline No. 8611, or equal.
 - f. Check Valve (CV-2): See Valve and Accessory System Q
 - g. Diaphragm Valves (DPV-2):
 - 1) Rating: 150 psi.
 - 2) Type: Weir type diaphragm.
 - 3) Connections: Flanged or true union.
 - 4) Materials: PVC bodies with EPDM/TFE bonded diaphragms.
 - 5) Manufacturers: Asahi/America Type 72, Gemü, or equal.
 - 6) Actuators:
 - a) Type: Manual, except where specified otherwise, or shown otherwise on Drawings. Provide local, visual, valve position indicators on all actuators. Provide manual override on all motor actuators.

- b) Motor Actuators: Provide motor, limit switches, and gearing within a NEMA 4 enclosure. Motor shall be reversible for use with 115V single-phase power. Unit shall accept remote open and close dry contacts and shall include position indicating limit switches for remote indication of open and closed positions.
- h. Diaphragm Valves (DPV-3): See Valve and Accessory System H.
- i. Butterfly Valves (BFV-3):
 - 1) Rating: Class 150
 - 2) Style: Lugged
 - 3) Construction
 - a) All materials in contact with process fluids shall be PFA, PTFE EPDM with EPDM seals. All valves shall be furnished with upper and lower bearings/bushings of PTFE material. Shaft seals shall be provided to prevent leakage and to protect bearings from internal or external corrosion.
 - b) Valve seats shall be of the reinforced resilient type and shall be field replaceable. Seats shall also act as a body liner to prevent flow from contacting the body casting. Seats shall have flange sealing to provide a positive seal without use of flange gaskets.
 - c) Body wall shall exceed requirement for AWWA C504 Class 150 standard.
 - 4) Materials
 - a) Body: 1 or 2 piece cast iron or ductile iron body
 - b) Disc: 316 stainless steel disc coated with one of the following materials:
 - (1) EPDM
 - (2) PFA
 - (3) PTFE.
 - c) Shaft/Stem: 316 or 416 Stainless Steel, blow out proof.
 - d) Bushings: PTFE
 - e) Pins: Stainless Steel
 - f) Seats and Seals one of the following:
 - (1) EPDM
 - (2) FKM (Viton)
 - (3) PTFE
 - (4) PFA
 - 5) Manufacturer:
 - a) John Crane (Xomox)
 - b) Keystone Keychem
 - c) Bray
 - d) DeZurik
 - e) Or equal.
- j. Strainers (STR-2):
 - 1) Rating: 150 psi.
 - 2) Type: Wye-type or cylinder basket strainers as shown. Strainer screen size as recommended by feed pump supplier or 20 mesh if not listed.
 - 3) Connections: Threaded less than 2-inches, flanged ANSI Class 150 above.

- 4) Materials: PVC or CPVC to match connected piping.
- 5) Manufacturers: Spears, Chemtrol, GF, or equal.
- 6) Installation: Each to be installed with ball valve blow-off and piping to drain.
- k. Vacuum Relief Valves (VRV-2):
 - 1) Type: Self-closing check valve; normally closed design; can be mounted in any position; spring to provide rapid closure against seat; minimum cracking pressure to open valve – 1.0 to 1.5 psi.
 - 2) Connection: Threaded.
 - 3) Rating: 100 psi at 120 degrees F.
 - 4) Material: PVC body; Teflon PFA encapsulated stainless steel spring.
 - 5) Manufacturer: Plast-O-Matic series CKS, or equal.
- l. Pressure gauges shall be as specified in Section 40 73 00 - Pressure Measurement.
- m. Rotameters shall be as specified in Section 40 71 00.
- n. Refer to Section 46 33 40 for calibration cylinders (CC-1), pulsation dampeners (PD-1), pressure relief valves (PRV-2) and backpressure control valves (PCV-3).
3. Valve and Accessory System E:
 - a. Applicable Service Conditions: Clean water at pressures to 150 psi and temperatures to 150°F utilizing copper piping.
 - b. Gate Valves through 2-½-inch:
 - 1) Rating: 200 psi water.
 - 2) Type: Rising stem, solid wedge.
 - 3) Connections: Solder ends for copper pipe.
 - 4) Materials: All bronze.
 - 5) Manufacturers: Jenkins; Crane; or equal.
 - c. Globe Valves through 2-½-inch:
 - 1) Rating: 200 psi water.
 - 2) Type: Renewable disc, globe or angle.
 - 3) Connections: Solder ends for copper pipe.
 - 4) Materials: All bronze.
 - 5) Manufacturers: Jenkins; Crane; or equal.
 - d. Check Valves through 2-½-inch:
 - 1) Rating: 200 psi water.
 - 2) Type: Regrinding swing check.
 - 3) Connections: Solder ends for copper pipe.
 - 4) Materials: Bronze with bronze or brass disc.
 - 5) Manufacturers: Jenkins; Crane; or equal.
 - e. Pressure Relief Valves:
 - 1) Rating: 150 psi for valves 2-inch and smaller.
 - 2) Type: Adjustable spring loaded.
 - 3) Connections: Threaded.
 - 4) Materials: Bronze body.
 - 5) Manufacturers: Consolidated 2478; Farris 1400S; or equal.
 - f. Ball Valves shall be as specified under Valve and Accessory System A.
 - g. Strainers shall be as specified under Valve and Accessory System A.
 - h. Pressure gauges shall be as specified in Section 40 73 00 - Pressure Measurement.

4. Valve and Accessory System H:
- a. Applicable Service Conditions: Sulfuric acid (concentrated) and Threshold Inhibitor, as well as the DR from associated spill containment areas.
 - b. Valves: Alloy 20 stainless steel conforming to ASTM A351/A296, Grade CN-7M, unless otherwise noted below. Socket weld ends, with pressure rating of 150 psi at 180°F. Suitable for use with concentrated sulfuric acid (93% concentration, 66 degree Baume).
 - 1) Ball Valves (BV-2): See Valve and Accessory System C.
 - 2) Check Valves (CV-7): Lift or ball type, suitable for horizontal or vertical installation, as applicable. Horizontal valves shall have a bolted cover. Provide metal-to-metal seats.
 - 3) Check Valves (CV-9): Alloy 20 corrosion-resistant, spring-assisted check valves shall operate via a poppet mechanism which deflects under pressure to allow flow and returns to position to seal flow. Maximum operating pressure shall be 750 psig. Body, disc, seat and springs shall be Alloy 20; Durabla Fluid Technologies (DFT) Inc. or equal.
 - 4) Pressure Control Valves (PCV-3): Chemical service backpressure regulator; specified in Section 46 33 40.
 - 5) Pressure Relief Valves (PRV-2): See Valve and Accessory System C.
 - 6) Diaphragm Valves:
 - a) DPV-1:
 - (1) Type of End Connection: Threaded, spigot, solvent weld, flanged.
 - (2) Size (inches): 1/2" - 6".
 - (3) Operator: Handwheel with indicating bonnet.
 - (4) Body Material: Polypropylene
 - (5) Diaphragm: EPDM backed PTFE
 - (6) O-ring: EPDM
 - (7) Manufacturer:
 - (a) GF Plastic Systems, Type 314, Type 317.
 - (b) ITT Dia-Flow,
 - (c) Asahi
 - (d) Or equal.
 - b) DPV-3:
 - (1) Type of End Connection: Butt-weld or Flanged, Class 150.
 - (2) Size (inches): 1/2" – 2".
 - (3) Operator: Handwheel with indicating bonnet.
 - (4) Rating and Description:
 - (a) Valves shall be butt weld or flanged weir type valves.
 - (b) They shall have Type 316 stainless steel bodies and hardware; EPDM backed Teflon diaphragm; and indicating cast iron sealed bonnet with adjustable travel stop. Stem bushing shall be bronze.

- (5) Manufacturer:
 - (a) ITT Dia-Flo Figure No 2466 (or No. 2433)-R2-913-S1-B316
 - (b) Or equal
- c) DPV-4:
 - (1) Type of End Connection: Spigot, Flanged.
 - (2) Size (inches): 1/2" - 6".
 - (3) Operator: Handwheel with indicating bonnet.
 - (4) Rating and Description:
 - (5) Body Material: PVDF
 - (6) Diaphragm: EPDM backed PTFE
 - (7) O-ring: Viton
 - (8) Manufacturer and Product: Provide the following:
 - (a) GF Plastic Systems, Type 314, Type 317.
 - (b) ITT Dia-Flow,
 - (c) Asahi
 - (d) Or equal.
- d) DPV-5:
 - (1) Type of End Connection: Flanged, Class 150
 - (2) Size (inches): 3/4" – 2"
 - (3) Rating and Description:
 - (a) Valves shall be flanged ductile iron weir type valves with PVDF lining and Type 316 stainless steel hardware.
 - (b) They shall have an EPDM backed Teflon diaphragm and manual actuator.
 - (c) The valves shall be furnished with an indicating cast iron sealed bonnet with adjustable travel stop; PVDF coated cast iron compressor; stainless steel tube nut; and PVDF coated body and topworks.
 - (4) Manufacturer:
 - (a) ITT Dia-Flo Model No. 2555-R2-903S-M8-M10-B316-C3
 - (b) Or equal
- c. Pressure Gauges: See Section 40 73 00 - Pressure Measurement.
- d. Static Mixers: Stainless steel Alloy 20 and with connections as shown on the Drawings. See Section 46 33 40.
- e. Quick Connect Coupling Assembly: Provide male adaptor coupler for connecting delivery truck hose to the sulfuric acid storage tank fill piping. Connection to fill pipe shall be threaded. Provide lockable coupling adaptor cap with chain secured to fill pipe. Material shall be Alloy 20 stainless steel. Cap gasketing shall be as recommended by the manufacturer to suit chemicals handled. Coupling adaptor and cap assembly shall be OPW Products Series 633, equivalent Andrews, or equal.
- f. Rotameters: Rotameters shall be as specified in Section 40 71 00.
- g. Flexible Connectors: Provide where shown on the Drawings. Flexible connectors shall be flexible spools as specified herein in paragraph 2.04D.1 except that:

- 1) The tubing elastomer shall be TFE and the tubing cover shall be Viton.
- 2) Retainer rings shall be Type 316 stainless steel.
- 3) Manufacturers: Holz, Spanflex, Model SFR; equivalent Garlock; or equal.
- h. Dielectric Unions: Materials shall be suitable for concentrated sulfuric acid service.
5. Valve and Accessory System I:
 - a. Applicable Service Conditions: Compressed air to 200 psig, including CA and HA.
 - b. Check Valves (CV-2): See Valve and Accessory System Q.
 - c. Check Valves ½-inch to 1-inch (CV-5)
 - 1) Check valves equal to or less than 1 inch used to isolate piping from air service shall be a spring-loaded poppet or ball style stainless steel with a 1/2 psi cracking pressure.
 - 2) Manufacturer:
 - a) Apollo, Model 62
 - b) Swagelok, Model C
 - c) Circle Seal, Models 100, 2200
 - d) Or equal
 - d. Automatic Drain Valve (ADV-1): See Section 43 42 20.
 - e. Pressure Relief Valves (PRV-1): See Section 43 42 20.
 - f. Pressure Reducing Valves: Valves shall have an adjustable range from 3 to 125 psi with integral gauges. Valves shall be as manufactured by Wilkerson Model 2001 or 2015; Parker Hannifin 2000; 4000, or 6000 Series; or equal. See Drawings for sizes, capacities, and pressure reduction.
 - g. Ball Valves (BV-1):
 - 1) Metal ball valves shall be used where indicated.
 - 2) Materials: 316 stainless steel ball and Teflon seat.
 - 3) Valves shall be rated for a minimum of 350 psi WOG, except 250 psi for PW surge tank service.
 - 4) Manufacturer:
 - a) Apollo, Model ~~8776~~
 - b) Warren, Model 1010
 - c) Nuline, Model S70
 - d) Or equal
 - h. Butterfly Valves: (BFV-1) See Valve and Accessory System Q; (BFV-2) See Valve and Accessory System P.
 - i. Solenoid Valves (SV-2):
 - 1) Type: 2-way, direct-lift, pilot-operated valves shall be rated for 150-psi min. operating pressure (air), 120-Volt ac service, Cv factor 5.0, with a watertight enclosure. Valves shall be normally closed except where noted otherwise. Provide manual override control.
 - 2) Materials: Valve body shall be brass, Buna-N (NBR) seat, with stainless steel plug.
 - 3) Manufacturer: ASCO Bulletin 8210; Skinner 7321 Series; or equal.
 - j. Automatic Drain Valves (ADV-1): See Section 43 42 20

- k. Needle Valves (NV-2):
 - 1) Needle valves for pressure transmitters shall be supplied with inlet isolation valve and a bleed valves located on the transmitter side of the process. Isolation and Bleed valve shall be provided with a tee type handle. Calibration and transmitter connections shall share and sense the same pressure. The calibration piping connection is plugged during normal operation. Calibration can be performed by removing the pipe plug.
 - 2) Materials: Type 316 stainless steel
 - 3) Acceptable Manufacturer
 - a) Anderson Greenwood
 - b) Parker
 - c) Swagelock (Whitey)
 - d) Or equal
- l. Flexible Connectors: American BOA Type BCT; or equal.
- m. Pressure Regulator (PCV-1): Norgen 11-004, stainless steel internals; Wilkerson; or equal.
- n. Pressure Gauges: See Section 40 73 00 - Pressure Measurement
- 6. Valve and Accessory System L:
 - a. Applicable Service Conditions: Hydrogen Peroxide, Oxygen (LOX), Gaseous Oxygen (GOX), Ozone, Ozone Gas Treated Secondary Effluent (OSE), Sample GOX, Sample OSE, and Sample OZ.
 - b. Ball Valves Through Size 4-Inch
 - 1) BV-1: See Valve and Accessory System I.
 - 2) BV-2: See Valve and Accessory System C.
 - 3) BV-9:
 - a) Rating: 275 psi.
 - b) Actuator Type: Pneumatic or electric or lever, as shown.
 - c) Connections: Flanged.
 - d) Materials: 316 stainless steel with teflon seats. Hydrogen peroxide service valves shall have vent hole drilled in upstream side of valve to allow degassing of peroxide.
 - e) Manufacturers: Neles-Jamesbury Type 5150, Worcester Model 8266 T150, or equal.
 - 4) BV-10:
 - a) Metal ball valves used in LOX system.
 - b) Actuator Type: Lever
 - c) Connection: Flanged
 - d) Materials: 316 stainless steel ball and teflon seat.
 - e) Valves shall be rated for a minimum of 300 psi WOG.
 - f) Manufacturer: Worcester C44, or equal
 - c. Check Valves (CV-2 & CV-3): See Valve and Accessory System Q.
 - d. Pressure Reducing Valves for Oxygen and Ozone Service:
 - 1) Rating: 400 psi.
 - 2) Type: Suitable for Cryogenic Service.
 - 3) Connections: Flanged.
 - 4) Materials: 316 stainless steel.
 - 5) Manufacturers: Cash Type G-60; Leslie equivalent; or equal.
 - e. Pressure Relief Valves for Oxygen and Ozone Service (PRV-3):
 - 1) Rating: 300 psi.

- 2) Type: Adjustable, spring-loaded type set to relieve not less than 100 SCFM at 0 psig.
 - 3) Connections: Flanged.
 - 4) Materials: 316 stainless steel.
 - 5) Manufacturers: Farris Series 1850-RS4; equivalent by Kunkle; or equal.
- f. Vacuum Relief Valve for Oxygen and Ozone Service (VRV-1):
- 1) Rating: 100 psi.
 - 2) Type: Suitable for ozone concentrations as high as 5.0%.
 - 3) Connections: Flanged.
 - 4) Materials: 316 stainless steel body and trim.
 - 5) Manufacturers: Varec Model 2010, or equal.
- g. Solenoid Valves for liquid and gaseous oxygen, with a gastight enclosure:
- 1) Rating: 250 psi for $\frac{1}{4}$ -inch valves; 50 psi for $\frac{1}{2}$ -inch valves).
 - 2) Type: Two-way normally closed. Provide manual override control.
 - 3) Connections: Flanged.
 - 4) Materials:
 - a) Body and plug: 316 stainless steel.
 - b) Seats: Viton.
 - 5) Manufacturers: ASCO, Actomatic, or equal.
- h. Rupture Disks for Hydrogen Peroxide and LOX Systems:
- 1) Rating: 150 psi.
 - 2) Type: Pre-bulged with screw type holder (30-seat).
 - 3) Connections: $\frac{1}{2}$ -inch NPT.
 - 4) Materials: Type 316 stainless steel holder, aluminum disc with Teflon coating on upstream side.
 - 5) Manufacturers: Fike or equal.
- i. Moisture Trap and Drainer:
- 1) Rating: 200 psi.
 - 2) Type: Snap action float.
 - 3) Materials: Stainless steel body and float.
 - 4) Manufacturers: Armstrong, No. 71A; Wilkerson 5100-4; or equal.
- j. Butterfly Valves: (BFV-1) see Valve and Accessory System Q; (BFV-2) see Valve and Accessory System P.
- k. Globe Valves - Modulating Service (FCV-1):
- 1) Description: High performance, linear and balanced cage guided globe valve with one- or two-stage anti-cavitation trim.
 - 2) Operating Conditions:
 - a) Service: RO concentrate control valve(s)
 - b) Flow Range
 - (1) 330 gpm maximum
 - (2) 195 gpm minimum
 - c) Pressure Drop
 - (1) 100 psi minimum
 - (2) 250 psi maximum
 - d) Minimum Outlet Pressure: 5 psig
 - 3) Provide design calculations at minimum and maximum flow and pressure conditions to determine that the valve is acceptable for operation without cavitation.

- 4) Design Requirements
 - a) Valve Size: 3.0 inches
 - b) Valve Coefficient (Cv) at 20 percent: 8.5 or less
 - c) Valve Coefficient (Cv) at 80 percent: 32 or higher
- 5) Stem Characteristics: Equal Percentage
- 6) End Connections: Flanged, raised face, ANSI Class 300 standard
- 7) Actuator: Power, Multiturn Type E2 for modulating service.
- 8) Materials:
 - a) Body: Type 316 stainless steel
 - b) Bonnet: Type 316 stainless steel
 - c) Cage Retainers: Type 316 stainless steel
 - d) Cage: 17-4 PH
 - e) Seat Ring: 17-4 PH
 - f) Plug: Heat treated Type 420 stainless steel
 - g) Packing: PTFE
 - h) Bolting: Type 316 stainless steel
- 9) Manufacturer:
 - a) Fisher, Design ET with two stage Cavitroll III trim;
 - b) Masoneilan, Model 41635;
 - c) Leslie Aeroflow with LesCav V trim
- l. : See Section 40 73 00 - Pressure Measurement.
- m. Other Valves and Accessories: Same as Valve and Accessory System A except stainless steel piping, material shall be 316 stainless steel and other material resistant to the specified chemicals.
- n. ARV-3:
 - 1) Materials of Construction: Type 316L, Stainless Steel/ CF8M/KEL-F/PTFE
 - 2) Inlet Connection: 3" DIA., ANSI B16.5, CLASS 150, RAISED FACE, SLIP-ON FLANGE
 - 3) Outlet Connection: 1" DIA., ANSI B1.20.1, FEMALE NATIONAL PIPE THREAD (FNPT)
 - 4) Gas Release:
 - a) 4800 SCFH @ 25 PSIG
 - b) 9000 SCFH @ 50 PSIG
 - 5) Cleaned for passivation per ASTM A380 Guidelines: passivated per ASTM A967 Specifications
 - 6) Manufacturers/Model: Mazzei Degas Relief Valves/DRV49-A, or equal

7. Valve and Accessory System P:
 - a. Applicable Service Condition: Air scour (LA). Temperature rating: Unless otherwise specified, valves shall be suitable for working temperature range of 45°F to 250°F.
 - b. Expansion Joint:
 - 1) Type: Bellows.
 - 2) Connection: Flanged.
 - 3) Axial movement: As shown.
 - 4) Materials:
 - a) Bellows: Molded PTFE T-62.

- b) Flanges: Ductile iron.
 - c) Reinforcing Rings: Stainless steel.
 - 5) Manufacturers: Proco or equal.
- c. Needle Valves (NV-2): See Valve and Accessory System I.
- d. Check Valves: See Section 43 42 30.
- e. Strainer (STR-5): See Valve and Accessory System I.
- f. Pressure Relief Valves (PRV-1): See Section 43 42 30.
- g. Butterfly Valves (BFV-2):
 - 1) General: Butterfly valves for air scour service shall conform to the following requirements.
 - 2) Type:
 - a) 3-inch through 20-inch: Wafer body, except short body lug wafer where shown as flanged on the Drawings.
 - b) Modulating or cyclic duty: Valves shall be double offset disc design.
 - c) Valves shall be bubble-tight at rated pressure in either direction.
 - 3) Pressure Rating: ANSI/ASME B16.5 Class 125/150, unless shown otherwise on the Drawings.
 - 4) Materials:
 - a) Body: Type 316 stainless steel
 - b) Disk: Type 316 stainless steel.
 - c) Valve Shaft: Type 316 or Type 416 stainless steel.
 - d) Seats: EPDM or reinforced PTFE suitable for temperatures up to 350°F.
 - 5) Construction:
 - a) Seats: Reinforced resilient type and field replaceable. If cast iron or carbon steel bodies provided, seats shall act as a body liner to prevent piped fluid from contacting the body casting.
 - b) Disk to Shaft Connection: Type 316 stainless steel pins or torque plug.
 - 6) Manufacturers: DeZurik BHP; Tyco Keystone K-Lok; equal.
- 8. Valve and Accessory System Q:
 - a. Applicable Service Condition: Aggressive water, including DPW, FF, FLW, ROF, ROP, UVF, UVP, and associated DRs and OFs.
 - 1) Air Release Valves: (ARV-2) see Valve and Accessory System C.
 - 2) Butterfly Valves
 - a) (BFV-2): use Valve and Accessory System L but at 300 psi class
 - b) (BFV-3): See Valve and Accessory System C.
 - c) (BFV-1):
 - (1) Service Conditions: Install where noted or shown.
 - (2) Style: Lugged
 - (3) Materials
 - (a) Body: 1 piece cast iron or ductile iron body
 - (b) Disc: 316 stainless steel disc
 - (c) Stem: 316 or 416 Stainless Steel
 - (d) Bushings: PTFE
 - (e) Pins: Stainless Steel
 - (f) Seats and Seals – EPDM

- d) All materials in contact with process fluids shall be stainless steel or EPDM. All valves shall be furnished with two upper and one lower bearings/bushings of PTFE material. Shaft seals shall be provided to prevent leakage and to protect bearings from internal or external corrosion.
 - e) Valve seats shall be of the reinforced resilient type and shall be field replaceable. Seats shall also act as a body liner to prevent flow from contacting the body casting. Seats shall have flange sealing to provide a positive seal without use of flange gaskets.
 - f) Valves shall be rated for a minimum of 150 psi bi-directional-“dead end” or 175 psi with directional (with the disc) / 100 psi (against the disc) “dead end” bubble tight shut-off capability without the use of backing flanges. Valves to be suitable for and rated for full vacuum service.
 - g) Body wall shall exceed requirement for AWWA C504 Class 150 standard.
 - h) The disc shall be secured to the shaft using at least 2 Type 316 stainless steel pins or self-locking setscrews.
 - i) Valves shall have the ability to be installed with the disc in the closed position.
 - j) Valves shall be suitable for process air or vacuum service.
 - k) Factory Testing: Test shall be conducted on each valve in accordance with Manufacturer's Quality Control procedures.
 - l) Acceptable Manufacturers:
 - (1) DeZurik – Type BRS
 - (2) Bray 31
 - (3) Centerline Model 200/225
 - (4) Keystone Series 60
- 3) Ball Valves:
- a) (BV-1): See Valve and Accessory System I.
 - b) (BV-2): See Valve and Accessory System C.
- 4) Check Valves:
- a) (CV-2): Same as CV-3 except ANSI Class 150
 - b) (CV-3):
 - (1) Service Conditions: For installation between ANSI Class 300 flanges
 - (2) Pressure Rating: 700 psig minimum.
 - (3) Body: 316 Stainless Steel
 - (4) Seat and Bushings: 316 Stainless Steel
 - (5) Spring and Screws: 316 Stainless Steel
 - (6) Seals: Teflon Seat (required for ozonated water and ozone gas pipelines), Viton (EPDM and Buna-N not allowed)
 - (7) Acceptable Manufacturer:
 - (a) Cameron Techno Style 5053-316
 - (b) Valmatic Model Dual Disc
 - (c) Centerline Model 800
 - (d) APCO Model 9000
 - c) (CV-10):

- (1) PVC or CPVC ball check valves are required for pressure gauges, pump casing drains and other locations as shown on the Drawings when located in a PVC or CPVC line. Mount in vertical direction with flow going up.
 - (2) PVC or CPVC Plastic Ball Check valves shall use a True Union Design.
 - (3) The elastomer shall be Viton.
 - (4) Pressure: 150 psi minimum.
 - (5) Acceptable Manufacturers
 - (a) Nibco - Chemtrol
 - (b) Asahi – Duo Block
 - (c) Spears
 - (d) Or equal
- 5) Needle Valves (NV-1):
 - a) Needle valves and sample valves shall be constructed from Type 316 stainless steel with a regulating stem.
 - b) Connection 1/4" MNPT x 1/4" Compression Fitting
 - c) Provide 90 degree bent tubing from valve
 - d) Acceptable Manufacturer
 - (1) Swagelok (Whitey) Models 1R, 18R
 - (2) Parker
 - (3) Circle Seal
- 6) Pressure Gauges: See Section 40 73 00 - Pressure Measurement.
- 7) Permeate Sample Valve (NV-3)
 - a) Sample Valves for pressure vessel sampling shall be threaded male NPT on the inlet with a hose barb outlet connection.
 - b) Pressure rating: 60 psi minimum.
 - c) Material: PVC with EPDM or Viton seals
 - d) Manufacturer: Asahi or Chemline
- 8) Vacuum Release Valve (VRV-3)
 - a) Description: 1-inch disc-spring type stainless steel vacuum relief valve used on RO train pipe headers
 - b) Operating Conditions: Install where noted or shown
 - c) Design Requirements:
 - (1) Maximum Operating Pressure: 300 psig
 - (2) Maximum Operating Temperature: 100° F
 - d) End Connections: MNPT for threading into header pipe cap
 - e) Relief Mechanism: Spring loaded ball
 - f) Materials:
 - (1) Body: Type 316 stainless steel
 - (2) Retaining Ring: Type 316 stainless steel
 - (3) Spring: Type 316 stainless steel
 - (4) Seals: Viton
 - g) Shall be as manufactured by Durable Fluid Technology, Inc., Model BSSV6; Or equal.
- 9) Multiport Valve (MPV-2)

- a) Description: Stainless steel, 4 way or 5-way rotating plug or ball type valve to be used for monitoring pressure at the train instrument panel.
- b) Operating Conditions: Install on pressure gauges to allow check of pressure at each stage of the RO trains.
- c) Design detent positioning (mechanical stops at 90°)
- d) Requirements:
 - (1) Valve shall incorporate positions) and a 4-position numbered nameplate suitable for panel mounting.
 - (2) Body shall be a two piece design.
 - (3) Lever shall be asymmetric handle type.
- e) Maximum Operating Pressure: 1000 psig.
- f) Rated Operating Temperature: 450 °F.
- g) End Connections: 1000 WOG, ¼-inch FNTF.
- h) Actuator: Manual.
- i) Materials:
 - (1) Body: Type 316 stainless steel
 - (2) Rotor: Type 316 stainless steel
 - (3) Lever: Type 316 stainless steel
 - (4) Seats: PTFE
 - (5) Seals: Viton
- j) Manufacturer:
 - (1) Conant Controls, Model 5316
 - (2) Swagelok
 - (3) Parker
 - (4) Or Equal
- k)

E. Miscellaneous Valves and Accessories:

1. Link-Type Seals: Link-type seals shall be interlocking synthetic rubber links connected by stainless steel bolts and nuts to form a continuous belt. Tightening of the bolts shall expand the rubber to form a watertight seal of the annular space between a pipe and the hole or sleeve in the wall.
2. Pipe Service Saddles for PVC Pipe other than Type V-4 pipe: Service saddles shall be provided where shown on the Drawings. Service saddles shall be the broad band strap type and be suitable for use in service up to 150 psi working pressure and 150°F. Body shall be stainless steel with ¾-inch NPT tap, except where other size is required on the Drawings.
3. Hose Bibb (standard): 'No-kink' design, ¾" female hose inlet (rear) x ¾" hose outlet. Nibco Model 55, Arrowhead Brass Model 353, or equal
4. Exterior Hose Bibb Assembly:
 - a. Hose: 1-½-inch hose in 50-foot lengths with brass pin lug expansion ring couplings having Standard Hose threads; W.D. Allen Figure 34SQ; Potter-Roemer Figure 2911; or equal. Couplings shall be W.D. Allen Figure 101; Potter-Roemer Figure 2938; or equal.
 - b. Spanners: For 1-½-inch pin lug couplings; W.D. Allen Figure 9; Potter-Roemer Figure 6050; or equal.
 - c. Nozzles: Brass shutoff nozzle for 1-½-inch hose with standard hose threads; 5/8-inch tip; W.D. Allen 108B; Potter-Roemer; or equal.
 - d. Angle Valves: Brass with 1-1/2-inch male outlet and 1-½-inch female inlet. Inlet threads shall be IPT, and outlet threads shall be standard

hose threads. Angle valves shall be W.D. Allen Figure 170U; Potter-Roemer Figure 4060; or equal. Provide cap with corrosion-resistant chain.

5. Flexible Rubber Hose:
 - a. General: At each hose rack, provide 50 feet of flexible rubber hose of the same diameter as the hose bibb. Also provide hose at other locations where shown on the Drawings. Provide each hose with nozzle, and male and female threaded connectors. Specifically design all hose to resist deterioration due to weather, sunlight, and outdoor exposure, and to hot water or chlorine solution where applicable.
 - b. Nozzles: Provide compatible nozzles on each hose associated with a hose bibb and hose rack. Nozzles shall be brass or bronze. Nozzles for hoses associated with the CLAW or Plant Utility Water Systems shall have a 5/16-inch-diameter opening.
 - c. Cold Water Service: Provide rubber hose with fiber-reinforced carcass designed for 150 psi working pressure. Provide Newtype Specification No. N-135 or Corsican Specification No. S-3 by Goodall Rubber; Standard Water Hose Style B-11 by American Rubber Manufacturing; or equal.
6. Floor Boxes (Bushing Type): Cast iron, installed with top set at finish grade. Floor boxes shall be suitable for 150 lb/ft² live load. Clow Figure F-5695; equivalent product by Mueller; or equal.
7. Valve Boxes for Buried Valves: Adjustable, cast-iron, screw-type, installed with top set at finished grade. All valve boxes and covers shall be suitable for H20 AASHTO wheel load. Clow Figure F-2454 with Figure F-2476 extension; equivalent products by Mueller; or equal.
8. Concrete Vaults and Valve Boxes: Precast reinforced concrete, of the size and orientation shown on the Drawings. Unless otherwise shown or noted, all vaults, boxes, and their covers shall be designed for H20 AASHTO wheel loads. Steel lids shall be galvanized. Provide Christy, Brooks, or equal.
9. Valve Tags: Plastic, fiberglass, or plastic material, 2-inch square with grommited hole. The tags shall be attached to valves with a brass jack chain. For buried installations use a nylon strap. Lettering shall be stamped or cut into the tag at least 3/16-inch high.
10. Chemical Fill Station Quick-Disconnect Assembly: Consists of a diaphragm or ball check valve, as shown on the Drawings, and a male/female coupling with cam seated washer type seal. Valve types shall be consistent with Valve and Accessory System C, except use Valve and Accessory System L for H2O2. The couplings shall be Monel. Couplings shall be "Kamlock" by OPW or equivalent. Coordinate coupling size with Owner for compatibility with local supplier's chemical delivery equipment.
11. Chemical Sample/Flushing Connections: Consist of a 3/4-inch NPT male fitting in Type 316 stainless steel on the outlet side of a ball or diaphragm valve. As shown on the Drawings. Provide a 5-foot length of 3/4-inch ID wire reinforced, rubber covered Teflon hose with crimped 3/4-inch couplings, male on one end and female on the other.
12. Pipe Escutcheons:
 - a. Manufactured wall, ceiling, and floor plates; cast brass, polished chrome plated, with set-screw, deep pattern type where required to conceal protruding fittings and sleeves.

- b. Inside Diameter: Closely fit around pipe, tube and insulation of insulated piping.
 - c. Outside Diameter: Completely cover opening.
 - d. One-piece design for piping to plumbing fixtures and to equipment in finished spaces.
 - e. Split concealed hinge type for piping not serving plumbing fixtures or equipment in finished spaces.
13. Duckbill Check Valves:
- a. Duckbill check valves shall be all neoprene rubber and flow operated check type with a flanged end connection. The port area shall contour down to a duckbill, which allows passage of flow in one direction while preventing reverse flow. The flange and flexible duckbill sleeve shall be one-piece rubber construction with nylon reinforcement.
 - b. The flange drilling shall conform to ANSI B16.1 Class 125/ANSI B16.5, Class 150 Standards; provide with a 316 stainless steel retaining ring.
 - c. Bolts, nuts, and other hardware for mounting the duckbill check valve shall be 316 stainless steel.
 - d. Manufacturer: Tideflex Series 35, or equal

2.07 THERMAL INSULATION AND HEAT TAPE FOR PLUMBING AND PIPING

A. General:

1. Delivery: Deliver insulation materials to the job in original packages with manufacturer's "R" values clearly shown. Provide certification of compliance.
2. Warning: The Contractor is warned that working with fiberglass or rock wool materials may constitute a serious health hazard. The Contractor shall take all necessary precautions to ensure the safety of the workers.
3. Shields: Insulation protection shields are required per paragraph 2.07C.
4. The following table summarizes the insulation system by use and service:

System	Location	Service	Insulation System	Insulation Thickness (Inches)
HW (Hot Water) (P)	All buildings	E	C	1-inch
All Chemicals	Exposed pipe outside buildings	E	C	¾-inch
LOX	Exposed pipe outside buildings	E	E	2-inch
Air Scour Air	Exposed pipe inside Blower Room	E	A	1-1/2-inch

For System: P = Potable Water

For Service: E = Exposed including concealed space

B = Buried

B. Insulation System A:

1. Material: Insulation shall be a pre-molded fiberglass with a maximum "K" factor of 0.25 at 70°F and having a factory-applied jacket. Fittings shall be insulated with insulating cement or mitered section of pre-molded fiberglass.

2. Fittings shall be covered with a Zeston, Thermazip, or equal jacket. Pipe insulation shall be Johns Manville "Micro-Lok" with foil scrim kraft jacket, with laps and butt straps secured with Benjamin Foster or Arobol adhesive; Owens Corning Fiberglas Type 25 ASJ/SSL; or equal.
 3. Insulation exposed to the weather shall have, in addition, an aluminum waterproof jacket alloy 3003 (0.024-inch); Childers, Alcorjac, or equal.
- C. Insulation System C:
1. Material: Insulation shall be nominal 3/8-inch wall thickness flexible closed celled foamed plastic. Insulation shall have a "K" factor of not more than 0.30 at 70°F. Insulation shall have a usage range from -30°F to 220°F. Insulation shall be Armstrong Armaflex 22; Johns-Manville Aerotube; or equal.
 2. Application: Seal all slit and butt joints with adhesive supplied by manufacturer. Fittings shall be covered with mitered insulation according to manufacturer's recommended procedures and sealed with adhesive. Insulation shall have first class appearance.
 3. Finish: Finish all exposed insulation with two coats of manufacturer supplied finish in a color selected by the Owner.
- D. Insulation System E:
1. Material: Insulation shall be closed cellular glass material. Insulation shall have a "K" factor of not more than 0.30 at 70°F (ASTM C518). Insulation shall have a service temperature range from -450°F to 900°F, zero flame spread and smoke development index (ASTM E84), zero water vapor permeability (ASTM E96), and be suitable for both outdoor and buried installation. Insulation shall be Pittsburg Corning 'FOAMGLAS ONE'; or equal.
 2. Application: Seal all slit and butt joints with adhesive supplied by manufacturer. Pre-manufactured fitting covers of the same insulating material and thickness are to be provided according to manufacturer's recommended procedures and sealed with adhesive.
 3. Finish: Finish all exposed insulation with two coats of manufacturer's vapor retarding mastic. Provide aluminum jacketing (16-mil thickness) with metal bands over applied mastic. Insulation shall have first class appearance.
- E. Electric Heat Tape:
1. Outdoor Exposed Sodium Hydroxide, Sodium Bisulfite, Ammonium Sulfate and Threshold Inhibitor Chemical Piping:
 - a. Provide UL-approved electric heat tape on the piping between the storage tank and the secondary containment/building wall.
 - b. Tape shall be self-regulating (150°F max.) approximately 4 watts per foot capacity. The heat tape and associated controls shall maintain the pipe at a minimum temperature of 50°F with a minimum ambient temperature of 20°F using 120-volt, single-phase electrical service.
 - c. Accessories shall include temperature control with thermostat, remote sensing bulb, cable ties and strap adhesive.
 - d. Control unit shall be mounted adjacent to the respective chemical storage tank ladder and shall include a power disconnect, signal light and temperature adjustment. Installation shall be strictly in accordance with manufacturer's instructions.
 - e. Heat tape shall be Chemelex; Chromolox; or equal.

2.08 PIPE SUPPORTS

- A. **Manufacture and Design:** Pipe supports shall to the maximum extent possible be standard factory fabricated units conforming to the typical supports and braces shown in the Drawings and as specified below. Where required support cannot be provided by standard factory fabricated units, and is not detailed on the Drawings, the Contractor shall provide special pipe supports. Supports shall be manufactured or special fabrications or combination as shown on the Drawings or specified. Special fabrications shall be in conformance with Section 05 50 00. Provide $\frac{3}{4}$ -inch chamfer on corners of all support elements and file or grind smooth. Supports designated to allow axial pipe movement shall have smooth and even contact surfaces.
- B. **Materials:** All support systems shall be galvanized steel except that those that are submerged or that are located within a tank, channel, or other structure designed to hold water, below the top of surrounding walkway elevation or tank wall top, or otherwise called out on the Drawings, shall be Type 304 stainless steel. Trays for continuous support of plastic pipe or tubing shall be made of 20-gauge galvanized steel.
- C. **Insulation Protection Shields:** Provide insulation protection shields at all pipe supports for insulated piping.
- D. Provide plastic caps with rounded corners on all exposed ends of channels.

PART 3 - EXECUTION

3.01 PIPING INSTALLATION

- A. **General Handling and Placing:**
 - 1. Exercise great care to prevent injury to or scoring of the pipe lining and coating, as applicable, during handling, transportation or storage. Handle fusion epoxy coated pipe and ceramic epoxy lined pipe in accordance with AWWA C213. Do not store pipe on rough ground and do not roll the pipe on the coating. Any damaged pipe sections, specials, or fittings shall be repaired or replaced at the expense of the Contractor as satisfactory to the Engineer.
 - 2. Carefully inspect each pipe, fitting, valve and accessory before installation to insure there is no defective workmanship or obstructions. Inspect the interior and exterior protective coatings and patch all damaged areas in the field or replace to the satisfaction of the Engineer.
 - 3. Place or erect all piping to accurate line and grade and backfill, support, hang, or brace against movement as specified or shown on the Drawings, or as required for proper installation. Remove all dirt and foreign matter from the pipe interior prior to installation and thoroughly clean all joints before joining.
 - 4. Use reducing fittings where any change in pipe size occurs. Do not use bushings unless specifically noted on the Drawings. Use eccentric reducing fittings wherever necessary to provide free drainage of lines.
 - 5. Cast all metallic pipes and sleeves 6-inch and larger into new concrete walls without blockout. Pipes 5 inches and smaller may be cast in place or installed in a smooth core drilled hole using a link type seal at the Contractor's option. Maintain at least $\frac{1}{2}$ -inch clearance between reinforcing steel and metal pipe in penetrations.

6. Cover polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC) and polyethylene (HDPE and PE) pipe stored outside for more than two months with canvas or other opaque material. Provide for air circulation under the covering.
 7. Certain installation requirements are contained in Section 21 00 00, and Section 22 10 00.
- B. General Buried Piping Installation:
1. Trenching, bedding, and backfill for buried piping shall be as shown on the Drawings and as specified in Section 31 00 00.
 2. Where pipe grade elevations are shown on the Drawings, install the pipe with straight grades between the indicated elevations.
 3. Where no pipe grade elevations are shown on the Drawings, install buried piping with at least 3 feet of cover to finished grade. Where piping crosses under buried electrical ducts, provide at least 4 feet 6 inches of cover. Provide 12 inches minimum separation between the buried pipes and ducts.
 4. Provide each pipe with a firm, uniform bearing for its full length in the trench except at field joints. Do not lay pipe in water or when trench conditions or weather are unsuitable for such work.
 5. Protect buried piping against thrust by use of restrained pipe joints and/or thrust blocks. All exposed free pipe ends shall be securely braced. Cap or plug pipe ends that are left for future connections as shown on the Drawings and in a manner favorably reviewed by the Engineer.
 6. Where piping leaves a structure or concrete encasement, provide a joint capable of angular deflection within 12 inches of the structure for pipes 12-inch and smaller or as shown on the Drawings for larger pipe sizes. Conform to details on the Drawings where such details are shown.
 7. Snake buried PVC pressure pipe from side to side in the trench in long sweeps.
 8. Concrete Encasements: All piping and conduits installed under slabs or footings on earth or crushed rock shall be encased in concrete not less than 6-inch thickness on all sides and extending up to the bottom of the slab or footing, unless otherwise specifically noted on the Drawings. Encasement shall extend to within 6 inches of the first pipe joint beyond the slab or footing. Provide concrete encasement whether or not the encasement is shown on the Drawings. Provide encasement under slabs on earth or crushed rock even if the structure is supported on piles, caissons, or footings. Provide continuous concrete cradles where shown.
 9. Do not pull bell and spigot, gasketed joints more than 75% of the maximum deflection permitted by the pipe manufacturer.
 10. Double Containment for Buried Chemical Pipe and Tubing: Enclose buried chemical pipe and tubing within PVC (Type V-1 Pipe) pipe. Terminate at watertight junction boxes.
 11. Double Containment for Exposed PFA Tubing: Enclose PFA chemical tubing within PVC (Type V-1 Pipe) pipe.
 12. Coat bolts on buried flanges or other buried appurtenances in accordance with Paint System 7 in Section 09 96 00. Wrap the appurtenance with polyethylene encasement and tape the encasement tightly closed to the pipe.
- C. General Exposed Piping Installation:
1. Unless shown otherwise, install piping parallel to building lines, plumb and level.

2. Install piping without springing or forcing the pipe in a manner that would set up stresses in the pipe, valves, or connected equipment.
3. Set all pipe flanges level, plumb, and aligned. All flanged fittings shall be true and perpendicular to the axis of the pipe. All bolt holes in flanges shall straddle vertical centerline of pipes.
4. Flexibility and Expansion: Provide flexible couplings, flexible hose, or flexible spools for all piping connections to motor driven equipment and where otherwise shown. The Contractor may install additional flexible couplings at favorably reviewed locations to facilitate piping installation, provided that he submits complete details describing location, pipe supports, and hydraulic thrust protection. Anchor piping subject to expansion or contraction in a manner permitting strains to be evenly distributed. Sleeves for branches through walls from adjacent mains shall be of sufficient size to allow for free side motion of covered pipe in sleeves.
5. Install unions or flexible connections where shown on the Drawings, and at all non-motor-driven equipment to facilitate removal of the equipment.
6. Provide valves wherever equipment drain connections are furnished and carry the discharge pipe to the nearest floor drain, drain trench or sump. Where no receptacle for drain exists, install drain piping to 1-inch above the floor. Drain piping and valve materials shall conform to the requirements of the system served.
7. Where piping conveying liquids passes over motor control centers, electrical panels and other electrical devices, install a protective drainage tray below the piping.

D. Water Main Installation:

1. The Contractor is advised that precautions taken to keep the pipeline clean during construction will facilitate achieving the disinfection requirements of this project with a minimum of effort and expense. Compliance with these suggested minimum procedures will not relieve the Contractor of the disinfection requirements.
2. Prior to installation, thoroughly clean the interior of each length of pipe and each fitting or valve and inspect to ensure that no foreign material remains. Cover both ends with plastic and do not uncover them until just prior to completing the joint.
3. Whenever pipe laying is discontinued for short periods, or whenever work is stopped at the end of the day, close the open ends of the pipe with water-tight plugs or bulkheads.
4. Provide adequate trench pumping to ensure against groundwater contacting the inside of the pipeline at any tie. Do not lower any pipe or fitting into a trench where groundwater is present and may enter the pipe. When necessary, pump the water from trenches and keep the trench dry until the joint have been completed and the open ends of the pipe have been closed with a water-tight plug. Do not remove the plug until the trench has again been pumped dry.
5. Keep new pipe sections clean and dry.
6. When making the connection between a new pipeline and an existing pipeline, or when repairing a damaged pipe, take the following extra precautions:
 - a. Clean the exterior of the existing pipeline of all dirt and debris, and spray or swab with a standard 5.25% or stronger chlorine solution (as

specified) in the immediate vicinity of the work. Clean equipment and materials, including new pipe and fittings, to be used in making these connections of all dirt and debris and disinfect them. Allow at least 30 minutes contact time before the chlorine solution is diluted or rinsed off. Provide sufficient trench pumps to prevent flooding of the trench.

- b. When an old line is opened either by accident or by design, the excavation may be wet or badly contaminated from groundwater. Apply liberal quantities of standard chlorine solution tablets to the open trench areas to lessen the danger from such pollution. Tablets are recommended because they dissolve slowly and continue to release hypochlorite as water is pumped from the excavation. Scatter liberally around and locate the tablets so that flow entering the work site will contact the disinfecting agent. Trenching application should be done very carefully to avoid contact by skin and clothing with chlorine solution. Minimally, safety dictates wearing safety goggles and rain gear.
- c. When excavating a leaking or broken pipeline, "valve-off" the system gradually to less than water-tightness. This is to prevent causing areas of zero pressure which would allow entry of foreign material. A flow should be maintained which is slightly less than trench pump capability. Once the break is exposed and cleaned to disallow site contamination, the valving can then be made water-tight.

E. Pipe Welding:

- 1. General: Unless specified otherwise, field welding of pipe shall conform to ANSI B31.1 as amended by this paragraph. Shop welding of pipe is included in the individual pipe material specifications.
- 2. All field and shop welding shall be done by the electric arc process unless otherwise specified. All field welding shall be done in passes not thicker than ¼-inch. Size and type of electrodes, and current and voltages used, shall be subject to the favorable review of the Engineer. Give particular attention to the alignment of edges to be joined, so that complete fusion and penetration will be effected throughout the bottom of the weld. Welds shall contain no valleys or undercuts in the center or edges of the weld. Thoroughly clean each pass, except the final one, of dirt, slag, and flux before the succeeding bead is applied.
- 3. Clean completed field welds of pipe joints of dirt, slag and flux, and then visually inspect. Completely chip out all defects in welds discovered during field inspection in a manner that will permit proper and complete repair by welding subject to the favorable review of the Engineer. Under no circumstances will caulking of defective welds be permitted.
- 4. All welding shall be done by experienced, skilled operators familiar with the methods and materials to be used. Hand welding will be done only by welders qualified under the standard qualification procedure of Section IX of the ASME Boiler and Pressure Vessel Code. The Contractor shall conduct tests of his welders, when required by the Engineer, in accordance with that code and in the presence of the Engineer. An independent testing laboratory, favorably reviewed by the Engineer, shall supervise the testing and determine the quality of the test work. Weld specimens in the same positions as those in which the welder is to qualify his/her work. The Engineer may require test specimens at any time. Any welder whose work is found unsatisfactory shall

not remain employed on this Contract, regardless of the quality of his/her earlier work. Each hand weld specimen shall be plainly marked with the welder's identifying symbol. The Contractor shall furnish all materials required and pay all costs for qualifying welders.

5. Field welds shall follow as closely as possible to the laying operation. All field welds shall be complete before lining or coating of the joints in steel pipe is begun. Where pipe is fusion epoxy lined and/or coated, follow AWWA C-213 procedures for field welded joints.
6. A single, continuous, watertight, full fillet weld shall be the minimum required at all field joints. Double welded joints are required on all piping specifically noted to be double welded.
7. See also installation specifics for welding of pipe.

F. Installation Specifics:

1. C20, Type W-3 Pipe:
 - a. Installation of system components and interconnections between system components and other plant systems shall be in accordance with the Specifications, manufacturer's printed instructions, and approved shop drawings.
 - b. Field taps in the Alloy 20 piping system are not acceptable.
 - c. Drying: Drain and dry the Alloy 20 lines and interconnected components which will be in direct contact with the sulfuric acid using compressed nitrogen.
2. CISP, Type N-3 Pipe:
 - a. Bell and Spigot: Fold and insert one-piece rubber gasket into properly cleaned hub. Apply lubricant to gasket and to spigot. Lubricant shall be a type recommended by the pipe and gasket manufacturers. Push or draw spigot into gasketed hub with a pulling tool devised especially for this purpose. Install rubber couplings with stainless steel bands for connections between existing house sewer service lateral and cast iron sewer pipe. Install elastomeric bushings as required to compensate for differences in outside diameters.
 - b. No Hub: Install in accordance with Cast Iron Soil Pipe Institute Pamphlet No. 100.
3. CPVC, Type V-9 Pipe:
 - a. No work shall be performed until the pipe manufacturer provides onsite installation training and certifies the plumbers are trained per ASTM 2855. The Owner's inspector shall be present for the training session.
 - b. Place CPVC pipe within the installation areas at least 24 hours prior to installation to permit temperature equalization.
 - c. Cut pipe ends squarely, ream and deburr inside and out, and bevel the ends.
 - d. Solvent Weld Joints: Install in accordance with ASME B31.3. Make joints in accordance with ASTM D2855. Follow all of the pipe manufacturer's recommended steps. Handle cements and primers in accordance with ASTM F402.
 - e. Install spray shields at all flanged and threaded joints on the sodium hypochlorite and caustic piping.
4. CU, Type T-1 Pipe:
 - a. Bends shall be made in a manner that does not crimp or flatten pipe.

- b. Dielectric unions shall be installed at connections with ferrous piping.
 - c. Pipe shall have joints squarely cut clean, soldered joints shall be properly fluxed and heated before solder is placed in the joint. Joints must be driven up tight before solder is added. Compression and flared joints shall be made up in accordance with the fitting manufacturer's installation instructions. Brazing shall be in accordance with ANSI B31.1.
 - d. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1-inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.
 - e. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, ¾-inch ball valve, and short ¾-inch threaded nipple and cap.
 - f. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using steel sleeves and mechanical sleeve seals.
 - g. Fire Barrier Penetrations: Where pipes pass through fire rated walls, partitions, ceilings, and floors, maintain the fire rated integrity.
 - h. Install branch connections to mains using tee fittings in main with take-off out the bottom of the main, except for up-feed risers, which shall have take-off out the top of the main line.
 - i. Install strainers on the supply side of each control valve, pressure reducing valve, pressure regulating valve, solenoid valve, inline pump, and elsewhere as indicated. Install nipple and ball valve in blowdown connection of strainers 2 inches and larger.
5. CUT, Type T-2 Pipe (Tubing): Install in accordance with tube and fitting manufacturers' instructions. Make buried connections in junction boxes.
6. DI (Buried), Type N-1 Pipe:
- a. Install buried pipe in accordance with AWWA C600.
 - b. Support and brace encased pipe to support the pipe and to prevent movement during testing and placement of the concrete encasement. The braces and supports shall be erected of materials and by methods that will prevent any future contact of the pipe with the environment surrounding the encasement.
 - c. Install restrained joints in accordance with manufacturer's instructions. Pull the slack out of restrained joints after they are made up.
 - d. Wherever a water pipeline crosses over or under a sewer main or house service lateral or a reclaimed water pipeline, center a standard length pipe, 18-foot minimum, on said sewer main or lateral or reclaimed water pipeline so as to have the pipeline joints as far as possible away from sewer. This may require field cutting of some pipe pieces.
7. DI (Flanged), Type N-2 Pipe:
- a. Flanged Joints: Flanged joints shall be made up tight with care being taken to avoid undue strain in the flanges, fittings, and other accessories. Bolt holes shall be aligned for each flanged joint. Bolts shall be full size for bolt holes; use of undersize bolts to make up for misalignment of bolt holes or for any other purpose will not be permitted. Adjoining flange faces shall not be out of parallel to such a degree that the flanged joint cannot be made watertight without

overstraining the flange. Any flanged pipe or fitting whose dimensions do not allow the making of a proper flanged joint as specified herein shall be replaced by one of the proper dimensions. Clean flanges prior to making joints. Buried flanged pipe connections shall be made with the smallest practical "bell" hole. After the joint is completed take special care to completely fill the "bell" hole under and around the pipe with compacted backfill.

- b. Mechanical Grooved Couplings: Install in accordance with the manufacturer's instructions.
- 8. FRP and PP, Type O Pipe and Type P Pipe: Install in accordance with manufacturer's instructions.
- 9. GS, Type Y-1 Pipe: Threaded joints shall have connections made metal to metal tight. Remove all burrs from ends of pipe, and clean threads of all oil and chips. Coat male threads with joint lubricant. Properly tape wrap joints of plastic coated pipe.
- 10. HDPE, Type U-1 Pipe:
 - a. Handling and laying of pipe and fittings shall be in accordance with the manufacturer's instructions, PPI guidelines, AWWA M55, and as specified herein to line and grades as shown on the Drawings.
 - b. Pipe and fittings shall not be dropped. All pipe and fittings shall be examined before laying and no piece shall be installed which is found to be defective. Any damage to the pipe shall be repaired as directed by the manufacturer and approved by the Owner. If any defective pipe is discovered after it has been laid, it shall be removed and replaced with a sound pipe in a satisfactory manner at the Contractor's expense. Any pipe with gouges exceeding 5% of the nominal wall thickness will be rejected.
 - c. All pipe and fittings shall be thoroughly cleaned before laying, shall be kept clean until they are used in the work.
 - d. The Contractor shall not drag the pipe. Rollers or other such devices shall be used to reduce dragging of the pipe. Damage to pipe caused by dragging is the responsibility of the Contractor and cause for replacement of damaged portion as determined by the Owner. If, in the opinion of the Owner, the pipe may have been dragged to an extent where damage may have occurred to the pipe wall, the Contractor will rotate the pipe in a manner which will facilitate inspection.
 - e. As much as practicable, the print line on the pipe shall be installed facing upward to facilitate identification of the pipe when initially installed.
 - f. Pipe fused above ground shall be carefully handled to avoid damage to the pipe. Chains or cable type chokers will not be allowed when lifting sections of pipe. Nylon or other wide fabric slings or other similar lifting apparatus with spreader bars shall be used where necessary.
 - g. Prior to installing a pipe section, the bedding material shall be brought to grade along the entire length of the section to be installed.
 - h. The joining method shall be the thermal butt fusion method and shall be performed in strict accordance with these Specifications, PPI guidelines, and the pipe manufacturer's recommendations. Should there be a conflict between these Specifications and the pipe manufacturer's recommendations, the more stringent requirement shall govern. The butt fusion equipment used in the joining procedures shall be capable of

- meeting all conditions and procedures recommended by the pipe manufacturer, including but not limited to, temperature requirements, alignment, and interfacial fusion pressure and automatic recording of parameters for joining.
- i. Heat fusion joining shall be complete, efficient, and match the outer diameter of the two pipe being heat fused. Any offset or mismatch shall not exceed 10% of the minimum wall thickness. In all cases, heat fusion pipe joints shall have a joint weld strength equal to or greater than the tensile strength of the pipe.
 - j. Submit detailed fusion joint reports as recorded by the heat fusion machine for all joints. Submit a report to the Owner's Inspector the same day the fusion is made. Submit a formal report of all fusions to the Owner's Project Manager on a weekly basis, no later than 4:00 p.m. each Friday. If any joint as indicated by these reports is found to be unsatisfactory, the Contractor shall remove portions of the pipe containing such joint and install a new pipe piece as required and approved by the Owner.
 - k. The first fusion shall be a trial fusion to be performed in the field in the presence of the Owner. The trial fusion shall be allowed to cool completely, then fusion test straps shall be cut out. The test strap shall be the longer of 12 inches or 30 times the wall thickness in length with the fusion in the center, and 1-inch minimum or 1.5 times the wall thickness in width. Then, the test strap shall be bent until the ends of the strap touch. If the fusion fails at the joint, or if the joint exhibits cracking or crazing, a new trial fusion shall be made, cooled completely and tested. Butt fusion of the pipe to be installed shall not commence until the trial fusion has passed the bend back test.
 - l. Following the successful initial trial fusion, the bend back test shall be performed once every fiftieth joint.
 - m. Bending of the pipe to achieve horizontal or vertical changes in direction is allowed. The minimum bending radius, measured along the centerline axis of the pipe is 50 times the nominal pipe size.
 - n. Flange connections shall be in accordance with the manufacturer's requirements. Flange bolts shall not be used to draw the connection into alignment. Bolt threads shall be lubricated and flat washers shall be used under nuts. Tighten bolts evenly according to the pipe manufacturer's tightening pattern and torque step recommendations. Retighten flange connections at least one hour after the initial tightening using the pipe manufacturer's tightening pattern and torque step recommendations.
 - o. Install tracer wire and warning tape.
 - p. All HDPE pipe must be at the temperature of the surrounding soil at the time of backfilling and compaction.
11. PFA, Type V-11 Pipe:
- a. Carefully install tubing, avoiding nicks and gouges.
 - b. Use only approved flare fittings. Flare tube ends with a manufacturer-approved tool.
 - c. Make-up all transitions between tubing and pipe interfaces with PTFE tape sealant.
12. PP, Type P-2: Install in accordance with manufacturer's instructions.
13. PVC-1, PVC-4 and PVC-6, Type V-1, V-4 and V-6 Pipe:

- a. Place PVC pipe within the installation areas at least 24 hours prior to installation to permit temperature equalization.
 - b. Cut pipe ends squarely, ream and deburr inside and out.
 - c. Solvent Weld Joints: Clean pipe ends and sockets and join in strict conformance with the pipe manufacturer's instructions. Make joints in accordance with ASTM D2855. Handle solvent cements and primers in accordance with ASTM F402.
 - d. Containment fittings for chemical and chemical solution lines shall be installed and tested in accordance with manufacturers' instructions. Install containment pipe with position clips at 3-foot centers and at fittings during installation of carrier pipe. Do not make joints until after successful leak tests of carrier pipes.
 - e. PVC-1, Type V-1 Pipe: Threaded connections shall use a short nipple, threaded at one end, socket at the other. Provide thread sealant in accordance with the pipe manufacturer's recommendations. Take care not to overtighten the connection.
 - f. PVC-1, Type V-1 Pipe: No work shall be performed until the pipe manufacturer provides onsite installation training and certifies the installers are trained per ASTM D-2855. The Owner's inspector shall be present for the training session.
 - g. PVC-4, Type V-4 Pipe: Conform to AWWA M23, Chapters 6 and 7, except as modified herein.
14. PVDF, Type V-10 Pipe:
- a. Place PVDF pipe within the installation areas at least 24 hours prior to installation to permit temperature equalization.
 - b. Cut ends of pipe squarely, ream and deburr inside and out.
 - c. Make joint using butt fusion weld method.
 - d. Install containment pipe with positioning clips at 3-foot centers and at fittings during installation of carrier pipe. Do not make joints until after successful leak test of carrier pipe.
15. SS, Type W-1 Pipe:
- a. Install and weld in accordance with CGA G-4.4 and ANSI B31.1. Back purge all welds with cover gas. Seal weld all slip-on flanges.
 - b. Provide anti-seize compound on threaded connections.
 - c. Temporarily plug or cap all points of connection to exclude moisture, dust or other contaminants or impurities prior to being connected.
 - d. Install spray shields at all flanged joints on sodium hydroxide piping.
 - e. Clean all oxygen and ozone piping and equipment as follows.
 - 1) Clean in accordance with CGA G-4.1 and G-4.4 for pipelines for oxygen, ozone and hydrogen peroxide service.
 - 2) After erection, the LOX, oxygen gas and ozone gas piping shall be blown out with dry, oil-free nitrogen gas at a rate that will give a velocity of at least 5 feet per second throughout the full length of the pipeline(s) until there is no evidence of dust, dirt or debris in the flow at the discharge end of the pipe(s). Thoroughly clean the pipe, valves, and accessories of any contaminants, particularly hydrocarbon contaminants, in accordance with the CGA standards for oxygen service, including CGA G-4, G-4.1, and G-4.4. If pipe, valves, or accessories become contaminated prior to or during assembly, re-clean the affected materials in accordance with CGA G-4.1.

- 3) Testing: Test the clean oxygen and ozone gas piping for the presence of hydrocarbon contaminants in accordance with CGA. If hydrocarbon materials are present, re-clean and re-test until free of hydrocarbon contaminants.
- 16. SST, Type W-2 Pipe: Install in accordance with manufacturer's instructions and SS Type W-1 Pipe requirements.
- 17. STL, Type M-2 Pipe:
 - a. Installation of pipe shall be in accordance with AWWA C600.
 - b. The maximum trench width at the top of the pipe shall be the pipe outside diameter plus 3 feet.
 - c. Field welding of joints shall be in accordance with AWWA C206. Acceptance of field welds will be based on visual inspection and non-destructive testing by the Engineer while the welds are being made and after they are completed. Hand or power wire brush each weld thoroughly after completion to facilitate the inspection. Correct defects not complying with AWS Code D1.1 Sections 3.6 and 8.15. Determine the cause of defects and take corrective measures to prevent a reoccurrence.
 - d. Following satisfactory testing of the weld, the interior of all joints shall be cement mortar lined. Pipe 24 inches and less shall be finished using the ball and burlap procedure described in AWWA C-205, paragraph 4.7.2.2.2. The exterior of the joints of buried pipe shall be cement mortar coated in accordance with Appendix A of AWWA C205. Prior to coating the exterior, tack weld one layer of wire mesh to the pipe.
 - e. Steel edges not encased in concrete or cement mortar shall receive a protective coating of 16 mils of high solids epoxy.

3.02 COUPLING INSTALLATION

- A. Flexible Couplings and Flange Coupling Adaptors: Prior to installation, thoroughly clean oil, scale, rust, and dirt from the pipe to provide a clean seat for the gasket. Wipe gaskets clean before they are installed. If necessary, flexible couplings and flanged coupling adapter gaskets may be lubricated with soapy water or manufacturer's standard lubricant before installation on the pipe ends. Install in accordance with the manufacturer's recommendations. Tighten bolts progressively, drawing up bolt on opposite sides a little at a time until all bolts have a uniform tightness. Workers tightening bolts shall be equipped with torque-limiting wrenches or other favorably reviewed type. Anchor studs on restrained flanged coupling adaptors shall be installed so as to lock into holes drilled through the pipe wall in accordance with manufacturer's recommendation.
- B. Tie Rods: Except where double-nutting is required, install the nuts snug. Tighten the nuts gradually and equally at opposite sides of the pipe until snug to prevent misalignment and to ensure that all rods carry equal loads. If double-nutting is required, double-nut each end of each tie rod. The space between the pairs of nuts shall be ½-inch greater than the distance between the lugs. Provide double-nutting at buried locations and where otherwise required on the Drawings.
- C. Flexible Rubber Spools:
 - 1. Install in accordance with manufacturer's instructions. Unless otherwise shown on the Drawings, install flat with one-half the maximum expansion.

2. Connect rubber spools only to full-face metal flanges.
3. Install control rod-compression sleeve assemblies with control rod nuts snug, to relieve stress on adjacent pipe, except at buried locations. Comply with manufacturer's instructions.
4. Paint buried galvanized steel retainer rings, bolts and other appurtenances in accordance with System 7 in Section 09 96 00.

3.03 INSTALLATION OF VALVES AND ACCESSORIES

- A. Wrap buried valve bodies as specified for flexible couplings and flanged coupling adapters.
- B. Use reducing fittings where any change in pipe size occurs between valves or accessories and the attached pipeline. Bushings shall not be used, unless specifically noted on the Drawings. Use eccentric reducing fittings wherever necessary to provide free drainage of lines.
- C. Install valves and accessories such that all parts are easily accessible for maintenance and operation. Provide valve boxes for buried valves.
- D. Where valve handwheels are shown on the Drawings, valve orientation shall be as shown. Where valve handwheels are not shown, orient valves to permit easy access to the handwheels or handles and to avoid interferences.
- E. Install pressure gauges and thermometers in a position to permit reading them from a point approximately 5 feet above floor level, except that pump pressure gauges shall be installed close to the pump elevation.
- F. Rigidly support pressure switches and connect them to piping and equipment using a suitable flexible linkage that will not permit transmission of vibrations from the piping or equipment to the pressure switches.
- G. Provide a union adjacent to each screwed end valve and accessory with additional unions as necessary to facilitate removal.
- H. Provide a shutoff valve below each pressure gauge, protective device or air valve unless otherwise specified.
- I. Connections between ferrous and non-ferrous piping, valves, accessories or pipe supports shall be made using a dielectric coupling, union, or flange.
- J. Where valves or other pipeline items require metal full-face connecting flanges, provide intermediate flanges if the connecting flange is not adequate.
- K. All insulated piping passing through walls or slabs shall be sleeved and insulation shall run continuously through the sleeves and shall allow for 1/8-inch annular clearance between outside of insulation and sleeve wall.
- L. Provide a suitable chrome plated escutcheon on pipes passing through walls, floors, ceilings and partitions in finished areas.
- M. Install link-type seals in cast-in-place metal sleeves or in smooth core drilled holes. Grout both sides flush with non-shrink grout unless otherwise shown on the Drawings.
- N. Install butterfly valves in accordance with AWWA C504, Appendix A, Sections A.2 through A.5, inclusive.

- O. Install thermometer wells in piping tees in vertical position. Fill with oil. Where wells are in lines 2 inches and smaller, increase line size so that velocity at well section is not increased.
- P. Provide test plugs on all closed water systems and condenser water systems located in inlet and outlet of coils, heat exchangers, cooling towers, and where indicated on Drawings. Locate test plugs where they will be easily accessible, have adequate clearance for insertion and removal of gage needles and thermometer stems, and position to allow unobstructed viewing of gages and thermometers.

3.04 INSTALLATION OF INSULATION

- A. General: Apply insulation material, accessories, and finishes according to the manufacturer's printed instructions. Seal joints and seams to maintain vapor barrier. Seal penetrations for hangers, supports, and anchors. Keep insulation material dry during application. Apply vapor barrier on seams, joints, over staples, and at end butt to fittings.
- B. Roof Penetrations: Apply insulation for interior applications to a point even with the top of the roof flashing. Seal with vapor barrier coating. Apply insulation for exterior applications butted tightly to interior insulation ends. Extend metal jacket for exterior insulation outside roof flashing at least 2 inches below top of roof flashing. Seal metal jacket to roof flashing with vapor barrier coating.
- C. Interior Walls and Partitions Penetration: Apply insulation continuously through walls and partitions, except fire-rated walls. Apply aluminum jacket with factory-applied moisture barrier over insulation. Extend 2 inches from both surfaces of wall on partition. Secure aluminum jacket with metal bands at both ends. Seal ends of jacket with vapor barrier coating. Seal around penetration with joint sealer.
- D. Whenever possible, slip insulation on pipe before making connections. Seal joints with adhesive. Where the slip-on technique is not possible, cut one side longitudinally and apply to the pipe. Seal seams and joints with adhesive.
- E. Cover exterior insulation, except for metal-jacketed insulation with PVC fitting covers and seal circumferential joints with butt strips. Paint all exterior PVC covering.

3.05 INSTALLATION OF PIPE SUPPORTS

- A. General:
 - 1. Install and adjust supports for each pipeline such that the pipeline is true to the indicated line and grade.
 - 2. Locate anchors and braces for any single support on a continuous structure; that is, not on two sides of a structural expansion joint.
 - 3. Tighten clamps to develop full friction along the pipeline except where loose fitting clamps are called for.
- B. Electrolytic Protection: Pipe supports serving copper pipe or tubing shall be dielectrically insulated from the pipe by dielectric sleeves or plastic pipe wrap at the point of contact.

3.06 PIPE AND VALVE IDENTIFICATION

- A. General: Identify all exposed piping in this project by painting, banding, system name labels, and direction arrows. The color and banding shall be as selected by the Engineer. Identify all buried and exposed valves with tags as specified below.
- B. Exposed Pipe Identification: Before painting, banding and labeling, pipes shall be identified by the Contractor with temporary wired-on cardboard tags showing the proposed marking for review by the Engineer.
- C. Piping: Paint all exposed pipes with the appropriate paint system as specified in Section 09 96 0 and provide pipe markers per the schedule specified in Section 10 14 00.
- D. Valves: Provide each buried valve with a valve tag identifying the pipeline contents, and either its valve number, or the area or item served by the valve for valves without a valve number. Contents shall be as designated in the Piping Schedule.
- E. Provide access panel markers for valves and control devices concealed behind access panels and above suspended ceilings. Locate markers on access doors and on ceiling T-bars.
 - 1. Markers for Ceiling T-bar Installation: Blue, pressure-sensitive, self-adhesive, at least 3 mils thick, 3/8-inch diameter.
 - 2. Markers for Access Doors: 1/16-inch thick, engraved plastic-laminate, with abbreviated terms and numbers corresponding to the concealed item. Provide 1/8-inch center attachment hole.

3.07 FIELD QUALITY CONTROL

- A. The Owner will:
 - 1. Inspect field welds and test the welds if it is deemed necessary.
 - 2. Perform bacteriological analysis for pipeline to be disinfected.
- B. Factory Quality Control: The Contractor shall test all products as required herein and by the reference specifications.
- C. The Contractor shall:
 - 1. Perform leakage tests.
 - 2. Be responsible for the costs of additional inspection and retesting by the Owner resulting from non-compliance.

3.08 CLEANING

- A. Prior to testing, thoroughly clean the inside of each completed piping system of all dirt, loose scale, sand and other foreign material. Cleaning shall be by sweeping, flushing with water or blowing with compressed air or oil-free nitrogen gas, as appropriate for the size and type of pipe. Flushing shall achieve a velocity of at least 3 feet per second. The Contractor shall install temporary strainers, temporarily disconnect equipment, or take other appropriate measures to protect equipment while cleaning piping. Cleaning shall be completed after any pipeline repairs.
- B. Special attention and skill is required to properly clean piping, valves and accessories for oxygen, ozone, sulfuric acid, threshold inhibitor and hydrogen peroxide service.

1. Clean pipe systems for oxygen, ozone and hydrogen peroxide service in accordance with CGA G-4.1 and G-4.4.

3.09 FIELD TESTING

- A. General: Perform leakage tests on all pipe installed in this project. Furnish all equipment, material, personnel and supplies to perform the tests and make all taps and other necessary temporary connections. The test pressure, allowable leakage and test medium shall be as specified and as shown in the following Schedule/Paragraphs. Test pressure shall be measured at the highest point on the line, except that pressure at lowest point shall not exceed pipe manufacturer's rated test pressure, unless specifically noted otherwise. Leakage tests shall be performed on all piping at a time agreed upon and in the presence of the Engineer. All visible leaks shall be repaired, regardless of the test results.
- B. Buried Piping: The leakage test for buried piping shall be made after all pipes are installed and backfilled. However, the Contractor may conduct preliminary tests prior to backfill. If the Contractor elects to conduct preliminary tests, provide any necessary temporary thrust restraint.
- C. Exposed Piping: All supports, anchors and blocks shall be installed prior to the leakage test. No temporary supports or blocking shall be installed for final test.
- D. Encased Piping: The leakage test for encased piping shall be made after all pipe is installed and encased, and before any structures are constructed above it. However, the Contractor may conduct preliminary tests prior to encasement. If the Contractor elects to conduct preliminary tests, provide any necessary temporary thrust restraint.
- E. Accessories: It shall be the responsibility of the Contractor to block off or remove equipment, valves, gauges, etc., which are not designed to withstand the full test pressure.
- F. Testing Apparatus: Provide pipe taps, nozzles and connections as necessary in piping to permit testing including valves to isolate the new system, addition of test media, and draining lines and disposal of water, as is necessary. These openings shall be plugged in a manner favorably reviewed by the Engineer after use. Provide all required temporary bulkheads.
- G. Pneumatic Testing: Piping tested by air or another gas shall show no reduction of pressure during the test period after corrections have been made for changes in temperature in conformance with the following relationship:

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

Where T_1 and T_2 are the absolute temperatures of the gas in the pipe and P_1 and P_2 are the absolute pressures. The subscript "1" denotes the starting conditions and the subscript "2" denotes the final conditions.

- H. Precautions for Pneumatic Testing: Where air or another gas is called for as the test medium, the Contractor shall take special precautions to protect personnel. During the initial pressurization of a pipeline to the specified test pressure, personnel shall be protected by suitable barricades or shall remove themselves to

locations where portions of the concrete structure itself are between them and the pipeline under test.

- I. Correction of Defects: If leakage exceeds the allowable, the installation shall be repaired or replaced and leakage tests shall be repeated as necessary until conformance to the leakage test requirements specified herein have been fulfilled. All visible leaks shall be repaired even if the pipeline passes the allowable leakage test.
- J. Drying: Gas lines tested with water shall be drained and blown dry with air or oil-free nitrogen gas.
- K. Reports: The Contractor shall keep records of each piping test, including:
 1. Description and identification of piping tested.
 2. Test pressure.
 3. Date of test.
 4. Witnessing by Contractor and Engineer.
 5. Test evaluation.
 6. Remarks, to include such items as:
 - a. Leaks (type, location).
 - b. Repairs made on leaks.
 7. Test reports shall be submitted to the Engineer.
- L. Venting: Where not shown on the Drawings, the Contractor may install valved "tees" at high points on piping to permit venting of air. Valves shall be capped after testing is completed.
- M. Testing Specifics: Piping shall be tested as indicated in the following Schedule. All other piping systems shall be tested as required for the pipe type used. Unless specified otherwise, test each system for four (4) hours.

Piping Test Schedule				
Legend	System	Test Pressure	Test Medium	Allowable Leakage
BWS	Backwash Supply	150 psi	Water	None
BWW	Backwash Waste	150 psi	Water	None
CF	RO Cleaning Feed	150 psi	Water	None
CIPR	MF CIP Return	150 psi	Water	None
CIPS	MF CIP Supply	150 psi	Water	None
CIPW	MF CIP Waste	150 psi	Water	None
CLW	RO Cleaning Waste	150 psi	Water	None
CR	RO Cleaning Return	150 psi	Water	None
CWS	Cooling Water Supply	150 psi	Water	None
CWR	Cooling Water Return	150 psi	Water	None
DPW	Decarbonated Product Water	150 psi	Water	None
FF	RO Flush Feed	150 psi	Water	None
FLW	RO Flush Waste	150 psi	Water	None
MFE	Membrane Filtration Effluent	150 psi	Water	None
MFF	Membrane Filtration Feed	150 psi	Water	None
PCR	RO Permeate Cleaning Return	150 psi	Water	None
PW	Product Water	250 psi	Water	None
REC	CIP Solution Recirculation	150 psi	Water	None
ROC	RO Concentrate	150 psi	Water	None

ROF	RO Feed	150 psi	Water	None
ROP	RO Permeate	150 psi	Water	None
SAMP	Sample	150 psi	Water	None
SBW	Strainer Backwash	150 psi	Water	None
SE	Secondary Effluent	150 psi	Water	None
UVF	UV Feed	150 psi	Water	None
UVP	UV Product	150 psi	Water	None
WW	Waste Water	150 psi	Water	None
CLWA	Class A Potable Water	150 psi	Water	None
FFW	Fire Fighting Water	150 psi	Water	None
FS	Fire Suppression	150 psi	Water	None
PUW	Plant Utility Water	150 psi	Water	None
CA	Compressed Air	250 psi	Air or N ₂	None
GOX	Gaseous Oxygen	150 psi	N ₂	None
HA	MF High Pressure CA Supply	250 psi	Air or N ₂	None
LA	MF Low Pressure CA Supply	150 psi	Air or N ₂	None
N2	Nitrogen	250 psi	Air or N ₂	None
OZ	Ozone Gas	150 psi	N ₂	None
CaOH2	Calcium Hydroxide	150 psi	Water	None
CIPA	Acid CIP Solution	150 psi	Water	None
CIPB	Base CIP Solution	150 psi	Water	None
FC	Ferric Chloride	150 psi	Water	None
H2O2	Hydrogen Peroxide	150 psi	Water	None
LOX	Liquid Oxygen	150 psi	N ₂	None
NaOCl	Sodium Hypochlorite	150 psi	Water	None
NaOH	Sodium Hydroxide	150 psi	Water	None
(NH4)2 SO4	Ammonium Sulfate	150 psi	Water	None
SA	Sulfuric Acid	150 psi	Water	None
SBS	Sodium Bisulfite	150 psi	Water	None
TI	Threshold Inhibitor	150 psi	Water	None

1. Allowable leakage is generally none; for PVC or ductile-iron gasketed bell and spigot joints, use the following formula:

$$L = \frac{NDP^{1/2}}{7400}$$

Where:

L = allowable leakage, gallons per hour
N = number of joints being tested
P = pressure, psi
D = nominal pipe diameter, inches

N. Testing Specifics by Pipe type:

1. CPVC, Type V-9 Pipe:
 - a. Duration: 4 hours.
 - b. Pressure: 150 psi.

- c. Medium: Water.
- d. Allowable Leakage: None.
- 2. CISP, Type N-3 Pipe:
 - a. Duration: 1 hour.
 - b. Pressure: 6 psi.
 - c. Medium: Water.
 - d. Allowable Leakage: None.
- 3. CU, Type T-1 Pipe:
 - a. Duration: 4 hours.
 - b. Pressure: 150 psi.
 - c. Medium: Water, except use air for vacuum and operating air systems.
 - d. Allowable Leakage: None.
- 4. CUT Type T-2 Pipe (Tubing):
 - a. Test in accordance with ISA-RP7.1.
 - b. Duration: 4 hours.
 - c. Pressure: 150 psi.
 - d. Medium: Clean Air.
 - e. Allowable Leakage: None.
- 5. DI (Buried), Type N-1 Pipe:
 - a. Duration: 4 hours.
 - b. Pressure: 150 psi measured at lowest point of section of pipeline being tested, except 300 psi for PW system.
 - c. Medium: Water.
 - d. Allowable Leakage:

$$L = \frac{NDP^{1/2}}{7400}$$

Where:

L = allowable leakage, gal. per hour.

N = number of joints being tested.

P = pressure, psi.

D = nominal pipe diameter, inches.

- 6. DI (Flanged), Type N-2 Pipe:
 - a. Duration: 4 hours.
 - b. Pressure: 150 psi, except as indicated in the Piping Test Schedule for PW service.
 - c. Medium: Water.
 - d. Allowable Leakage: None.
- 7. FRP, Type O Pipe:
 - a. Duration: 1 hour.
 - b. Pressure: 150 psi.
 - c. Medium: Water.
 - d. Allowable Leakage: None.
- 8. GS, Type Y-1 Pipe:
 - a. Duration:
 - 1) Pressure Pipe Service: 4 hours.
 - 2) Drain Pipe Service: 1 hour.
 - b. Pressure:
 - 1) Pressure Pipe Service: 150 psi.
 - 2) Drain Pipe Service: 20 psi.

- c. Medium: Water, except use air for the vacuum and operating air systems.
 - d. Allowable Leakage: None.
- 9. HDPE, Type U-1 Pipe:
 - a. Test per ASTM F 2164 and AWWA M55
 - b. Duration: 4 hours.
 - c. Pressure: 150 psi.
 - d. Medium: Water.
 - e. Allowable Leakage: None.
- 10. PFA, Type V-11 Pipe:
 - a. Duration: 1 hour.
 - b. Pressure: 150 psi.
 - c. Medium: Water.
 - d. Allowable Leakage: None.
- 11. PP, Type P Pipe:
 - a. Duration: 1 hour.
 - b. Pressure: 150 psi.
 - c. Medium: Water.
 - d. Allowable Leakage: None.
- 12. PVC-1, Type V-1 Pipe:
 - a. Liquid Service:
 - 1) Duration: 4 hours.
 - 2) Pressure: 150 psi.
 - 3) Medium: Water.
 - 4) Allowable Leakage: None.
 - b. Double Containment for chemical and chemical solution pipes.
 - 1) Duration: 4 hours.
 - 2) Pressure: 5 psi.
 - 3) Medium: Air.
 - 4) Allowable Leakage: None.
- 13. PVC-4, Type V-4 Pipe:
 - a. Duration: 4 hours.
 - b. Pressure: 15 psi.
 - c. Medium: Water.
 - d. Allowable Leakage:

$$L = \frac{NDP^{1/2}}{7400}$$

Where:

L = allowable leakage, gal. per hour.

N = number of joints being tested.

P = pressure, psi.

D = nominal pipe diameter, inches.

- 14. PVC-6, Type V-6 Pipe:
 - a. Duration: 1 hour.
 - b. Pressure: 15 psi.
 - c. Medium: Water.
 - d. Allowable Leakage: None.
- 15. PVDF, Type V-10 Pipe:
 - a. Liquid Service:
 - 1) Duration: 4 hours.

- 2) Pressure: 150 psi.
 - 3) Medium: Water.
 - 4) Allowable Leakage: None.
 - b. Double containment for hydrogen peroxide solution:
 - 1) Duration: 4 hours.
 - 2) Pressure: 5 psi.
 - 3) Medium: Air.
 - 4) Allowable Leakage: None.
- 16. SS, Type W-1 Pipe:
 - a. Duration: 4 hours.
 - b. Pressure:
 - 1) Liquid Service: 150 psi.
 - 2) Gaseous or Air Service: 250 psi.
 - c. Medium:
 - 1) Liquid Service: Water
 - 2) Gaseous or Air Service: Oil-free nitrogen gas or air.
 - d. Allowable Leakage: None.
- 17. SST, Type W-2 Pipe:
 - a. Duration: 4 hours.
 - b. Pressure:
 - 1) Liquid Service: 150 psi.
 - 2) Gaseous or Air Service: 250 psi.
 - c. Medium:
 - 1) Liquid Service: Water.
 - 2) Gaseous or Air Service: Oil-free nitrogen gas or air.
 - d. Allowable Leakage: None.
- 18. STL, Type M-2 Pipe:
 - a. Duration: 4 hours.
 - b. Pressure: Test as indicated on the Piping Test Schedule.
 - c. Medium: Water.
 - d. Presoaking: Fill piping at least 4 hours before beginning test.
 - e. Allowable Leakage: None.

END OF SECTION