
USACE / NAVFAC / AFCEA / NASA UFGS-02150 (March 2005)

Preparing Activity: USACE MasterFormat™ 2004 - 31 21 00
Superseding
UFGS-02150 (August 2004)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 23 June 2005

Latest change indicated by CHG tags

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DIVISION 02 - SITE CONSTRUCTION

SECTION 02150

PIPING; OFF-GAS

03/05

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SECTION 02150

PIPING; OFF-GAS
03/05

NOTE: This guide specification covers the requirements for pipe systems for the transmission of gases and vapors.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

PART 1 GENERAL

1.1 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update

the issue dates.

References not used in the text will automatically
be deleted from this section of the project
specification when you choose to reconcile
references in the publish print process.

The publications listed below form a part of this specification to the
extent referenced. The publications are referred to within the text by the
basic designation only.

AMERICAN GAS ASSOCIATION (AGA)

AGA B109.2	(2000) Diaphragm-Type Gas Displacement Meters (500 cubic ft./hour Capacity and Over)
AGA XR0104	(2001) AGA Plastic Pipe Manual for Gas Service

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z400.1	(1998) Hazardous Industrial Chemicals - Material Safety Data Sheets - Preparation
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AMERICAN PETROLEUM INSTITUTE (API)

API Spec 5L	(2004) Line Pipe
API Spec 6D	(2002) Specification for Pipeline Valves

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C218	(2002) Coating the Exterior of Aboveground Steel Water Pipelines and Fittings
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ASME INTERNATIONAL (ASME)

ASME B1.20.1	(1983; R 2001) Pipe Threads, General Purpose, Inch
ASME B16.11	(2002) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(1992) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.40	(2002) Manually Operated Thermoplastic Gas Shutoffs and Valves in Gas Distribution Systems
ASME B16.5	(2003) Pipe Flanges and Flanged Fittings
ASME B16.9	(2003) Factory-Made Wrought Steel Buttwelding Fittings
ASME B31.8	(2003) Gas Transmission and Distribution Piping Systems

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M	(2002) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153/A 153M	(2004) Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 181/A 181M	(2001) Carbon Steel Forgings, for General-Purpose Piping
ASTM A 307	(2004) Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A 53/A 53M	(2004a) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM B 837	(2001) Seamless Copper Tube for Natural Gas and Liquefied Petroleum (LP) Gas Fuel Distribution Systems
ASTM C 581	(2003) Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures Intended for Liquid Service
ASTM C 920	(2002) Elastomeric Joint Sealants
ASTM D 1248	(2004) Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D 1598	(2002) Time-to-Failure of Plastic Pipe Under Constant Internal Pressure
ASTM D 1693	(2001) Environmental Stress-Cracking of Ethylene Plastics
ASTM D 1784	(2003) Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D 2241	(2004b) Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D 2447	(2003) Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter
ASTM D 2466	(2002) Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D 2467	(2004e1) Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D 2513	(2004a) Thermoplastic Gas Pressure Pipe, Tubing, and Fittings
ASTM D 2517	(2000e1) Reinforced Epoxy Resin Gas

Pressure Pipe and Fittings

ASTM D 2564	(2004) Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D 2657	(2003) Heat Fusion Joining Polyolefin Pipe and Fittings
ASTM D 2672	(1996a; R 2003) Joints for IPS PVC Pipe Using Solvent Cement
ASTM D 2683	(2004) Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
ASTM D 2774	(2004) Underground Installation of Thermoplastic Pressure Piping
ASTM D 2855	(1996; R 2002) Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D 2992	(2001) Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings
ASTM D 3035	(2003a) Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
ASTM D 3139	(1998) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D 3261	(2003) Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM D 3308	(2001) PTFE Resin Skived Tape
ASTM D 3839	(2002e1) Underground Installation of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D 3892	(1993; R 2003) Packaging/Packing of Plastics
ASTM D 3915	(1999ae1; R 2004) Rigid Poly(Vinyl Chloride) (PVC) and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds for Plastic Pipe and Fittings Used in Pressure Applications
ASTM E 515	(1995; R 2000) Leaks Using Bubble Emission Techniques
ASTM F 1055	(1998e1) Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing

ASTM F 402 (1993; R 1999) Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings

ASTM F 442/F 442M (1999) Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR)

ASTM F 656 (2002) Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25 (1998) Standard Marking System for Valves, Fittings, Flanges and Unions

MSS SP-58 (2002) Pipe Hangers and Supports - Materials, Design and Manufacture

MSS SP-69 (2002) Pipe Hangers and Supports - Selection and Application

MSS SP-72 (1999) Ball Valves with Flanged or Butt-Welding Ends for General Service

MSS SP-89 (1998) Pipe Hangers and Supports - Fabrication and Installation Practices

NACE INTERNATIONAL (NACE)

NACE RP0185 (1996) Extruded, Polyolefin Resin Coating Systems with Soft Adhesives for Underground or Submerged Pipe

NACE RP0274 (2004) High Voltage Electrical Inspection of Pipeline Coatings

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 325-1 (1994) Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids

NFPA 49 (3003) Hazardous Chemicals Data

NFPA 58 (2004) Liquefied Petroleum Gas Code

NFPA 704 (2001) Identification of the Hazards of Materials for Emergency Response

PLASTICS PIPE INSTITUTE (PPI)

PPI TR-21 (2001) Thermal Expansion and Contraction in Plastic Piping Systems

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6 (2000) Commercial Blast Cleaning

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

49 CFR 192

Transportation of Natural and Other Gas by
Pipeline: Minimum Federal Safety Standards

UNDERWRITERS LABORATORIES (UL)

UL Gas&Oil Dir

(2003) Flammable and Combustible Liquids
and Gases Equipment Directory

1.2 SUBMITTALS

NOTE: Review submittal description (SD) definitions in Section 01330 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Off-gas Piping System

Drawings containing graphical relationship of various components

of the work, schematic diagrams of the systems, details of fabrication, layouts of particular elements, connections, clearance required for maintenance and operation, and other aspects of the work to demonstrate that the system has been coordinated and will properly function as a unit. Drawings to demonstrate that thermal expansion of plastic pipe exposed to ambient conditions as predicted by PPI TR-21 has been incorporated into the design.

SD-03 Product Data

Materials and Equipment

Manufacturer's descriptive data and technical literature for each piping system, including design recommendations, pressure and temperature ratings, dimensions, type, grade and strength of pipe and fittings, thermal characteristics (coefficient of expansion and thermal conductivity) and chemical resistivity for each chemical constituent in the off-gas stream. Manufacturer's recommended installation procedures including materials preparation, and installations.

Material Safety Data Sheet

Material safety data sheet in conformance with ANSI Z400.1 for solvents, solvent cements, or glues used in pipe connections.

Statement of Satisfactory Installation

A statement signed by the principal officer of the contracting firm stating that the installation is satisfactory and in accordance with the contract plans and specifications and the manufacturer's prescribed procedures and techniques, upon completion of the project and before final acceptance.

SD-06 Test Reports

Destructive Joint Tests

Bubble Tests

Pressure Testing

Leakage Testing

Vacuum Testing

Hanger Acceptance Testing

Reports of inspections or test, including analysis and interpretation of test results. Each report shall be properly identified. Test methods used shall be identified and test results shall be recorded.

SD-07 Certificates

Off-gas Piping System

A written certificate from the testing agency stating that the items have been tested and that they conform to the applicable requirements of the specifications. The certificate shall indicate the methods of testing used by the testing agency. In lieu of a certificate from a testing agency, published catalog specification data, accompanied by the manufacturer's certified

statement that the items are in accordance with the applicable requirements of the specifications will be acceptable as evidence that the items conform with agency requirements.

Manufacturer's Representative

The name and qualifications of the manufacturer's representative and written certification from the manufacturer that the representative is technically qualified.

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

[Six] [_____] copies, in indexed booklet form, of site specific operation and maintenance manual for the piping system including system operation, system maintenance, equipment operation, and equipment maintenance manuals described below. If operation and maintenance manuals are provided in a common volume, they shall be clearly differentiated and separately indexed.

1.3 SYSTEM DESCRIPTION

The off-gas piping system shall consist of buried and above ground pipe, pipe supports, fittings, equipment and accessories.

1.3.1 Design Requirements

NOTE: Determine design wind speed from ASCE 7, and/or TI 809-01 LOAD ASSUMPTIONS FOR BUILDINGS. Use 161 km/h (100 miles per hour) minimum. Use 1.2 kPa (25 psf) snow load for most heavy snow climates; delete snow load where maximum snow is insignificant. In some cases, local climates and topography will dictate that a value greater than 197 Pa (25 psf) be used for snow loading. This may be determined from ANSI A58.1, local codes, or by research and analysis of the effect of local climate and topography.

Provide seismic requirements, if a Government designer (either Corps office or A/E) is the Engineer of Record, and show on the drawings. Delete the bracketed phrase if seismic details are not included. Sections 13080 and 15070, properly edited, must be included in the contract documents.

Piping shall be in accordance with 49 CFR 192. Design for installation of plastic pipe above grade shall have provisions for movement due to thermal expansion and contraction documented to be in accordance with PPI TR-21. Seismic details shall be in accordance with Sections 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 15070A SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT [as shown on the drawings].

Soil bearing capacity: [_____] MPa psf.

Seismic parameters: [_____] .

Wind speed (maximum): [_____] km/h mph.

Ground snow load: [_____] kPa psf.

Ambient air temperature (maximum): [_____] degrees C F.

Ambient air temperature (minimum): [_____] degrees C F.

1.3.2 Performance Requirements

NOTE: Enter names and concentrations of organic chemicals in the blank provided and additional lines or provide a reference to another section of the specification as necessary to provide complete information. Conditions encountered during construction frequently differ from the design conditions and/or worst conditions. Plume migration affects the concentrations that will be encountered during startup and testing. Design velocity range for vapors, gases, and smoke is between 5.1 and 10 m/sec (1,004 and 1,970 ft/min) in NFPA 91 Exhaust Systems for Air Conveying of Materials. Consider the requirements of ASTM D 543 in selection of pipe materials.

Identify pipe runs on the drawings and fill in the blanks with the maximum positive and negative anticipated gauge pressures.

Capacity and design of the piping and accessories shall be suitable for 24-hour full load service in an outdoor location. Expansion of plastic pipe exposed to ambient conditions shall be calculated using the procedures from PPI TR-21. Pipe materials shall be compatible with each of the following off-gas properties.

a. Pipe segment [A-B] [B-C] [C-D] [D-E] [_____] :

Pressure (gauge maximum): [_____] MPa psig.

Pressure (gauge minimum): [_____] MPa psig.

Flow rate (maximum): [_____] cubic m/s cubic ft/s.

Flow rate (minimum): [_____] cubic m/s cubic ft/s.

Ambient temperature (maximum): [_____] degrees C F.

Ambient temperature (minimum): [_____] degrees C F.

Off-gas temperature (maximum): [_____] degrees C F.

Off-gas temperature (minimum): [_____] degrees C F.

b. Estimated chemical concentrations of [vapor] [off-gas]:

pH:

Minimum [_____] .
Average [_____] .
Maximum [_____] .

Sulfide:

Maximum [_____] mg/L.
Minimum [_____] mg/L.
Average [_____] mg/L.

Ammonia:

Maximum [_____] mg/L.
Average [_____] mg/L.

[_____] :

Minimum [_____] .
Average [_____] .
Maximum [_____] .

1.4 UNIT PRICES

**NOTE: When it is determined that lump sum contract
is advisable this paragraph will be deleted.**

Measurement and payment will be based on completed work performed in accordance with the drawings, specifications, and the contract payment schedules. No payment will be made under this section for excavation, trenching, or backfilling. Payment for such work will be made under Section 02300 EARTHWORK.

1.4.1 Measurement

The length of pipe lines to be paid for will be determined by measuring along the centerline of the various sizes of pipe furnished and installed. Pipe will be measured from center of fitting to center of fitting and from connection to connection to wells or treatment units. No deduction will be made for the space occupied by valves or fittings.

1.4.2 Payment

Payment will be made for off-gas piping at the contract unit price per linear meter linear foot for the various types and sizes of piping, and shall be full compensation for pipes, joints, specials, and fittings, complete in place. Payment for valves, valve boxes, and standard valve manholes will be made at the respective contract unit price each for such items complete in place. Payment will include the furnishing of testing, plant, labor, and material and incidentals necessary to complete the work, as specified and as shown.

1.5 QUALIFICATIONS

1.5.1 Contractor

Contractor shall have had a minimum of [2] [3] [5] [_____] years of experience in the construction of piping systems for sour gas, condensable gas, off-gas or vapor.

1.5.2 Single Source Supplier

The Contractor shall assign to a single supplier full responsibility for the furnishing of the off-gas piping system. The designated single supplier, however, need not manufacture the system but shall coordinate the selection, assembly, installation, and testing of the entire system as specified herein.

1.5.3 Manufacturer's Representative

Services of a manufacturer's field service representative who is experienced in the installation of the materials and equipment furnished and who has complete knowledge of the proper operation and maintenance of the system shall be provided.

1.5.4 Welding

Qualifications of welding procedures, welders, and welding operators shall be in accordance with welding and nondestructive testing procedures for pressure piping specified in Section 05093 WELDING PRESSURE PIPING. Structural members shall be welded in accordance with Section 05090A WELDING, STRUCTURAL.

1.5.5 Jointing Plastic and Fiberglass Reinforced Pipe

Manufacturer's prequalified joining procedures shall be used. Joints shall be inspected by an inspector qualified in the joining procedures being used and in accordance with AGA XR0104. Joiners and inspectors shall be qualified at the job site by a person who has been trained and certified by the manufacturer of the pipe, to train and qualify joiners and inspectors in each joining procedure to be used on the job. Training shall include use of equipment, explanation of the procedure, and successfully making joints which pass tests specified in AGA XR0104. The Contracting Officer shall be notified at least 24 hours in advance of the date to qualify joiners and inspectors.

1.6 GENERAL REQUIREMENTS

Piping material and appurtenances shall be as specified and as shown on the drawings, and shall be suitable for the service intended. Materials and equipment shall be new and unused, except for testing equipment. Components that serve the same function and are the same size shall be identical products of the same manufacturer.

1.6.1 Standard Products

Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Pipe, valves, fittings and appurtenances shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

1.6.2 Identification

Each piece of pipe shall bear the ASTM designation and the ASTM markings required for that designation. Each valve shall be marked in accordance with MSS SP-25 to identify the manufacturer, size, pressure rating, body disc and seat material. A tag with the manufacturer's name, catalog number

and valve identification shall be securely attached.

1.6.3 Verification of Dimensions

The Contractor shall become familiar with details of the work, verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing the work.

1.7 DELIVERY AND STORAGE

1.7.1 Packaging

Plastic pipe shall be packed, packaged and marked in accordance with ASTM D 3892.

1.7.2 Cleaners, Solvents and Glues

A material safety data sheet in conformance with ANSI Z400.1 shall accompany each chemical delivered for use in pipe installation. Handling shall be in accordance with ASTM F 402.

1.7.3 Storage

Storage facilities shall be classified and marked in accordance with NFPA 704, with classification as indicated in NFPA 49 and NFPA 325-1. Materials shall be stored with protection from puncture, dirt, grease, moisture, mechanical abrasions, excessive heat, ultraviolet (UV) damage, or other damage. Pipe and fittings shall be handled and stored in accordance with the manufacturer's recommendations. Piping bundles shall be stored on a prepared surface and should not be stacked more than two bundles high.

1.8 PARTNERING/PRE-INSTALLATION CONFERENCE

NOTE: Remove this paragraph when conference is not required.

[Partnering] [Pre-installation] conference will be required. The Contractor shall ensure that involved subcontractors, suppliers, and manufacturers are [notified] [represented]. The date and time of the conference shall be furnished to the Contracting Officer for approval.

1.9 SEQUENCING AND SCHEDULING

NOTE: Coordinate with UFGS-13110A CATHODIC PROTECTION SYSTEM (SACRIFICIAL ANODE) or UFGS-13112A CATHODIC PROTECTION SYSTEM (IMPRESSED CURRENT) if steel pipe is allowed. Blowers and control valves are specified in UFGS-11215A FANS/BLOWERS/PUMPS; OFF-GAS.

Installation shall be as specified in Section 02300 EARTHWORK, except as modified herein or required by ASTM D 2774, ASTM D 2855, ASTM D 3839, or ASTM F 402, as appropriate for the pipe material.

1.10 MAINTENANCE SERVICE

NOTE: This paragraph covers provisions for maintenance service as applicable to critical systems, equipment, and landscaping. Insert text as required or omit.

Maintenance service shall include [_____].

1.11 EXTRA MATERIALS

NOTE: This paragraph covers items to be furnished to the Government by the Contractor for future maintenance and repair. Insert text as required.

Extra material consisting of [_____] shall be provided. A special wrench for removal of locking covers shall be provided for each valve box and for each pressure regulator box.

PART 2 PRODUCTS

NOTE: If thermoplastic pipe is specified for above ground use, verify that the referenced standards allow use of the specified materials for vapor transport or note the exceptions. Thermoplastic pipe is specified and installed above grade for vacuum applications. The ASME B31.3 advises that "special precautions should be observed" when using thermoplastic pipe to transport compressed gases above ground. Recommendation B of the Plastic Pipe Institute recommends against the use of thermoplastic pipe to transport air or other compressed gases in exposed above ground locations, e.g. in exposed plant piping." The industry standards for use of thermoplastic pipe for transmission of gas, ASTM D 2513 and ASTM D 3839, both recommend only underground use.

Combustible and explosive properties of the vapor, accumulation of static electrical charge and changes in strength characteristics due to elevated temperatures should be considered in material selection. Consideration should be given to compatibility of the construction materials with the condensate that will accumulate in the system. Select materials to avoid softening and loss of physical properties due to polymer degradation by depolymerization; stiffening or embrittlement due to loss of plasticizers resulting from repeated usage; deterioration of mechanical properties due to swelling; and failure of adhesive or heat fused joints due to interaction with condensate or leachate and physical stress.

See EM 1110-1-4008 Liquid Process Piping for chemical resistivity information.

Delete inapplicable materials or equipment. Options for other material, such as ductile iron in iron pipe sizes, may be added for noncorrosive gases.

2.1 DESIGN STRENGTH

Design strength of piping shall be suitable for the operating pressure and temperature ranges indicated and/or shown. With the exception of vacuum pipe segments [A-B] [B-C] [D-E] [____], thermoplastic pipe shall not be used to transport air or vapors in exposed above ground locations.

2.2 STEEL PIPE

NOTE: Verify that pipe wall thickness conforms to ASME B31.8 for larger sizes and high pressures.

For exposure potential to pressures less than 70 kPa (10 psig) and temperatures less than 100 degrees C (212 degrees F) and mild chemical exposure surface shall be blasted in accordance with SSPC SP 6.

For exposure potential to pressures greater than 70 kPa (10 psig) and temperatures greater than 100 degrees C (212 degrees F) and mild chemical exposure intermediate options may be appropriate.

For severe chemical exposure, the baked phenolic system should be used.

Steel pipe shall be Schedule 40 conforming to [Grade A or B, Type E or S of ASTM A 53/A 53M,] [API Spec 5L,] [ASME B31.8,] [or] [NFPA 58]. Pipe threads shall conform to ASME B1.20.1. Fittings for pipe 40 mm 1-1/2 inches and smaller shall conform to ASME B16.11. Butt weld fittings for pipe 40 mm 1-1/2 inches or less shall conform to ASME B16.9. Joint sealing compound shall conform to UL Gas&Oil Dir, Class 20 or less. Polytetrafluoroethylene tape shall conform to ASTM D 3308. Weld neck flanges shall be used. Connections shall conform to ASTM A 181/A 181M, Class 60, carbon steel. Carbon steel components shall be coated with corrosion resistant [materials.] [materials suitable for exposure to condensates.] Coatings and finishes shall be 100 percent holiday free.

2.2.1 Carbon Steel Located Above Grade

NOTE: Color must be specified only for the "-S" systems. The color is automatic (-A, Aluminum; -B, Black; -W, white) for the other systems.

Surfaces of aboveground carbon steel components shall be [____] coated in accordance with AWWA C218 [three-coat alkyd system 1-91-A] [three-coat alkyd system 1-91-W] [three-coat alkyd system 1-91-S] [four-coat alkyd

system 2-91-A] [four-coat alkyd system 2-91-W] [four-coat alkyd system 2-91-S] [three-coat alkyd/silicone alkyd system 3-91-W] [three-coat alkyd/silicone alkyd system 3-91-S] [three-coat epoxy/urethane system 4-91-W] [three-coat epoxy/urethane 4-91-S] [three-coat inorganic or organic zinc/epoxy/urethane 5-91-W] [three-coat inorganic or organic zinc/epoxy/urethane 5-91-S] [two- or three-coat epoxy/coal tar epoxy 6-91-B] [two or three- coat water reducible epoxy-polyamid 7-91-W] [two- or three-coat water reducible epoxy-polyamid 7-91-S] [three-coat water reducible acrylic or alkyd-modified acrylic emulsion 8-91-W] [three-coat water reducible acrylic or alkyd-modified acrylic emulsion 8-91-S] [two- or three-coat epoxy/high-build aliphatic polyurethane over existing coated substrates 9-95-W] [two- or three-coat epoxy/high-build aliphatic polyurethane over existing coated substrates 9-95-S].

2.2.2 Silicone Coating

Surfaces of carbon steel components shall be blasted in accordance with SSPC SP 6. Surface shall have an alkyd primer 62.5 micrometers 2.5 mils dry film thickness followed by two alkyd modified silicone final coats.

2.2.3 Zinc Coating

Surfaces of carbon steel components shall be coated with zinc in accordance with ASTM A 123/A 123M or ASTM A 153/A 153M.

2.2.4 Thermoplastic Resin Coating System

[Surfaces of carbon steel components shall have a minimum of [4] [5] [6] coats of phenolic type coatings applied [40] [50] micrometers [1.6] [2] mils minimum dry film thickness per coat. Each coat shall be baked at 149 degrees C 300 degrees F for 10 minutes. Full coating system shall be cured in oven at [190] [232] degrees C [375] [450] degrees F for 30 minutes.] [Continuously extruded polyethylene and adhesive coating system materials shall conform to NACE RP0185 Type A.]

2.2.5 Cathodic Protection

Buried ferrous pipe systems shall have cathodic protection.

2.3 COPPER TUBING

Copper tubing shall conform to ASTM B 837.

2.4 POLYVINYL CHLORIDE (PVC) PIPING

Design and fabrication of below grade components of the off-gas piping system shall be in accordance with ASTM D 2513 except as modified herein.

2.4.1 PVC Pipe

NOTE: CPVC in accordance with ASTM F 422 provides a heat protection factor that is important near blowers but is not generally necessary for buried piping.

ASTM D 3915 should be used unless aggressive chemical conditions dictate that D 1784 be used.

Pipe shall be in accordance with ASTM F 442/F 442M, ASTM D 2241, SDR [26] [21] [17] [_____]. Materials shall conform to ASTM D 3915, ASTM D 1784, Type IV, Grade 1, rigid (23447-B). The maximum eccentricity of the inside and outside circumferences of the pipe walls shall be 12 percent. Pipe shall be provided which does not fail, balloon, burst, or weep as defined in ASTM D 1598.

2.4.2 PVC Joints

Joints shall be pressure rated solvent cemented bell joints in accordance with ASTM D 2672 except where flanged or threaded fittings are required at expansion joints, valves, flowmeter, equipment connections or otherwise shown. Flanges shall be joined to pipe by solvent cementing. Primer shall conform to ASTM F 656. Solvent cement shall conform to ASTM D 2564.

2.4.3 PVC Fittings

Fittings shall be in accordance with [ASTM D 2466] [ASTM D 2467].

2.5 POLYETHYLENE (PE) PIPING

Design and fabrication of below grade components of the off-gas piping system shall be in accordance with ASTM D 2513 except as modified herein.

2.5.1 PE Pipe

Pipe shall be in accordance with [ASTM D 3035] [ASTM D 2447], Schedule [40] [80]. Wall thickness shall be SDR [11] [_____]. Melt flow shall be less than 1.5 g/10 min. with method ASTM D 1248, Condition F. Environmental stress crack resistance shall exceed 1000 hours, ASTM D 1693, Condition C.

2.5.2 PE Joints and Fittings

Fittings shall be pressure rated electrofusion fittings in accordance with ASTM F 1055, butt heat fusion fittings in accordance with ASTM D 3261 or socket-type fittings in accordance with ASTM D 2683 except where flanged connections are required at expansion joints, valves, flowmeter, equipment connections or otherwise shown. Flanges shall be joined to pipe by heat fusion in accordance with ASTM D 2657.

2.6 REINFORCED EPOXY RESIN PIPING

Design and fabrication of below grade components of the off-gas piping system shall be in accordance with ASTM D 2992 except as modified herein.

2.6.1 Epoxy Resin Pipe

Pipe shall be in accordance with ASTM D 2517. Resin shall be chemically resistant to condensates as determined by ASTM C 581.

2.6.2 Epoxy Resin Joints and Fittings

Joints and fittings shall be in accordance with ASTM D 2517.

2.7 DUCT SYSTEMS

NOTE: Consult Sheet Metal and Air Conditioning

Contractors' National Association (SMACNA) for metal and PVC duct design and construction recommendations. Consult Thermal Insulation Manufacturers' Association (TIMA) for design and construction standards for fiberglass ducts.

Ductwork shall comply with Section 15566A WARM AIR HEATING SYSTEMS.

2.8 FLANGED CONNECTIONS

2.8.1 Flanges

Flanges shall be Class [150] [____], socket weld, flat face in accordance with ASME B16.5. Drilling and dimensions of flanges, bolts, nuts, and bolt patterns shall be in accordance with ASME B16.5, Class [150] [____]. Bolts and nuts shall [conform to ASTM A 307] [be 304 stainless steel].

2.8.2 Gaskets

NOTE: Use gasket materials compatible with condensates. High temperature gaskets for above 160 degrees C (320 degrees F) should be aramid fibers bonded with nitrile butadiene rubber (NBR) or glass fibers bonded with polytetrafluoroethylene. EPDM is suitable for 100 degrees C (212 degrees F) or less. Chloroprene rubber is suitable for 80 degrees C (176 degrees F) or less. Florin rubber (i.e. Viton) and nitrile are suitable for 160 degrees C (320 degrees F) or less.

Gaskets shall be full face, non-asbestos compressed material compatible with the expected condensates in accordance with ASME B16.21, [3] [1.6] mm [1/8] [1/16] inch minimum thickness, full face or self-centering flat ring type. Gaskets shall be aramid fibers bonded with nitrile butadiene rubber (NBR) or glass fibers bonded with polytetrafluoroethylene suitable for [315] [____] degrees C [600] [____] degrees F service and meeting applicable requirements of [ASME B31.8] [NFPA 58]. [High temperature gaskets shall be suitable for above 160 degrees C 320 degrees F.] [Chloroprene rubber shall be suitable for [80] [100] degrees C [176] [212] degrees F service.] [EPDM shall be suitable for 100 degrees C 212 degrees F service.] [Florin rubber (i.e. Viton) or nitrile rubber shall be suitable for 160 degrees C 320 degrees F service.]

2.8.3 Sealants

Sealants shall conform to ASTM C 920.

2.9 EQUIPMENT AND APPURTENANCES

2.9.1 Manually Operated Valves

Ball valves shall be in accordance with MSS SP-72. Gate, plug, ball, and check valves shall be in accordance with API Spec 6D. Thermoplastic gas shutoffs and valves shall be in accordance with ASME B16.40.

2.9.2 Relief Valves

Relief valve with manually adjustable pressure differential shall be provided for each blower or vacuum pump. Relief valve shall be [weighted] [spring] [pilot-operated diaphragm type] with a [_____] percent accumulation. Relief valve diameter shall be line sized or as otherwise indicated and shall be rated to relieve [_____] cubic meters/s cubic feet per minute at a set pressure of [_____] kPa psig or a vacuum of [_____] kPa inches Hg. Materials shall be [aluminum] [bronze] [cast iron] [stainless steel] [_____] body, [bronze] [316 stainless steel] [_____] trim, and [Buna-N] [EPR] [nitrile] [Viton] [Teflon] [_____] elastomers. Maximum operating temperature and pressure shall be [_____] degrees C F and [_____] kPa psi.

2.9.3 Unloading Valves

Unloading valves shall be included to minimize pump/motor overloading during start and stop operations. Unloading valves shall be [pilot-operated diaphragm type with auxiliary solenoid operator] [actuated butterfly valve control by blower system controls]. Unloading valve shall be rated to relieve [_____] cubic meters/s cubic feet/minute at a set pressure of [_____] kPa psi or a vacuum of [_____] mm Hg inches Hg. Materials shall be [aluminum] [bronze] [stainless steel] body, [bronze] [316 stainless steel] trim, and [Buna-N] [EPR] [Viton] [Teflon] elastomers. Maximum operating temperature and pressure shall be [_____] degrees C F and [_____] kPa psi respectively.

2.9.4 Vacuum Breakers

Vacuum breakers shall be provided to protect blowers and vacuum pumps from damage due to excessive vacuum surges. Vacuum Breakers shall be [pilot-operated diaphragm type with auxiliary solenoid operator] [actuated butterfly valve control by blower system controls]. Valve shall be rated to relieve [_____] cubic m/s cfm at a set pressure of [_____] kPa psi or a vacuum of [_____] kPa inches Hg. Materials shall be [aluminum] [bronze] [stainless steel] body, [bronze] [316 stainless steel] trim, and [Buna-N] [EPR] [Viton] [Teflon] elastomers. Maximum operating temperature and pressure shall be [_____] degrees C F and [_____] kPa psi.

2.9.5 Dielectric Fittings

Dielectric fittings shall be installed between threaded ferrous and nonferrous metallic pipe, fittings and valves, except where corporation stops join mains. Dielectric fittings shall prevent metal-to-metal contact of dissimilar metallic piping elements and shall be suitable for the required working pressure.

2.9.6 Meters

Gas meters shall conform to AGA B109.2.

2.9.7 Insulation

Insulation of above grade exterior pipe, fittings and valves shall be as specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.9.8 Supports for Aboveground Piping

NOTE: Pipe materials differ greatly in their respective changes in size as temperature changes. The thermal expansion coefficient of PE is three times that of PVC pipe. In a buried environment, where the temperature fluctuations should be minimal and the pipe is supported on all sides by soil, thermal expansion is of less concern. However, in systems where the collector pipes are above ground, thermal expansion and contraction must be considered.

Pipe hangers and supports shall be furnished complete with necessary inserts, bolts, nuts, rods, washers, and accessories. Design and construction shall be in accordance with MSS SP-58. Specific application shall be in accordance with MSS SP-69. Hanger and supports shall be capable of adjustment after placement of piping. Hangers and supports shall be the product of one manufacturer. Hangers, supports and accessories shall be hot dip galvanized in accordance with ASTM A 123/A 123M unless copper or plastic coated. Restrained joints and thrust protection shall be provided. Concrete and metal cradles, collars, floor stands, supports, kickers, and block shall be provided as recommended by manufacturer. Pipe cradle cushion material shall be elastomer sheet strapped to pipe to prevent chafing at pipe support. Elastomer sheet shall be utilized around top of pipe to prevent chafing of pipe strap.

2.9.9 Valve Boxes

Valve boxes shall be adjustable extension type with screw or slide-type adjustments constructed of cast iron not less than 5 mm 3/16 inch thick. Valve boxes shall be provided with locking covers that require a special wrench for removal and the word "gas" cast in the box cover.

2.10 FACTORY TESTS

[Steel piping] [A representative unit of each diameter of steel piping] shall be tested by the manufacturer or a nationally recognized testing agency in compliance with NACE RP0274.

PART 3 EXECUTION

NOTE: Operations required to accomplish construction of plastic piping systems shall conform to the requirements of ASTM F 402.

3.1 CONDENSATE CONTROL

Off-gas piping shall be sloped uniformly between control elevations to enhance the removal of liquids. Provisions shall be made to collect and drain liquids from [condensation] [mist accumulation] [_____] in each pipe run. Liquid removal sumps and traps shall be located in the piping systems.

3.2 PRESSURE REGULATOR AND METER INSTALLATION

A valve shall be installed on each side of each meter or regulator for isolating the regulator for calibration, maintenance, and removal. An insulating joint constructed to prevent flow of electrical current shall be installed between metallic pipe and the meter or regulator.

3.2.1 Pressure Regulators

NOTE: Delete inapplicable requirements. Remove reference to bypasses around pressure regulators unless continuity is imperative and the bypass is regulated to prevent possible over pressure of downstream lines.

Pressure regulators shall be installed [450 mm 18 inches above the ground on the riser] [where shown]. A 10 mm 3/8 inch tapped fitting equipped with a plug shall be provided on both sides of the regulator for installation of pressure gauges for adjusting the regulator. Regulators and valves shall be installed in rectangular reinforced concrete boxes. Boxes shall be large enough so that required equipment can be properly installed, operated, and maintained. Sidewalls shall extend above ground line. The boxes shall be provided with [steel door] [cast iron manhole] covers with locking provisions and 100 mm 4 inch diameter vents.

3.2.2 Meters

Meters shall be installed in accordance with ASME B31.8.

3.2.3 Vents

Discharge stacks, vents, or outlet ports of devices shall be located where gas can be discharged into the atmosphere without undue hazard. Vents shall terminate in the outside air in rain and insect resistant fittings. [The open end of the vent shall be located where gas can escape freely into the atmosphere, away from any openings into the building and above areas subject to flooding.] [Stacks and vents shall be provided with fittings to preclude entry of water.]

3.3 INSTALLING PIPE UNDERGROUND

NOTE: Coordinate Section 02300 EARTHWORK and details on the drawings to assure that pipe bedding materials are appropriate for the allowed pipe.

Installation shall be as specified in Section 02300 EARTHWORK, except as modified herein; and as required by ASTM F 402 and ASTM D 2855 for using solvents and cleaners, ASTM D 2774 for polyvinyl chloride and polyethylene pipe, and ASTM D 3839 for fiberglass pipe.

3.3.1 Cathodic Protection

NOTE: Cathodic protection is mandatory for underground ferrous pipelines. The type and design of cathodic protection will be in accordance with TM 5-811-7. Stations will be provided for testing the cathodic protection system.

Cathodic protection shall be provided for ferrous piping installed

underground as specified in [Section 13110A CATHODIC PROTECTION SYSTEM (SACRIFICIAL ANODE)] [Section 13112A CATHODIC PROTECTION SYSTEM (IMPRESSED CURRENT)].

3.3.2 Valve Boxes

Valve boxes shall be installed at each underground valve except where concrete or other type of housing is indicated. When the valve is located in a roadway, the valve box shall be protected by a suitable concrete slab at least 1 square meter 3 square feet. When in a sidewalk, the top of the box shall be in a concrete slab 600 mm 2 feet square and set flush with the sidewalk. Valve boxes shall be separately supported, not resting on the pipe, so that traffic loads cannot be transmitted to the pipe.

3.3.3 Magnetic Tape

When non-metallic piping is installed underground, foil backed magnetic tape shall be placed above the pipe to permit locating with a magnetic detector.

3.3.4 Pipe Coatings

Any damage to the protective covering during transit and handling shall be repaired before installation.

3.4 INSTALLING PIPE ABOVEGROUND

With the exception of vacuum pipe segments [A-B] [B-C] [D-E] [_____] as indicated and/or shown, thermoplastic pipe shall not be installed aboveground. Vertical pipe shall be installed plumb in all directions. Perpendicular piping shall be installed parallel to building walls. Piping at angles and 45 degree runs across corners will not be accepted unless specifically shown. Small diameter piping shall be installed generally as shown when specific locations and elevations are not indicated. Piping shall be located to avoid ducts, equipment, and beams. Piping shall be installed to avoid obstructing corridors, walkways, work areas, and like spaces. A minimum headroom clearance of 2.2 m 7 feet shall be provided under piping unless otherwise indicated. Temporary caps or plugs shall be provided at pipe openings at the end of each day's work. Piping shall be run in groups where practicable. Minimum clearance shall be 25 mm 1 inch between pipe and other work.

3.4.1 Hangers and Supports

Pipe hangers and supports shall be installed in accordance with MSS SP-89 and MSS SP-69. Hangers or supports shall be installed at locations where pipe changes direction. Hanger rods shall be installed straight and vertical. Chain, wire, strap or perforated bar hangers will not be permitted. Hangers shall not be suspended from piping. Where proper hanger or support spacing does not correspond with joist or rib spacing, pipe shall be suspended from structural steel channels attached to joists or ribs. Contact between dissimilar metals shall be prevented when supporting copper tubing, by use of copper plated, rubber or vinyl coated, or stainless steel hangers or supports. Thin walled stainless steel piping shall be isolated from carbon steel by use of plastic coated hangers or supports or by taping at points of contact with PVC or vinyl. Galvanized or stainless steel hangers and supports shall be used in basins or submerged locations. Maximum support spacing unless otherwise shown or approved for standard weight steel pipe shall be as follows:

Pipe Size	Spacing
Up to size 38 mm	2 m
50 to 75 mm	3 m
Greater than 90 mm	4 m

Pipe Size	Spacing
Up to size 1-1/2 in	6 feet
2 to 3 in	10 feet
Greater than 3-1/2 in	12 feet

Maximum support spacing for pipe other than standard weight steel shall be two-thirds of the corresponding spacing for steel pipe unless otherwise shown or approved.

3.4.2 Insulation

Insulation shall be furnished and installed in accordance with Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.4.3 Coatings or Finishes

NOTE: Where the using service has specific requirements for color coding differing from the color specified, this paragraph will be modified accordingly and coordinated with paragraph, Identification and UFGS 09964 PAINTING: HYDRAULIC STRUCTURES. Off-gases from landfills often consist of large quantities of Methane (CH₄), Hydrogen Sulfide (H₂S) and Carbon Dioxide (CO₂) with a lesser amount of other organic compounds present. Phenolic or epoxy type coatings are generally recommended for this type of service.

Coatings and finishes shall be in accordance with Section 09964 PAINTING: HYDRAULIC STRUCTURES. Damage to the factory covering during transit and handling shall be repaired before installation. Painting is not required where piping is insulated, stainless steel, galvanized steel or nonferrous.

Factory painted items requiring touching-up in the field shall be cleaned of foreign material and shall be primed and top coated with the manufacturer's standard factory finish. Exposed ferrous surfaces shall be painted with two coats of enamel paint. Factory primed surfaces shall be solvent cleaned before painting. Surfaces that have not been factory primed shall be prepared and primed in accordance with the enamel paint manufacturer's recommendations.

3.5 JOINTING PIPE

Non-metallic piping shall be joined by performance qualified joiners using qualified procedures in accordance with AGA XR0104. Joints shall be inspected by an inspector qualified in the joining procedures being used and in accordance with AGA XR0104.

3.5.1 O-Ring Joints

Jointing surfaces and adjacent areas shall be cleaned before making joint. Gaskets and "O"-rings shall be lubricated and adjusted in accordance with manufacturer's recommendations. Each gasket shall be checked for proper position around full circumference of the joint after "O"-rings are compressed and before pipe is brought fully home. Jointing pipe shall be done in accordance with ASTM D 3139 and manufacturer's recommendations.

3.5.2 Mechanical Joints

The plain end shall be centered and pushed into the bell. The gasket shall be firmly pressed evenly into the bell. The gland shall be slipped to the bell for bolting. The bolt threads shall be oiled. Bolts shall be tightened alternately 180 degrees opposite to each other to seat the gasket evenly. Bituminous coating shall be applied to ferrous bolts and nuts before assembly. The maximum torque on bolts shall be as follows:

Bolt Size	Applied Torque
160 mm	68 Nm
190 mm	108 Nm
254 mm	122 Nm
317 mm	149 Nm
Bolt Size	Applied Torque
5/8 in	50 ft-lb
3/4 in	80 ft-lb
1 in	90 ft-lb
1-1/4 in	110 ft-lb

3.5.3 Flanged Joints

Hexagon head nuts and bolts shall be used. Bolt projection through the end of the nut shall be limited to [6] [_____] mm [1/4] [_____] inch maximum. Manufacturer's rating and instructions for specified service shall be followed.

3.5.4 Expansion Couplings

Expansion couplings in tension shall be provided to facilitate their removal. Stretcher bolts shall be set for maximum allowable elongation of expansion coupling as recommended by the manufacturer. Expansion couplings shall be provided as shown and as recommended by the manufacturer.

3.5.5 Destructive Joint Tests

NOTE: Destructive tests are provided as a designer option. Destructive tests are considered useful in assuring that good joints will be made. Delete the paragraph if this option is not exercised.

Each day, prior to making [heat fusion] [adhesive] [or] [solvent welded] joints, a joint of each size and type to be installed that day shall be

made by each person assembling these joints that day and shall be destructively tested. At least 3 longitudinal straps shall be cut from each joint. Each strap shall be visually examined, shall not contain voids or discontinuities on the cut surfaces of the joint area, and shall be deformed by bending, torque, or impact, and if failure occurs, it must not initiate in the joint area. If a joint fails the visual or deformation test, the qualified joiner who made that joint shall not make further field joints in plastic pipe on this job until that person has been retrained and requalified. The results of the destructive tests shall be recorded to include the date and time of the tests, size and type of the joints, ambient conditions, fusion iron temperature and names of inspectors and joiners.

3.6 CONNECTIONS

3.6.1 Transitions Between Types of Pipe

Necessary adapters, specials and connector pieces shall be provided when connecting different types and sizes of pipe or pipe furnished by different manufacturers. Underground connecting joints shall be encased with, 150 [_____] mm [6] [_____] inches minimum, Class B concrete unless otherwise shown, or recommended by manufacturer. Connections between piping and equipment, where required, shall be made using [approved] [proper] fittings to suit the actual conditions.

3.6.2 Connections to Off-Gas Source and Discharge Points

Contractor shall connect the off-gas pipelines to the source and discharge locations. The Contractor shall notify the Contracting Officer, in writing, 10 days before final connections and activation of the system.

3.6.3 Connection to Equipment

**NOTE: Coordinate the drawings and specifications
for blowers and treatment equipment.**

The Contractor shall provide connections to the equipment in accordance with approved procedures. Isolation of equipment shall only be done [immediately on each side of the equipment] [at the valve location shown on the drawings].

3.6.4 Location of Existing Piping

Locations of existing piping shown should be considered approximate. Contractor shall be responsible for determining exact location of existing piping which may be affected by his work during earth moving operations.

3.6.5 Removing Existing Pipelines from Service

Pipelines shall not be removed from service unless specifically listed or approved by Contracting Officer. Contracting Officer shall be notified at least [48] [_____] hours prior to removing each pipeline from service.

3.7 PRESSURE AND LEAKAGE TESTS

Tests shall be performed on [pipe segments as shown] [the system as a whole] [sections that can be isolated]. Joints shall be tested in sections

prior to backfilling when trenches must be backfilled before the completion of other pipeline sections. Labor, materials and equipment for conducting the tests shall be furnished by the Contractor and shall be subject to inspection during the tests. The Contractor shall be responsible for the cost of repair, replacement, and retesting required because of failure to meet testing requirements. Prior to testing the system, the interior shall be blown out, cleaned and cleared of foreign materials. Meters, regulators, and controls shall be removed before blowing out and cleaning and reinstalled after clearing of foreign materials. The Contractor shall maintain safety precautions for pressure testing during the tests. Contractor shall notify Contracting Officer [_____] [48] hours in advance of pressure, leakage and/or vacuum testing. Tests shall be conducted in the presence of the Contracting Officer unless otherwise directed. During the test, the entire system shall be completely isolated from compressors and other sources of pressure. Testing shall be done with due regard for the safety of employees and the public during the test. Persons not working on the test operations shall be kept out of the testing area while testing is proceeding. Leakage test shall be conducted only after satisfactory completion of pressure test.

3.7.1 Bubble Tests

Each joint shall be tested in accordance with ASTM E 515 prior to backfilling or concealing any work.

3.7.2 Pressure Testing

NOTE: Thermoplastic piping should not be pressure tested with air. Specify test pressure (including Class Location) to be used in accordance with ASME B31.8. Test pressure shall be not less than 1.5 times the design pressure, but shall not exceed 1.5 times the maximum rated pressure of the lowest-rated component in the system. Test pressures should recognize the weakest component of each segment tested for the design pressure and the maximum allowable operating pressure.

Backfill shall be placed and compacted to at least the pipe centerline before testing. Concrete for blocking shall be allowed to reach design strength and shall be backfilled and compacted to assure restraint by harnessed joints before testing. Section to be tested shall be slowly filled with [air.] [water, and air shall be expelled. Corporation cocks shall be installed as necessary to remove air.] Test pressure shall be applied for one hour and gauge pressure shall be observed. Leaks shall be continuously checked while test pressure is being maintained. The off-gas piping system shall be tested after construction and before being placed in service using [water] [air] as the test medium. The pressure test shall continue for at least [24] [36] [48] hours from the time of the initial readings to the final readings of pressure and temperature. The initial test readings of the instrument shall not be made for at least 1 hour after the pipe has been subjected to the full test pressure, and neither the initial nor final readings shall be made at times of rapid changes in atmospheric conditions. The temperatures shall be representative of the actual trench conditions. There shall be no indication of reduction of the test pressure, [_____] kPa psig, applied at the lowest elevation of the pipeline section, during the test after corrections have been made for

changes in atmospheric conditions in conformity with the relationship $T(1)P(2)=T(2)P(1)$, in which T and P denote absolute temperature and pressure, respectively, and the numbers denote initial and final readings. Lines which fail to hold specified test pressure or which exceed the allowable leakage rate shall be repaired and retested.

3.7.3 Leakage Testing

Pipe shall be allowed to stand full of water at least 12 hours prior to starting leakage test. Exposed pipe, joints, fittings and valves shall be examined. Visible leakage shall be stopped, and the defective pipe, fitting or valve shall be replaced. The line under test shall be refilled to reach the required test pressure. The amount of water permitted as leakage shall be placed in a container attached to the supply side of the test pump. Container shall be sealed. No other source of supply to the pump or line under test shall be attached. Water shall be pumped into the line with the test pump to hold [] kPa psig for [2] [4] [8] hours. Water remaining in the container and the amount used during the test shall be measured and recorded on the test report. Test shall be considered as failed upon exhaustion of supply and/or inability to maintain the required pressure.

3.7.4 Vacuum Testing

Test shall be performed on [the entire system] [individual sections] as approved by the Contracting Officer. Openings shall be sealed in system or section to be tested. Vacuum [] kPa psig shall be pulled for one hour (isolating system from vacuum by closing valves). System shall be allowed to normalize and then the initial vacuum readings shall be recorded. The vacuum shall be recorded at intervals of [15 minutes] [1 hour] [] for the duration of the [8] [] hour test. Measurable leakage (loss of vacuum) after corrections have been made for changes in atmospheric conditions in conformity with the relationship $T(1)P(2)=T(2)P(1)$, in which T and P denote absolute temperature and total pressure, respectively, and the numbers denote initial and final readings, shall be repaired and retested.

3.7.5 Hanger Acceptance Testing

Pipe systems shall be brought up to operating pressures and temperatures. Systems shall be recycled to duplicate operating conditions.

3.7.6 Demonstration

Upon completion of the work the Contractor shall submit a Statement of Satisfactory Installation as specified in the Submittals paragraph and, at a time designated by the Contracting Officer, the services of a qualified engineer shall be provided by the Contractor for a period of not less than [8] [] hours to instruct a representative of the Government in the contents of the operation and maintenance manuals for the equipment furnished under this Section. The field instructions shall cover the items contained in the bound instructions.

a. The System Operation Manual shall include but not be limited to the following:

- (1). Maps showing piping layout and locations of system valves and line markers.

- (2). Step-by-step procedures required for system startup, operation, and shutdown. System components and equipment shall be indexed to the maps.
 - (3). Isolation procedures and valve operations to shut down or isolate each section of the system. Valves and other system components shall be indexed to the maps.
 - (4). Descriptions of Site Specific Standard Operation Procedures including permanent and temporary pipe repair procedures, system restart and test procedures for placing repaired lines back in service, and procedures for abandoning piping and system components.
 - (5). Descriptions of Emergency Procedures including: isolation procedures including required valve operations with valve locations indexed to the map, recommended emergency equipment, and checklist for major emergencies.
- b. The Equipment Operation Manual shall include but not be limited to detail drawings, equipment data, and manufacturer supplied operation manuals for equipment, valves and system components.
- c. The System Maintenance Manuals shall include but not be limited to:
- (1). Maintenance check list for entire system.
 - (2). Descriptions of site specific standard maintenance procedures.
 - (3). Maintenance procedures for installed cathodic protection systems.
 - (4). Piping layout, equipment layout, and control diagrams of the systems as installed.
 - (5). Identification of pipe materials and manufacturer by location, pipe repair procedures, and jointing procedures at transitions to other piping materials or piping from different manufacturer.
- d. The Equipment Maintenance Manuals shall include but not be limited to the following:
- (1). Identification of valves and other equipment by materials, manufacturer, vendor identification and location.
 - (2). Maintenance procedures and recommended maintenance tool kits for valves and equipment.
 - (3). Recommended repair methods, either field repair, factory repair, or whole-item replacement for each valve component or piece of equipment or component item.
 - (4). Routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide.

-- End of Section --