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USACE / NAVFAC / AFCEC **UFGS-31 21 00 (February 2021)**

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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2025
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SECTION 31 21 00

OFF-GASSING MITIGATION
02/21

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

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
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PART 1 GENERAL

1.1 UNIT PRICES

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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 31 00 00 EARTHWORK.

1.1.1 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.

1.1.2 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 will 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.

1.2 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 Reference Identifier (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.

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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 ANSI B109.2	(2000) Diaphragm Type Gas Displacement Meters (500 cubic ft./hour Capacity and Over)
AGA XR0603	(2006; 8th Ed) AGA Plastic Pipe Manual for Gas Service

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z400.1/Z129.1	(2010) Hazardous Workplace Chemicals – Hazard Evaluation and Safety Data Sheet

and Precautionary Labeling Preparation

AMERICAN PETROLEUM INSTITUTE (API)

API Spec 5L	(2018; 46th Ed; ERTA 2018) Line Pipe
API Spec 6D	(June 2018, 4th Ed; Errata 1 July 2018; Errata 2 August 2018) Specification for Pipeline and Piping Valves

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B1.20.2M	(2006; R 2011) Pipe Threads, 60 Deg. General Purpose (Metric)
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2024) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2022) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.40	(2024) Manually Operated Thermoplastic Gas Shutoffs and Valves in Gas Distribution Systems
ASME B31.8	(2022; Supplement 2022) Gas Transmission and Distribution Piping Systems

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C218	(2023) Liquid Coatings for Aboveground Steel Water Pipe and Fittings

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2024) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A123/A123M	(2024) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2023) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A181/A181M	(2014; R 2020) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping

ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM B837	(2019) Standard Specification for Seamless Copper Tube for Natural Gas and Liquified Petroleum (LP) Gas Fuel Distribution Systems
ASTM C581	(2020) Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures, Intended for Liquid Service
ASTM C920	(2018; R 2024) Standard Specification for Elastomeric Joint Sealants
ASTM D1248	(2016) Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D1598	(2015a) Time-to-Failure of Plastic Pipe Under Constant Internal Pressure
ASTM D1693	(2015) Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D2241	(2020) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D2466	(2023) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2467	(2020) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2513	(2018a) Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings
ASTM D2517	(2018) Standard Specification for Reinforced Epoxy Resin Gas Pressure Pipe and Fittings
ASTM D2564	(2020) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2657	(2007; R 2015) Heat Fusion Joining

	Polyolefin Pipe and Fittings
ASTM D2672	(2014) Joints for IPS PVC Pipe Using Solvent Cement
ASTM D2683	(2020) Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
ASTM D2774	(2021a) Standard Practice for Underground Installation of Thermoplastic Pressure Piping
ASTM D2855	(2020) Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets
ASTM D2992	(2012) Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings
ASTM D3035	(2022) Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
ASTM D3139	(2019) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D3261	(2016) Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM D3308	(2012; R 2017) Standard Specification for PTFE Resin Skived Tape
ASTM D3839	(2014; R 2019) Standard Guide for Underground Installation of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D3892	(2015) Standard Practice for Packaging/Packing of Plastics
ASTM E515	(2011; R 2022) Standard Practice for Leaks Using Bubble Emission Techniques
ASTM F402	(2018) Standard Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings
ASTM F442/F442M	(2023) Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC)

	Plastic Pipe (SDR-PR)
ASTM F656	(2021) Standard Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings
ASTM F1055	(2016; R 2022a) Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene and Crosslinked Polyethylene (PEX)Pipe and Tubing

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

MSS SP-25	(2018) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service

NACE INTERNATIONAL (NACE)

NACE SP0185	(2024) Extruded Polyolefin Resin Coating Systems with Soft Adhesives for Underground or Submerged Pipe
NACE SP0274	(1974; R 2011) High Voltage Electrical Inspection of Pipeline Coatings

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 58	(2024; TIA 24-2) Liquefied Petroleum Gas Code
NFPA 704	(2022) Standard System for the Identification of the Hazards of Materials for Emergency Response

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2023; with Change 2, 2024) Structural Engineering

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

49 CFR 192	Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards

UL SOLUTIONS (UL)

UL FLAMMABLE & COMBUSTIBLE	(2012) Flammable and Combustible Liquids and Gases Equipment Directory

1.3 SYSTEM DESCRIPTION

Provide off-gas piping system consisting of buried and above ground pipe, pipe supports, fittings, equipment and accessories. Submit 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 has been incorporated into the design. Submit 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. 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.

1.3.1 Design Requirements

****

NOTE: Determine design wind speed from ASCE 7-16, and/or UFC 3-301-01 STRUCTURAL LOAD DATA. 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. Pertinent portions of UFC 3-301-01 and Sections 13 48 73 and 23 05 48.19, properly edited, must be included in the contract documents.

****

Provide piping in accordance with 49 CFR 192. Ensure design for installation of plastic pipe above grade has provisions for movement due to thermal expansion and contraction. Provide seismic details in accordance with UFC 3-301-01 and Sections 13 48 73 SEISMIC CONTROL FOR MISCELLANEOUS EQUIPMENT and 23 05 48.19 SEISMIC BRACING FOR MECHANICAL SYSTEMS [as shown on the drawings].

a. Soil bearing capacity: [_____] MPa psf.

b. Seismic parameters: [_____].

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

d. Ground snow load: [_____] kPa psf.

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

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 D543 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.

****

Provide capacity and design of the piping and accessories suitable for 24-hour full load service in an outdoor location. Calculate expansion of plastic pipe exposed to ambient conditions. Provide pipe materials compatible with each of the following off-gas properties.

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

b.

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

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

d.

	Minimum	Average	Maximum
pH	[_____]	[_____]	[_____]
Sulfide	[_____] mg/L	[_____] mg/L	[_____] mg/L
Ammonia	-----	[_____] mg/L	[_____] mg/L
[_____]	[_____]	[_____]	[_____]

1.4 SUBMITTALS

****

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters 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 and Air Force projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

****

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Off-Gas Piping System

SD-03 Product Data

Materials and Equipment

Safety Data Sheet

Statement of Satisfactory Installation

SD-06 Test Reports

Destructive Joint Tests

Bubble Tests

Pressure Testing

Leakage Testing

Vacuum Testing

Hanger Acceptance Testing

SD-07 Certificates

Off-gas Piping System

Manufacturer's Representative

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G, [_____]

1.5 QUALITY ASSURANCE

1.5.1 Contractor Qualifications

Have 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

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 must coordinate the selection, assembly, installation, and testing of the entire system as specified herein.

1.5.3 Welding

Provide qualifications of welding procedures, welders, and welding operators in accordance with welding and nondestructive testing procedures for pressure piping specified in Section 40 05 13.96 WELDING PROCESS PIPING. Weld structural members in accordance with Section 05 05 23.16 STRUCTURAL WELDING.

1.5.4 Jointing Plastic and Fiberglass Reinforced Pipe

Use manufacturer's prequalified joining procedures. Inspect joints by an inspector qualified in the joining procedures being used and in accordance

with AGA XR0603. Ensure joiners and inspectors are 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 must include use of equipment, explanation of the procedure, and successfully making joints which pass tests specified in AGA XR0603. Notify the Contracting Officer at least 24 hours in advance of the date to qualify joiners and inspectors.

1.5.5 Pre-Installation Meeting

****
NOTE: Remove this paragraph when conference is not required.
****

[Partnering] [Pre-installation] meeting will be required. Ensure that involved subContractors, suppliers, and manufacturers are [notified] [represented]. Furnish date and time of the conference to the Contracting Officer for approval.

1.6 DELIVERY, STORAGE, AND HANDLING

1.6.1 Packaging

Pack, package and mark plastic pipe in accordance with ASTM D3892.

1.6.2 Cleaners, Solvents and Glues

A safety data sheet in conformance with ANSI Z400.1/Z129.1 must accompany each chemical delivered for solvents, solvent cements, or glues used in pipe connections or pipe installation. Handling must be in accordance with ASTM F402.

1.6.3 Storage

Classify and mark storage facilities in accordance with NFPA 704. Store materials with protection from puncture, dirt, grease, moisture, mechanical abrasions, excessive heat, ultraviolet (UV) damage, or other damage. Handle and store pipe and fittings in accordance with the manufacturer's recommendations. Store piping bundles on a prepared surface and do not stack more than two bundles high.

1.7 SEQUENCING AND SCHEDULING

****
NOTE: Coordinate with Section Section 26 42 13 GALVANIC (SACRIFICIAL) ANODE CATHODIC PROTECTION (GACP) SYSTEM or Section 26 42 17 IMPRESSED CURRENT CATHODIC PROTECTION (ICCP) SYSTEM if steel pipe is allowed. Blowers and control valves are specified in Section 43 11 00.10 OFF-GAS FANS, BLOWERS AND PUMPS.
****

Perform installation as specified in Section 31 00 00 EARTHWORK, except as modified herein or required by ASTM D2774, ASTM D2855, ASTM D3839, or ASTM F402, as appropriate for the pipe material.

1.8 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.

****

Provide extra material consisting of [_____]. Provide a special wrench for removal of locking covers for each valve box and for each pressure regulator box.

1.9 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 includes [_____].

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 D2513 and ASTM D3839, 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 MATERIALS AND EQUIPMENT

Provide materials and equipment that are new and unused, except for testing equipment. Ensure components that serve the same function and that are the same size are identical products of the same manufacturer. Provide piping material and appurtenances suitable for the service intended as specified and as shown on the drawings. Submit 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.

2.1.1 Standard Products

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

2.1.2 Identification

Provide each piece of pipe bearing the ASTM designation and the ASTM markings required for that designation. Mark each valve in accordance with MSS SP-25 to identify the manufacturer, size, pressure rating, body disc and seat material. Securely attach a tag with the manufacturer's name, catalog number and valve identification.

2.2 DESIGN STRENGTH

Ensure design strength of piping is 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] [_____], do not use thermoplastic pipe to transport air or vapors in exposed above ground locations.

2.3 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, blast surface in accordance with SSPC SP 6/NACE No.3.

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.

****

Provide Schedule 40 steel pipe conforming to [Grade A or B, Type E or S of ASTM A53/A53M,] [API Spec 5L,] [ASME B31.8,] [or] [NFPA 58]. Provide pipe threads conforming to ASME B1.20.2MASME B1.20.1. Use fittings for pipe 40 mm 1-1/2 inches and smaller conforming to ASME B16.11. Use buttweld fittings for pipe 40 mm 1-1/2 inches or less conforming to ASME B16.9. Provide joint sealing compound conforming to UL FLAMMABLE & COMBUSTIBLE, Class 20 or less. Use polytetrafluoroethylene tape conforming to ASTM D3308. Use weld neck flanges. Ensure connections conform to ASTM A181/A181M, Class 60, carbon steel. Coat carbon steel components with corrosion resistant [materials.] [materials suitable for exposure to condensates.] Ensure coatings and finishes are 100 percent holiday free.

2.3.1 Carbon Steel Located Above Grade

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

****

[_____] coat surfaces of aboveground carbon steel components 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].

2.3.2 Silicone Coating

Blast surfaces of carbon steel components in accordance with SSPC SP 6/NACE No.3. Provide surface with an alkyd primer 62.5 micrometers 2.5 mils dry film thickness followed by two alkyd modified silicone final coats.

2.3.3 Zinc Coating

Coat surfaces of carbon steel components with zinc in accordance with ASTM A123/A123M or ASTM A153/A153M.

2.3.4 Thermoplastic Resin Coating System

[Provide surfaces of carbon steel components with 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. Bake each coat at 149 degrees C 300 degrees F for 10 minutes. Cure full coating system in oven at [190] [232] degrees C [375] [450] degrees F for 30 minutes.] [Ensure continuously extruded polyethylene and adhesive coating system materials conform to NACE SP0185 Type A.]

2.3.5 Cathodic Protection

Provide buried ferrous pipe systems with cathodic protection.

2.4 COPPER TUBING

Provide copper tubing conforming to ASTM B837.

2.5 POLYVINYL CHLORIDE (PVC) PIPING

Design and fabaricate below grade components of the off-gas piping system in accordance with ASTM D2513 except as modified herein.

2.5.1 PVC Pipe

****

NOTE: CPVC in accordance with ASTM F422 provides a heat protection factor that is important near blowers but is not generally necessary for buried piping.

****

Provide pipe in accordance with ASTM F442/F442M, ASTM D2241, SDR [26] [21] [17] [_____]. Provide materials conforming to ASTM D1784, Type IV, Grade 1, rigid (23447-B). Use maximum eccentricity of the inside and outside circumferences of the pipe walls of 12 percent. Provide pipe which does not fail, balloon, burst, or weep as defined in ASTM D1598.

2.5.2 PVC Joints

Provide pressure rated solvent cemented bell joints in accordance with ASTM D2672 except where flanged or threaded fittings are required at expansion joints, valves, flowmeter, equipment connections or otherwise shown. Join flanges to pipe by solvent cementing. Use primer conforming to ASTM F656. Use solvent cement conforming to ASTM D2564.

2.5.3 PVC Fittings

Provide fittings in accordance with [ASTM D2466] [ASTM D2467].

2.6 POLYETHYLENE (PE) PIPING

Design and fabricate below grade components of the off-gas piping system in accordance with ASTM D2513 except as modified herein.

2.6.1 PE Pipe

Provide pipe in accordance with ASTM D3035, Schedule [40] [80]. Ensure

wall thickness is SDR [11] [_____]. Ensure melt flow is less than 1.5 g/10 min. with method ASTM D1248, Condition F. Ensure environmental stress crack resistance exceeds 1000 hours, ASTM D1693, Condition C.

2.6.2 PE Joints and Fittings

Provide pressure rated electrofusion fittings in accordance with ASTM F1055, butt heat fusion fittings in accordance with ASTM D3261 or socket-type fittings in accordance with ASTM D2683 except where flanged connections are required at expansion joints, valves, flowmeter, equipment connections or otherwise shown. Join flanges to pipe by heat fusion in accordance with ASTM D2657.

2.7 REINFORCED EPOXY RESIN PIPING

Design and fabricate below grade components of the off-gas piping system in accordance with ASTM D2992 except as modified herein.

2.7.1 Epoxy Resin Pipe

Provide pipe in accordance with ASTM D2517. Provide resin that is chemically resistant to condensates as determined by ASTM C581.

2.7.2 Epoxy Resin Joints and Fittings

Provide joints and fittings in accordance with ASTM D2517.

2.8 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.
****

Provide ductwork in compliance with Section 23 54 19 BUILDING HEATING SYSTEMS, WARM AIR.

2.9 FLANGED CONNECTIONS

2.9.1 Flanges

Provide Class [150] [_____], socket weld, flat face flanges in accordance with ASME B16.5. Ensure drilling and dimensions of flanges, bolts, nuts, and bolt patterns are in accordance with ASME B16.5, Class [150] [_____]. Provide bolts and nuts that [conform to ASTM A307] [are 304 stainless steel].

2.9.2 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.

****

Provide gaskets consisting of 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. Provide gaskets consisting of 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]. [Provide high temperature gaskets which are suitable for above 160 degrees C 320 degrees F.] [Provide chloroprene rubber suitable for [80] [100] degrees C [176] [212] degrees F service.] [Provide EPDM suitable for 100 degrees C 212 degrees F service.] [Provide florin rubber (i.e. Viton) or nitrile rubber suitable for 160 degrees C 320 degrees F service.]

2.9.3 Sealants

Provide sealants conforming to ASTM C920.

2.10 EQUIPMENT AND APPURTENANCES

2.10.1 Manually Operated Valves

Provide ball valves in accordance with MSS SP-72. Provide gate, plug, ball, and check valves in accordance with API Spec 6D. Provide thermoplastic gas shutoffs and valves in accordance with ASME B16.40.

2.10.2 Relief Valves

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

2.10.3 Unloading Valves

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

2.10.4 Vacuum Breakers

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

2.10.5 Dielectric Fittings

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

2.10.6 Meters

Gas meters conforming to AGA ANSI B109.2.

2.10.7 Insulation

Provide insulation of above grade exterior pipe, fittings and valves as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.10.8 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.

****

Furnish pipe hangers and supports complete with necessary inserts, bolts, nuts, rods, washers, and accessories. Design and construction must be in accordance with MSS SP-58. Specific application must be in accordance with MSS SP-58. Provide hanger and supports capable of adjustment after placement of piping. Ensure hangers and supports are the product of one manufacturer. Hot dip galvanize hangers, supports and accessories in accordance with ASTM A123/A123Munless copper or plastic coated. Provide restrained joints and thrust protection. Provide concrete and metal cradles, collars, floor stands, supports, kickers, and block as recommended by manufacturer. Pipe cradle cushion material must be elastomer sheet strapped to pipe to prevent chafing at pipe support. Utilize elastomer sheet around top of pipe to prevent chafing of pipe strap.

2.10.9 Valve Boxes

Provide adjustable extension type valve boxes with screw or slide-type adjustments constructed of cast iron no less than 5 mm 3/16 inch thick. Provide valve boxes with locking covers that require a special wrench for removal and the word "gas" cast in the box cover.

2.11 FACTORY TESTS

Test [steel piping] [a representative unit of each diameter of steel piping] by the manufacturer or a nationally recognized testing agency in compliance with NACE SP0274.

PART 3 EXECUTION

****
NOTE: Operations required to accomplish construction of plastic piping systems will conform to the requirements of ASTM F402.
****

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 MANUFACTURER'S REPRESENTATIVE

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

3.3 CONDENSATE CONTROL

Slope off-gas piping uniformly between control elevations to enhance the removal of liquids. Make provisions to collect and drain liquids from [condensation] [mist accumulation] [_____] in each pipe run. Locate liquid removal sumps and traps in the piping systems.

3.4 PRESSURE REGULATOR AND METER INSTALLATION

Install a valve on each side of each meter or regulator for isolating the regulator for calibration, maintenance. and removal. Install an insulating joint constructed to prevent flow of electrical current between metallic pipe and the meter or regulator.

3.4.1 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.
****

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

3.4.2 Meters

Install meters in accordance with ASME B31.8.

3.4.3 Vents

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

3.5 INSTALLING PIPE UNDERGROUND

****
NOTE: Coordinate Section 31 00 00 EARTHWORK and details on the drawings to assure that pipe bedding materials are appropriate for the allowed pipe.
****

Perform installation as specified in Section 31 00 00 EARTHWORK, except as modified herein; and as required by ASTM F402 and ASTM D2855 for using solvents and cleaners, ASTM D2774 for polyvinyl chloride and polyethylene pipe, and ASTM D3839 for fiberglass pipe.

3.5.1 Cathodic Protection

****
NOTE: Cathodic protection is mandatory for underground ferrous pipelines. The type and design of cathodic protection will be in accordance with UFC 3-570-02A. Stations will be provided for testing the cathodic protection system.
****

Provide cathodic protection for ferrous piping installed underground as specified in [Section 26 42 13 GALVANIC (SACRIFICIAL) ANODE CATHODIC PROTECTION (GACP) SYSTEM] [Section 26 42 17 IMPRESSED CURRENT CATHODIC PROTECTION (ICCP) SYSTEM].

3.5.2 Valve Boxes

Install valve boxes at each underground valve except where concrete or other type of housing is indicated. When the valve is located in a roadway, protect the valve box by a suitable concrete slab at least 1 square meter 3 square feet. When in a sidewalk, place the top of the box in a concrete slab 600 mm 2 feet square and set flush with the sidewalk.

Support valve boxes separately, not resting on the pipe, so that traffic loads cannot be transmitted to the pipe.

3.5.3 Magnetic Tape

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

3.5.4 Pipe Coatings

Repair any damage to the protective covering during transit and handling before installation.

3.6 INSTALLING PIPE ABOVEGROUND

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

3.6.1 Hangers and Supports

Install pipe hangers and supports in accordance with MSS SP-58 at locations where pipe changes direction. Install hanger rods straight and vertical. Chain, wire, strap or perforated bar hangers will not be permitted. Do not suspend hangers from piping. Where proper hanger or support spacing does not correspond with joist or rib spacing, suspend pipe from structural steel channels attached to joists or ribs. Prevent contact between dissimilar metals when supporting copper tubing, by use of copper plated, rubber or vinyl coated, or stainless steel hangers or supports. Isolate thin walled stainless steel piping from carbon steel by use of plastic coated hangers or supports or by taping at points of contact with PVC or vinyl. Use galvanized or stainless steel hangers and supports in basins or submerged locations. Provide maximum support spacing, unless otherwise shown or approved for standard weight steel pipe, as follows:

Pipe Size	Spacing
Less than 50 mm 2 inches	2 m6 feet
50 to 75 mm2 to 3 inches	3 m10 feet
Greater than 75 mm3 inches	4 m12 feet

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

3.6.2 Insulation

Furnish and install insulation in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.6.3 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 09 97 02 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.

****

Provide coatings and finishes in accordance with Section 09 97 02 PAINTING: HYDRAULIC STRUCTURES. Repair damage to the factory covering during transit and handling before installation. Painting is not required where piping is insulated, stainless steel, galvanized steel or nonferrous. Clean factory painted items requiring touching-up in the field of foreign material and prime and top coat with the manufacturer's standard factory finish. Paint exposed ferrous surfaces with two coats of enamel paint. Solvent clean factory primed surfaces before painting. Prepare and prime surfaces that have not been factory primed in accordance with the enamel paint manufacturer's recommendations.

3.7 JOINTING PIPE

Join non-metallic piping by performance qualified joiners using qualified procedures in accordance with AGA XR0603. Inspect joints by an inspector qualified in the joining procedures being used and in accordance with AGA XR0603.

3.7.1 O-Ring Joints

Clean jointing surfaces and adjacent areas before making joint. Lubricate and adjust gaskets and "O"-rings in accordance with manufacturer's recommendations. Check each gasket for proper position around full circumference of the joint after "O"-rings are compressed and before pipe is brought fully home. Jointing pipe must be done in accordance with ASTM D3139 and manufacturer's recommendations.

3.7.2 Mechanical Joints

Center the plain end and push into the bell. Firmly press gasket evenly into the bell. Slip gland to the bell for bolting. Oil the bolt threads. Tighten bolts alternately 180 degrees opposite to each other to seat the gasket evenly. Apply bituminous coating to ferrous bolts and nuts before assembly. Use maximum torque on bolts as follows:

Bolt Size (mminch)	Applied Torque (Nmft-lb)
165/8	6850
193/4	10880
251 inch	12290
321-1/4	149110

3.7.3 Flanged Joints

Use hexagon head nuts and bolts. Limit bolt projection through the end of the nut to [6] [_____] mm [1/4] [_____] inch maximum. Follow manufacturer's rating and instructions for specified service.

3.7.4 Expansion Couplings

Provide expansion couplings in tension to facilitate their removal. Set stretcher bolts for maximum allowable elongation of expansion coupling as recommended by the manufacturer. Provide expansion couplings as shown and as recommended by the manufacturer.

3.7.5 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, make a joint of each size and type to be installed that day by each person assembling these joints that day and destructively test. Cut at least 3 longitudinal straps from each joint. Visually examine each strap. Ensure strap does not contain voids or discontinuities on the cut surfaces of the joint area, and is 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, ensure the qualified joiner who made that joint does not make further field joints in plastic pipe on this job until that person has been retrained and requalified. Record results of the destructive tests 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.

3.8 CONNECTIONS

3.8.1 Transitions Between Types of Pipe

Provide necessary adapters, specials and connector pieces when connecting different types and sizes of pipe or pipe furnished by different manufacturers. Encase underground connecting joints with 150 [_____] mm [6] [_____] inches minimum, Class B concrete unless otherwise shown, or recommended by manufacturer. Make connections between piping and equipment, where required, using [approved] [proper] fittings to suit the actual conditions.

3.8.2 Connections to Off-Gas Source and Discharge Points

Connect the off-gas pipelines to the source and discharge locations. Notify the Contracting Officer, in writing, 10 days before final connections and activation of the system.

3.8.3 Connection to Equipment

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

Provide connections to the equipment in accordance with approved procedures. Only isolate equipment [immediately on each side of the equipment] [at the valve location shown on the drawings].

3.8.4 Location of Existing Piping

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

3.8.5 Removing Existing Pipelines from Service

Do not remove pipelines from service unless specifically listed or approved by Contracting Officer. Notify the Contracting Officer at least [48] [_____] hours prior to removing each pipeline from service.

3.9 PRESSURE AND LEAKAGE TESTS

Perform tests on [pipe segments as shown] [the system as a whole] [sections that can be isolated]. Test joints in sections prior to backfilling when trenches have to be backfilled before the completion of other pipeline sections. Furnish labor, materials and equipment for conducting the tests which are subject to inspection during the tests. The Contractor is responsible for the cost of repair, replacement, and retesting required because of failure to meet testing requirements. Prior to testing the system, blow out the interior, clean and clear of foreign materials. Remove meters, regulators, and controls before blowing out and cleaning and reinstall after clearing of foreign materials. Maintain safety precautions for pressure testing during the tests. Notify Contracting Officer [_____] [48] hours in advance of pressure, leakage and/or vacuum testing. Conduct tests in the presence of the Contracting Officer unless otherwise directed. During the test, completely isolate the entire system from compressors and other sources of pressure. Perform testing with due regard for the safety of employees and the public during the test. Keep persons not working on the test operations out of the testing area while testing is proceeding. Conduct leakage test only after satisfactory completion of pressure test.

3.9.1 Bubble Tests

Test each joint in accordance with ASTM E515 prior to backfilling or concealing any work.

3.9.2 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 will not be less than 1.5 times the design pressure, but not exceeding 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.

****

Place and compact backfill to at least the pipe centerline before testing. Allow concrete for blocking to reach design strength and backfill and compact to assure restraint by harnessed joints before testing. Fill section to be tested slowly with [air.] [water, and expell air. Install corporation cocks as necessary to remove air.] Apply test pressure for one hour and observe gauge pressure. Check leaks continuously while test pressure is being maintained. Test off-gas piping system after construction and before being placed in service using [water] [air] as the test medium. Continue pressure test for at least [24] [36] [48] hours from the time of the initial readings to the final readings of pressure and temperature. Do not make the initial test readings of the instrument for at least 1 hour after the pipe has been subjected to the full test pressure, and make neither the initial nor final readings at times of rapid changes in atmospheric conditions. Ensure temperatures are representative of the actual trench conditions. There must 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. Repair and retest lines which fail to hold specified test pressure or which exceed the allowable leakage rate.

3.9.3 Leakage Testing

Allow pipe to stand full of water at least 12 hours prior to starting leakage test. Examine exposed pipe, joints, fittings and valves. Stop visible leakage, and replace the defective pipe, fitting or valve. Refill the line under test to reach the required test pressure. Place the amount of water permitted as leakage in a container attached to the supply side of the test pump. Seal the container. Do not attach other source of supply to the pump or line under test. Pump water into the line with the test pump to hold [_____] kPa psig for [2] [4] [8] hours. Measure water remaining in the container and the amount used during the test and record on the test report. Consider test as failed upon exhaustion of supply and/or inability to maintain the required pressure.

3.9.4 Vacuum Testing

Perform test on [the entire system] [individual sections] as approved by the Contracting Officer. Seal openings in system or section to be tested. Pull vacuum [_____] kPa psig for one hour (isolating system from vacuum by closing valves). Allow system to normalize and then record the initial vacuum readings. Record vacuum at intervals of [15 minutes] [1

hour] [_____] for the duration of the [8] [_____] hour test. Repair and retest 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.

3.9.5 Hanger Acceptance Testing

Bring pipe systems up to operating pressures and temperatures. Recycle systems to duplicate operating conditions. Submit reports of all inspections or tests, including analysis and interpretation of test results. Identify each report and test methods used, and record test results.

3.9.6 Demonstration

Upon completion of the work and before final acceptance, submit a Statement of Satisfactory Installation signed by the principal officer of the contracting firm stating that: the installation is satisfactory and in accordance with the contract plans and specifications; the manufacturer's prescribed procedures and techniques have been followed; and at a time designated by the Contracting Officer. Provide the services of a qualified engineer for a period of no 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. Submit [6] [_____] 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, ensure they are clearly differentiated and separately indexed. Ensure the field instructions cover the items contained in the bound instructions.

a. The System Operation Manual includes but is not 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. Index system components and equipment to the maps.

(3) Isolation procedures and valve operations to shut down or isolate each section of the system. Index valves and other system components 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 includes but is not limited to detail

drawings, equipment data, and manufacturer supplied operation manuals for equipment, valves and system components.

c. The System Maintenance Manuals include but are not 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 include but are not 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 --