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USACE / NAVFAC / AFCEC **UFGS-33 56 53 (May 2020)**

Preparing Activity: USACE **Superseding without Revision**
UFGS-33 56 53 (April 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2024
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SECTION TABLE OF CONTENTS

DIVISION 33 - UTILITIES

SECTION 33 56 53

COMPRESSED GASES STORAGE TANKS

05/20

-- End of Section Table of Contents --

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SECTION 33 56 53

COMPRESSED GASES STORAGE TANKS
05/20

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NOTE: This guide specification covers the requirements for pressure vessels for the storage of compressed gases.

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

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NOTE: This guide specification is intended to be used for installation of unfired pressure vessels for the storage of compressed gases such as helium, nitrogen, oxygen, and air in the temperature range of plus 49 degrees C to minus 40 degrees C plus 120 degrees F to minus 40 degrees F. Its use is not intended for cryogenic fluids nor for commercial compressed air receivers operating at pressures of approximately 2.1 MPa 300 psig or below. If corrosive gases are stored, special treatment for the interior of the vessel will be specified. Lining materials such as alloy or epoxy coatings may be used for the interior of the vessels. The drawings will show all piping connection points both

in physical location and size.
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1.1 REFERENCES

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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 SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.20	(2023) Metallic Gaskets for Pipe Flanges
ASME B31.3	(2022; Errata 2023) Process Piping
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC V	(2017) BPVC Section V-Nondestructive Examination
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A182/A182M	(2024) Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service

ASTM A193/A193M	(2024) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2024) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A240/A240M	(2024) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A312/A312M	(2022a) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A320/A320M	(2024) Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service
ASTM A370	(2024) Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM A376/A376M	(2022) Standard Specification for Seamless Austenitic Steel Pipe for High-Temperature Service
ASTM A403/A403M	(2022b) Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings
ASTM E165/E165M	(2023) Standard Practice for Liquid Penetrant Examination for General Industry
ASTM E709	(2021) Standard Guide for Magnetic Particle Testing

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

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 21	(1982; E 2004) White or Colored Silicone Alkyd Paint (Type I, High Gloss and Type II, Medium Gloss)
SSPC Paint 25	(1997; E 2004) Zinc Oxide, Alkyd, Linseed Oil Primer for Use Over Hand Cleaned Steel, Type I and Type II

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AS598	(2018; Rev A; R 2024) Aerospace Microscopic Sizing and Counting of Particulate Contamination for Fluid Power Systems

1.2 SUBMITTALS

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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.

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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

Installation; G, [_____]

SD-06 Test Reports

Test

Procedure for Welding Vessels and Manifolds

SD-07 Certificates

Cleaning

PART 2 PRODUCTS

2.1 MATERIALS

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NOTE: The vessel design pressure will determine the schedule of pipe, type of flange facing, and whether pipe or tubing and flanges or high-pressure fittings are required.

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Use a nameplate on vessels except when stamping is directly applied. Permanently attach a nameplate plainly stamped in letters no less than 10 mm 3/8 inch high to vessel or vessel assembly structure at a conspicuous location. Weld, braze, or solder attachment to shell or head portions or around the nozzle openings of vessel, or attach by tamper-resistant mechanical fasteners of suitable metal construction. Attachment by pressure sensitive adhesives of any type is not acceptable. Show serial number, symbols of the manufacturer, specification number, date of manufacture, design pressure, test pressure, maximum allowable working pressure at operating temperature, minimum working temperature for vessels that operate, and water volume capacity in cubic feet to nearest tenth. Identify manifolds by a stainless steel plate or tag attached by stainless steel bands or clamps and show serial number, if any, symbols of the manufacturer, specification number, date of manufacture, design pressure, and test pressure. Code stamp vessels in accordance with ASME BPVC SEC VIII D1. Asbestos and asbestos-containing products will not be allowed.

2.1.1 Piping for Manifolds

Provide seamless stainless steel pipe or stainless steel tubing suitable for service and pressure through a temperature range of plus 49 to minus 87 degrees C plus 120 to minus 125 degrees F, in accordance with ASME B31.3. Provide stainless steel pipe in thicknesses up to and including Schedule 80S in conformance to ASTM A312/A312M, Grade TP 304L or ASTM A376/A376M, Grade TP 304; ensure thicknesses greater than Schedule 80S conform to ASTM A376/A376M, Grade TP 304.

2.1.2 Fittings for Manifolds

Provide seamless buttweld or socket-weld type fittings for manifolds consisting of material conforming to ASTM A403/A403M, Grade WP 304L, or if tubing is used, provide stainless steel positive mechanical high-pressure threaded type fittings. Ensure fittings are suitable for pressures specified for vessels and are compatible with manifold piping or tubing.

2.1.3 Flanges for Manifolds

Provide flanges for manifolds consisting of forged stainless steel conforming to ASTM A182/A182M, Grades F 304, F 316, or F 347. Ensure flanges conform to ASME B16.5 where pressure-temperature ratings fall within limits established therein. For pressure-temperature outside such limits, flanges must conform to Appendix 2 of ASME BPVC SEC VIII D1.

2.1.4 Bolts, Studs, and Nuts for Flanges

Provide strain hardened bolts and studs for flanges for stainless steel manifolds conforming to ASTM A320/A320M, Grade B8 or equivalent age-hardened material. Provide nuts conforming to ASTM A194/A194M, Grade 4, that are hexagonal American Standard Heavy Series. For manways and for other than stainless steel flanges, use bolts and studs conforming to ASTM A193/A193M, Grade B7, and nuts conforming to ASTM A194/A194M, Grade 2H.

2.1.5 Flange Gaskets

Provide octagonal, fully annealed stainless steel ring type gaskets with dimensions conforming to ASME B16.20 for ring type joint flanges. Provide oval type gaskets for helium service.

2.1.6 Supports and Attachments

Provide structural steel for supports or structural attachments conforming to requirements specified for vessel or to ASTM A36/A36M. Where legs of ASTM A36/A36M steel are attached to stainless steel vessels, use pads of ASTM A240/A240M steel to make the attachment.

2.1.7 Vessels

Construct vessels of steels which meet the requirements for design pressure and temperatures. Do not use steel which does not meet the following minimum requirements at room temperature: elongation in 50 mm 2 inches, minimum 15 percent; reduction of area, minimum 40 percent. Where heat treatment is employed, reheat treatment will be permitted. Furnish supporting information attesting to chemical composition and mechanical properties based on test results of the steel used for the design of the vessels. Where ASME BPVC SEC VIII D1 is applicable to material from which the pressure vessels are fabricated, adhere to requirements of ASME BPVC SEC VIII D1, except as modified in this section.

2.2 SPECIAL REQUIREMENTS

2.2.1 Multiple-Layered or Banded Vessels

Space longitudinally-welded seams in individual layers in an offset pattern so that centers of the welded longitudinal joints of adjacent layers are separated circumferentially by a distance of at least 5 times the layer thickness. Ensure thickness of circumferential welds for attaching heads or flanges, and the combined thickness of circumferential welds for layers, is not less than minimum required thickness of a hemispherical head divided by the efficiency of head-to-shell joint. Longitudinal seam welds on inner shell and all intermediate layers must be ground flush before application of next layer.

2.2.1.1 Slag

Remove slag after each weld layer in both longitudinal and circumferential weld joints, and visually inspect each layer of weld for undercut, lack of fusion, irregularity of weld deposit, slag inclusions, and porosity. Make corrections before next weld layer is deposited.

2.2.1.2 Post-Weld Heat Treatment

Accomplish post-weld heat treatment in accordance with ASME BPVC SEC VIII D1. Stress relieve heads after forming operations and attachments by welding have been completed, and before assembly to vessel. Stress relieve inner shell after completion of longitudinal welds.

2.2.1.3 Inner Shell Thickness Less Than One-Half Head Thickness

Where thickness of inner shell is less than one-half the required head thickness and layers are 10 mm 3/8 inch thick or less, provide vessel conforming to the following:

a. Provide multiple-layered shells in which layers are welded circumferentially in which each layer may be made of one or more plates with holes drilled radially from the outside of vessel to inner shell. Provide each layer plate with at least two vent holes of 6 mm 1/4 inch minimum diameter. Holes are not allowed topenetrate inner shell of vessel. Show such holes in detail on drawings.

b. After longitudinal seam of each layer has been welded, hammer test the layer for contact with layer underneath. A loose area greater than 300 mm 12 inches circumferentially and 600 mm 24 inches longitudinally will not be accepted. A maximum single radial gap of 3 mm 0.120 inch between any two layers, as measured at the ends of the shell sections at right angles to vessel axis, will be acceptable. Limit a gap of 1.5 mm 0.060 inch to a length of 100 mm 4 inches; limit a gap of 1 mm 0.040 inch to 150 mm 6 inches; limit a gap of 0.508 mm 0.020 inch to 300 mm 12 inches. In event of more than one loose area circumferentially in any 600 mm 24 inch length, ensure total of such areas does not exceed the area prescribed by the above limits.

2.2.1.4 Inner Shell Thickness Greater Than One-Half Head Thickness

Where thickness of inner shell is greater than one-half required head thickness, ensure vessel conforms to one of the following requirements, as applicable.

a. Establish tightness of layers having a nominal thickness of 10 mm 3/8 inch and under as specified.

b. Determine tightness of vessels with layers over 10 mm 3/8 inch nominal thickness, in which inner layer is expanded to outer layer, by demonstrated elastic behavior as substantiated by pressure volume curve during repressurization, after expansion to the design pressure to demonstrate that the layers act together.

c. Determine the tightness of vessels with layers over 10 mm 3/8 inch nominal thickness, in which outer layer or layers are shrunk over inner layer or layers, by measuring the diameter or circumference of layers in cold condition to show that there is sufficient interference between layers to demonstrate that the layers act together.

2.2.2 Seamless Cylinders

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NOTE: End connections will be determined by piping system to which vessels will be connected and by the design pressure.

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Provide seamless cylinders of a type and size suitable for manifolding together to meet gaseous-storage volume requirements. Provide seamless cylinders with two outlets, one at each end on longitudinal centerline; each outlet must be a minimum of 50 mm 2 inches in diameter for connection to piping or manifold and for inspection purposes. Make vessel connections for seamless vessels that are [adapted for and connected to in accordance with ASME B16.5] [suitable for connection of stainless steel positive mechanical high-pressure threaded type fittings]. Make connections that are suitable for pressures specified for vessels. After fabrication, normalize or liquid-quench and temper seamless cylinders.

2.3 DESIGN AND FABRICATION

Design and fabricate vessels conforming to ASME BPVC SEC VIII D1, except as modified herein. Provide vessels consisting of welded cylinders or spheres, seamless cylinders, or cylinders of multiple-layered or banded construction. Ensure vessels are suitable for stationary, aboveground [horizontal] [vertical] installation, exposed to atmospheric elements. Provide vessels with capacities as shown.

2.3.1 Design Pressure

Design vessels for a pressure of [_____] kPa psig.

2.3.2 Design Temperature

Design vessels for a temperature range of plus 49 to minus 40 degrees C plus 120 to minus 40 degrees F.

2.3.3 Outlets

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NOTE: The drawings will indicate high-pressure threaded type fittings where required, based on design pressure.

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2.3.3.1 Nozzles

Nozzles or outlets for welded monobloc, multiple-layered, and banded vessels must be a minimum of two in number, one at each end on the longitudinal centerline for connection to piping or manifold, and for inspection purposes and must have a minimum diameter of 50 mm 2 inches. Reinforce nozzles and outlets fully regardless of size. Provide flanged outlets conforming to ASME B16.5 or to ASME BPVC SEC VIII D1. Provide nozzles or outlets suitable for the pressures specified for vessels. Use material for nozzles, outlets and flanges that is preferably the same as that of the vessel, but may be of any other material that is compatible with vessel material. [Where shown, provide outlets suitable for connection to stainless steel positive mechanical high-pressure threaded type fittings.]

2.3.3.2 Manholes and Handholes

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NOTE: Manholes and handholes for internal inspection of the vessels will be specified if

required.
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Provide manholes and handholes conforming to the requirements of subsections UG-36 through UG-46 of ASME BPVC SEC VIII D1 as applicable.

2.3.3.3 Drains and Vents

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NOTE: Drains and vents to facilitate cleaning of the vessels will be specified if required.
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Provide leakproof drains and vents to facilitate cleaning of vessels.

2.3.4 Multiple Vessels

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NOTE: To provide for maximum competition and latitude by the Contractor in sizing the pressure vessels, the total volume of each system will be specified in cubic feet (water volume) and ample physical space allocated to accommodate various arrangements and sizes of pressure vessels.

The drawings will show the piping connection point both in physical location and size.
****

Manifold multiple-vessel assemblies together to furnish required gaseous-storage volume. Terminate manifold at the piping connection point as indicated. The total cross-sectional area of manifold piping in a system must be not less than 1.5 times the cross-sectional area of the piping connection point.

2.3.5 Structural Attachments

Do not weld permanent structural attachments, including lifting lugs and erection brackets, to vessel parts subject to pressure stress, unless otherwise approved. If approved, ensure such welds are full penetration and have welded layers inspected progressively by the magnetic particle method. Do not perform welding after final stress relief or hydrostatic testing.

2.3.6 Shell and Head Thickness

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NOTE: If vessels are used for the storage of compressed air, an appropriate corrosion allowance on the shell and head thickness will be included.
****

Calculate shell and head thickness in conformance with ASME BPVC SEC VIII D1.

2.3.7 Procedure for Welding Vessels and Manifolds

Use welding procedures conforming to requirements of ASME BPVC SEC IX and to requirements specified below. Submit information required by

recommended Form QW-483, Article IV, of ASME BPVC SEC IX for approval. Submit certified copies of performance test records indicating that the welders have passed qualification test in conformance with ASME BPVC SEC IX, prior to work on piping or vessel fabrication. Where such test records are not furnished, perform qualification tests witnessed by Contracting Officer. Ensure each welder is qualified for the position and type of material assigned. Requalification tests will be required when work of the welder creates a reasonable doubt as to the welder's proficiency. Such a retest may include both radiographic and mechanical tests. Welders failing a requalification test will not be permitted to work. Use an inert-gas shielded welding process with an inert-gas backup for the first pass of all manifold welds. Make separate qualification tests on maximum joint thickness of each material and use each procedure in production of double-welded butt joints and single-welded joints. Procedures qualified for thickness greater than those specified are acceptable without requalification. Use joint design in test plates which is the same design used for joints in production. Make a requalification test for any change in the nominal weld metal composition and for changes in any essential variables listed in ASME BPVC SEC IX. Make a separate qualification test for each joint design. For multiple-layered or banded vessels, perform the tension and guided-bend tests on inner shell and outer layer thicknesses. For girth welds between multiple-layered shells and heads, include head material as well as layered shell material with the test specimen. In addition to tests specified in ASME BPVC SEC IX, radiograph procedure qualification test plates following the same heat-treating procedure used in production. Using radiographic procedures specified for production welds, ensure radiographs conform to requirements specified.

2.3.7.1 Weld Layer Thickness

Individual layer thickness of production welds must not exceed 1.1 times that of individual layer thickness deposited in the performance qualification.

2.3.7.2 Continuity of Backing Ring

Backing rings are permitted only for circumferential weld joints which, due to access limitations, cannot be welded from both sides. If a backing bar, strap, or ring is used on inside of single buttweld joints, weld ends of backing bar to produce a continuous backing element.

2.3.8 Joint Efficiency

Use a joint efficiency no greater than 0.95 for staggered buttwelded longitudinal seams of multiple-layered or banded vessels, provided welds in inner shell and adjacent layer are fully radiographed and the finished weld in each of the subsequent layers is fully magnetic-particle inspected and is 7 mm 9/32 inch or less in thickness. Use a penetrometer thickness no more than 1 percent of total wall thickness being radiographed when radiographing adjacent layer. Joint efficiency for other buttwelded seams must conform to ASME BPVC SEC VIII D1.

2.3.9 Pressure Relief Devices

Provide all vessels, regardless of size or internal pressure, with protective pressure relief devices conforming to the design requirements of parts UG-125 through UG-136 of ASME BPVC SEC VIII D1.

2.4 TESTING

Notify the Contracting Officer [_____] days before the performance and fabrication tests are to be conducted. Perform tests in the presence of the Contracting Officer.

2.4.1 Notched-Bar Impact Tests for Material

Impact test materials for shells, heads, nozzles, and other vessel parts subject to stress due to pressure at minus 40 degrees C minus 40 degrees F in accordance with requirements of ASME BPVC SEC VIII D1, with the following modifications:

2.4.1.1 Impact Specimens

2.4.1.1.1 Test Plates for Welded Vessels

In addition to requirements of ASME BPVC SEC VIII D1, take one set of impact specimens from the head-to-shell weld with notch in adjacent head metal in heat-affected zone. Take test specimens from mid-length of test plates.

2.4.1.1.2 Multiple-Layered Plate Material

In multiple-layered vessels which use plates 10 mm 3/8 inch or less in thickness, exclusive of the inner shell, meet the requirements for testing plates by testing at least one set of impact specimens for each 600 mm 2 feet of cylindrical length of each vessel.

2.4.1.1.3 Seamless Vessels

Meet requirements for testing impact specimens by testing one set of specimens from a test sample of the lot it represents. A lot consists of a maximum of six vessels having the same inside diameter and wall thickness in a heat-treat furnace charge from the same heat of steel. Subject the minimum 600 mm 24 inches long test sample to the same working, normalizing or quenching, and tempering and heat with the lot of production vessels. Cut impact test specimens from the central 300 mm 12 inchesof the test sample.

2.4.1.2 Minimum Impact Value

In lieu of requirements in ASME BPVC SEC VIII D1, each specimen of the set of three 10 by 10 mm 3/8 by 3/8 inch specimens must have a specified minimum impact value of 20 J 15 foot pounds for material thickness of 13 mm 1/2 inch or greater. For thinner material, use a similar specimen, except reduce the dimension along the axis of the notch and the specified minimum impact value to the largest possible of:

7.5 mm and 17 J 12.5 foot pounds minimum.

5.0 mm and 14 J 10 foot pounds minimum.

2.5 mm and 7 J 5 foot pounds minimum.

If the value of only one of the specimen is less than the specified value, a retest will be permitted, in which case all three retest specimens must have an impact value of not less than the specified value.

2.4.1.3 Additional Tests of Welded and Seamless Vessels

a. Test materials and weld metal at the lowest temperature at which pressure will be applied to the vessel, or the design temperature, whichever is lower, and meet the following:

(1) Provide specimen in accordance with ASTM A370 for Charpy Impact Test.

(2) Minimum values are as given below:

Size of Speciment	Base Metal and Heat-Affected Zone (joules) (foot-pound)	Weld Metal (joules) (foot-pound)
10 mm x 10 mm	41 30	34 25
10 mm x 7.5 mm	34 25	27 20
10 mm x 5 mm	27 20	22 16
10 mm x 2.5 mm	14 10	11 8
If the value of only one of the specimens is less than the specified value, a retest will be permitted, in which case all three retest specimens must have an impact value of not less than the specified value.		

b. For welded vessels, make one set of Charpy Tests with notch located in base metal at least 50 mm 2 inches from weld, one set with notch located in heat-affected zone of shell, and one set with notch located in weld metal.

c. For seamless vessels, perform tests on base metal only, in the same quantities as required above for seamless vessels.

2.4.2 Mechanical Property Tests

2.4.2.1 Welded Vessels

Make two tension tests and one bend test from each parent plate as rolled from a slab or ingot. Test plates which are quenched and tempered by steel supplier by performing one bend test from each parent plate as rolled from a slab or ingot, and two tension tests from each plate as heat-treated. In addition, make one tension test on each quenched and tempered plate used for vessel shells and heads when the heat-treatment is performed by fabricator.

2.4.2.2 Seamless Vessels

Make one impact specimen tension test from test sample for each lot. Take test specimen from the central 300 mm 12 inches of test sample.

2.4.3 Hydrostatic Testing

Perform hydrostatic testing after fabrication and heat treatment. Hydrostatically test pressure vessels and manifolds in accordance with

ASME BPVC SEC VIII D1, except use a holding time at test pressure no less than 6 hours.

2.5 INSPECTION AND REPAIR OF DEFECTS

2.5.1 Personnel Qualifications

Perform radiographic, liquid penetrant and magnetic particle inspections of buttwelded pipe joints and welded vessels listed below by personnel qualified in accordance with applicable portion of ASME BPVC SEC V as appropriate. Submit certified test results by the reviewing inspector. Submit test reports for radiographic, magnetic particle, liquid penetrant, impact, and hydrostatic tests performed to prove compliance with specified criteria, upon completion and testing of the installed system.

2.5.2 Radiography of Buttwelded Pipe Joints

Buttwelded pipe joints must be radiographed 100 percent. Use radiographic technique and interpretation conforming to ASME B31.3, except as modified. Submit negatives and interpretation report for examination within 24 hours after taking radiographs. Unacceptable areas of joints must be cut out, remade, and reradiographed. Ensure negatives are accessible for examination by the Contracting Officer.

2.5.3 Radiography of Welded Vessels

Base extent of radiography on joint efficiencies used for design purposes. Use radiographic technique and interpretation conforming to ASME BPVC SEC VIII D1. Provide fine grain or extra fine type radiographic film. Submit radiographic negatives and interpretation for approval at fabricator's plant. Repair and reradiograph unacceptable welds. Ensure a complete set of radiographs and records for each vessel or vessel part is retained by the manufacturer until the Manufacturer's Data Report has been signed by the inspector.

2.5.4 Magnetic Particle Inspection

Except for inside surface of closing girth seam, magnetic-particle inspect accessible surfaces of welds, including all layers of multiple-layered or banded vessels, in accordance with ASTM E709, using dc direct probe only. In addition, inspect accessible outside surface of welds after hydrostatic testing. Magnetic-particle inspect swaged ends of seamless vessels after forming and heat treatment. Repair cracks. Repair linear defects, except linear inclusions not exceeding 6 mm 1/4 inch for thicknesses up to 19 mm 3/4 inch, 8 mm 1/3 inch for thicknesses 19 mm 3/4 inch to 57 mm 2-1/4 inches, and 19 mm 3/4 inch for thicknesses over 57 mm 2-1/4 inches.

2.5.5 Inspection for Laminations

Chip or grind out laminations found at edges of plates to depth of the lamination or 13 mm 1/2 inch, whichever is less, and repair the resulting groove by welding. Linear defects 75 mm 3 inches or less in length which are parallel to plate surface are not considered as laminations and are acceptable. Consider linear defects over 75 mm 3 inches in length which are parallel to plate surface as laminations and repair.

2.5.6 Dye Penetrant Inspection

Liquid-penetrant inspect piping and seal at the root and final weld

layers. Eliminate cracks and linear indications, except minor inclusions. Use inspection procedure in conformance with ASTM E165/E165M.

2.5.7 Repair of Defects

Repair defects in accordance with approved procedures. Wherever a defect is removed and repair by welding is not required, blend affected area into the surrounding surface so as to avoid sharp notches, crevices, or corners. After a defect is removed, and prior to making repairs, examine the area by suitable methods to ensure that the defect has been eliminated. After repairs have been made, re-examine the repaired area by the same methods that were originally required for the area. Any indication of a defect is regarded as a defect unless reevaluation by nondestructive methods and/or by surface conditioning shows that no unacceptable defect is present.

2.6 CLEANING

Submit a certified record of satisfactory cleaning of similar vessels or a record certifying not less than 2 years of experience in chemical cleaning to similar standards and for similar service. No organization performing cleaning will be considered qualified unless such proof of cleaning experience is submitted.

2.6.1 Internal Cleaning

****
NOTE: If this specification is used for the procurement of vessels, but not for installation, the time of final inspection will be revised.
****

Clean internal surfaces of each vessel and manifold until permissible contamination limits are complied with and then dry and protect. Employ cleaning procedures as necessary to comply with the specified permissible contamination limits. Perform cleaning, except during fabrication, at place of manufacture or at installation site. Do not use cleaning solvents that contain chlorine on stainless steel vessels. Inspection and tests will be witnessed by the Contracting Officer at time of final acceptance.

2.6.2 Permissible Contamination Limits

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NOTE: Each individual vessel and its application has to be considered from the standpoint of the control system and end use of the product. Permissible contamination limits will be inserted to suit requirements. The limits specified will not be more stringent; for economical reasons, the limits will be relaxed wherever possible.
****

Permissible contamination limits for vessels and manifolds must not exceed the following:

a. No hydrocarbon as evidenced by visual and ultraviolet light inspections.

b. No solid or fibrous particle concentration greater than [54] [_____] mg/square m [5] [_____] mg/psf as measured in effluent on final rinse or [10] [_____] ppm by weight of sample.

c. No particles greater than [150] [_____]-micrometer size.

d. No fibers greater in size than [150] [_____]-micrometer diameter by [1,000] [_____]-micrometer length.

2.6.3 Miscellaneous Requirements

2.6.3.1 Nominal-Rated Filters

Provide filters that remove 98 percent by weight of particles whose two smallest dimensions are greater than openings in filter media. Do not use filters made by powder metallurgy processes.

2.6.3.2 Clean Water

Use color free water containing no visible suspended particles or hydrocarbons.

2.6.3.3 Dry Air

Ensure air is oil-free and processed through a dehydrator so that the dew point is minus 53 degrees C minus 63.5 degrees F at 101 kPa (one atmosphere) one atmosphere or a maximum of 26.3 ppm water vapor by volume.

2.6.3.4 Nitrogen

Nitrogen must have been filtered through a 40-micrometer absolute-rated filter with an element constructed of stainless steel dutch twill weave. Clean filter so as not to contaminate the system in excess of filter rating.

2.6.3.5 Hydrocarbon

Hydrocarbon must be a combustible compound containing carbon and hydrogen.

2.6.3.6 Solid Particle

Provide solid material which cannot be classified as a fiber. Determine size of a solid particle by longest dimension.

2.6.3.7 Fiber

Ensure fiber is a threadlike structure composed of any material.

2.6.3.8 White Metal

"White metal" must have surface of a gray white, uniform metallic color. Surface, when viewed without magnification, must be found free of visible mill scale, rust, corrosion, oxides, paint, or other foreign matter.

2.6.4 Cleaning Procedures

Cleaning procedures are as follows, and employ additional procedures as necessary to comply with the permissible contamination limits.

2.6.4.1 Cleaning During Fabrication

During vessel fabrication, clean surfaces and welds of vessels and manifolds which will be exposed to gas thoroughly to white metal. Use stainless steel wire brushes on stainless steel. Do not use grinding discs that have been used on carbon steel on stainless steel vessels. Descaling may be accomplished prior to welding of final seam. When performed after cleaning, use an inert gas within the vessel to relieve stress .

2.6.4.2 After Cleaning

After cleaning, treat surfaces to inhibit rust.

2.6.5 Drying

Dry vessels by heating or vacuum evacuation. Dry manifolds by purge with gaseous nitrogen or dry air at a minimum of 60 degrees C 140 degrees F. Vessels and manifolds are considered dry when the dew point apparatus shows that the purging medium has a dew point no higher than the dew point of influent gas which is not above minus 53 degrees C minus 63.5 degrees F at 101 kPa (one atmosphere) one atmosphere or 26.3 ppm water vapor by volume. If vacuum evacuation is used, vessel is considered dry when pressure is maintained at 1.69 kPa (0.5 inch of mercury absolute) 0.5 inch of mercury absolute for a minimum of 5 minutes at a temperature of 15.6 degrees C 60 degrees F or higher temperature or at such lower pressure which is 96 percent of the vapor pressure of water for the vessel temperature. For example, for a vessel at 4 degrees C 40 degrees F maintain a pressure of 804 Pa (0.238 inch of mercury absolute) 0.238 inch of mercury absolute 5 minutes. Filter dry gas used for purging and drying through a 10-micron nominal rated filter.

2.6.6 Testing of Cleaned Vessels and Manifolds

Do not contaminate vessels or manifolds during tests or after cleaning. Reclean contaminated vessels and manifolds.

2.6.7 Inspection

Inspect each vessel and manifold for compliance with permissible contamination limits specified herein. Submit certified results of such inspections for approval. Perform inspections, tests, and sampling in the order listed below. Reclean or rework any vessel or manifold which is rejected in any one of these inspection procedures to the extent necessary to meet requirements specified.

2.6.7.1 Inspection No. 1, Final Rinse

During final rinse and prior to drying operation, examine a 1-liter sample of effluent by Millipore method or equivalent method in accordance with SAE AS598. For this purpose, rinse using clean water and a pressure spray nozzle on interior surfaces to ensure dislodgement of particles. Effluents containing contamination in excess of permissible contamination limits are cause for recleaning and reinspection.

2.6.7.2 Inspection No. 2, Visual

Examine vessels and manifolds for evidence of corrosion products including rust, metal chips, scale, weld scale, oil, grease, paints, preservatives,

decals, or other foreign matter. Use special devices such as inspection mirrors or bore scopes to visually examine inaccessible areas of vessels or manifolds. Contamination in excess of permissible contamination limits is cause for recleaning and reinspection.

2.6.7.3 Inspection No. 3, Ultraviolet Light

Visually inspect, with aid of an ultraviolet light, accessible surfaces to determine the presence of petroleum type hydrocarbons. Also inspect wipe pads by ultraviolet light. Ensure inspectors are qualified to use the ultraviolet light. Contamination in excess of permissible contamination limits are cause for recleaning and reinspection. Use ultraviolet light for this inspection and light-intensity meter conforming to the following:

a. Provide light source consisting of 100-watt spot mercury and bulb 250 to 370 nanometers (2500 to 3700 Angstrom units) 2500 to 3700 Angstrom units.

b. Prvide transformer meeting the recommendations of bulb manufacturer.

c. Provide filter approximately 127 mm 5 inches in diameter, convex and round.

d. Replace bulb when intensity of ultraviolet light through filter is less than 550 microwatts per square centimeter when measured 600 mm 24 inches from outside surface of filter, or after 500 hours of use, whichever occurs first.

2.6.7.4 Inspection No. 4, Wipe Test

Make wipe test at each end of each cleaned section of pipe and on interior surfaces of vessels and manifolds which are accessible with a probe. Use clean filter paper. Interior surfaces are to be wiped on a random basis or as indicated by the results of visual inspection. Perform test consisting of a linear movement of filter paper over a distance approximately 600 mm 2 feet long when large areas are being tested. Perform a full circular wipe on smaller areas such as manifold ends. Then examine filter paper under clean-room conditions. Contamination in excess of permissible contamination limits is cause for recleaning and reinspection.

2.7 SEALING

2.7.1 Seals

Seal vessels and manifolds immediately after passing the cleaning inspections. Ensure seals are tight enough to prevent contamination and protect so that they will not be broken or warped. Use tape for sealing procedures that does not leave any residue on connections when removed.

2.7.2 Flanged Openings

****
NOTE: Comparable type closures will be specified for other type connections.
****

Seal flanged openings with a suitable full-face blank gasket 3.2 mm 1/8 inch thick or disk at least 1.6 mm 1/16 inch thick consisting of

polytetrafluorethylene or other nonflammable, noncontaminating material and a bolted blank flange of aluminum or corrosion-resisting steel at least 6 mm 1/4 inch thick. Use stainless steel bolts in contact with stainless steels. Cadmium-plated bolts may be used in contact with aluminum, but do not use cadmium-plated bolts in contact with stainless steels. Place a bolt correctly torqued to correspond to particular blank flange and gasket design in each bolt hole. Clean gaskets and flanges as specified.

2.7.3 Threaded Openings

Seal threaded openings with appropriately cleaned caps or plugs made of corrosion-resisting steel.

2.8 CERTIFICATE

Attach certificate of inspection indicating conformance to requirements specified to each item. Show the date of inspection and the signature of the Contractor's inspector.

2.9 PRESSURIZING

Pressurize vessels to 103 kPa 15 psig with nitrogen immediately following cleaning inspections and sealing of vessels. Maintain vessels at positive pressure up to and during the time of final acceptance. Equip vessels with a shutoff valve and gauge for pressurizing. Ensure gauge is capable of 103 kPa 15 psig minimum with 10 kPa 1.5 psig increments between 0 to 34 kPa 0 to 5 psig. Provide a protective metal cover around the gauge and valving. Complete loss of pressure is cause for reinspection and recleaning as necessary to meet permissible contamination limits by and at the expense of the Contractor.

2.10 PAINTING

2.10.1 Exterior Surfaces

Clean and paint exterior surfaces of all vessels, including supports but excluding stainless steel surfaces, in the shop. Wire bruch abraded or corroded spots and touch up with the same material as the paint coat.

2.10.2 Cleaning and Preparation of Surfaces

Clean exterior surfaces before applying paint. Remove oil, grease, dirt, loose dust, loose mill scale, and other foreign substances. Remove oil and grease before mechanical cleaning is started, using mineral spirits or other paraffin-free solvents having a flash point higher than 37 degrees C 100 degrees F. Clean with clean cloths, fluid emulsions, steam, flame cleaning, high-speed power wire brushing, blast cleaning, or other approved methods. Do not use chipping tools that produce cuts, burrs, and other forms of excessive roughness. Tight mill scale that cannot be removed by applying a sharp knife to any edge and minor amounts of residual rust not removable except by thorough blast cleaning will be permitted.

2.10.3 Painting of Surfaces

Apply a primer coat of paint conforming to SSPC Paint 25 to exterior surfaces of the vessel. Finish vessel with two coats of gray enamel conforming to SSPC Paint 21. Apply paint under dry and dust-free conditions when an ambient temperature is not below 4 degrees C 40 degrees

F. Paint an even film of uniform thickness. Apply the three-coat paint system so that their dry film thickness at any point is no less than 0.10 mm 4.0 mils, with the primer having a minimum dry film thickness of 0.04 mm 1.5 mils. Edges, corners, crevices, and thoroughly clean and paint joints.

PART 3 EXECUTION

3.1 FOUNDATIONS

Foundations must be designed by the Contractor. Base design on the soils investigation provided by the Government. Any additional information required must be specified by the Contractor and obtained by the Government. Construct foundations for the pressure vessel [and manifold] of [21] [_____] MPa [3000] [_____] psi concrete, reinforced where necessary, and construct in conformance with the applicable requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE, except as shown or specified herein.

3.1.1 Excavation, Filling, and Grading

Perform excavating, filling, and grading in conformance to the applicable requirements of Section 31 00 00 EARTHWORK.

3.1.2 Anchor Bolts

Accurately set anchor bolts of adequate length to install the pressure vessel. When embedded in concrete, provide anchor bolts with plates welded on the head and protect against damage until the equipment is installed.

3.2 INSTALLATION

Submit drawings showing the locations of weld seams, sizes and types of welds, piping arrangements, nozzle reinforcement, method of nozzle attachment, plate and head thicknesses, vessel weights, details of gas relief holes in multiple-layered shells, lifting lugs [manways] [details of drains and vents] details required for fabrication of the vessels, and a complete list of materials. Include design calculations for vessels and manifolds with the drawings, including chemical composition and mechanical properties of the steels used, and including reference to ASME BPVC SEC VIII D1. Loading, lifting, shipping, unloading, field testing, and installation instructions, prior to completion of fabrication. [Installation drawings for piping manifolds showing field piece markings.] [The pressure vessel foundation design drawings.]

3.2.1 Equipment

Install all tanks and equipment in accordance with fabricator's instructions and recommendations. Bolt all vessels in place on concrete foundations. Exercise care during the placement of vessel on foundation so as not to scratch or dent vessel, or crack foundation.

3.2.2 Piping

Assemble all interconnecting piping in accordance with fabricator's drawings and instructions. Provide all piping conforming to the requirements of ASME B31.3. Adequately support interconnecting piping to avoid producing large stresses on the pipe or the vessel nozzles. Provide

pipe hangers and supports conforming to MSS SP-58. Use piping supports that allow for movement of the pipe from thermal expansion or contraction. Ensure pipe support spacing and installation conform to the requirements of MSS SP-58.

3.3 FIELD TESTING

Upon completion of all related work and prior to acceptance, subject the pressure vessel and associated piping and instrumentation to a pressure test to demonstrate system performance. Notify the Contracting Officer [_____] days prior to conducting the test. The Contracting Officer will be present during the testing.

3.3.1 Testing Materials

Furnish all equipment, instruments, materials, and personnel required to perform the test. The Government will supply the utilities to perform the test such as [nitrogen,] [water,] [and] electric power.

3.3.2 Procedure

The test medium must be clean, dry nitrogen. Piping test pressure must be no less than 1.2 nor more than 1.5 times the design pressure. Maintain test pressure continuously for a minimum of 10 minutes, and ensure the required test procedure is in accordance with ASME B31.3. To pass the pressure test, the piping system must show no evidence of leaking at all joints and connections by soap bubble or equivalent method. If system does not pass the pressure test, the problem will be corrected and the system will be retested. Any retesting will be performed by the Contractor at the Contractor's expense. If piping test pressure is above the pressure vessel test pressure, the pressure vessel will be isolated from the piping test.

3.4 TOUCHUP PAINTING

Perform touchup painting to equipment [and piping manifold] as required from the inspection of the Contracting Officer. Painting materials and procedure must conform to the requirements of paragraph PAINTING.

-- End of Section --