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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2012
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PRESSURE VESSELS FOR STORAGE OF COMPRESSED GASES

04/08

SECTION 33 56 53

PRESSURE VESSELS FOR STORAGE OF COMPRESSED GASES
04/08

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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 items(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 2.07 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 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.

ASME INTERNATIONAL (ASME)

ASME B16.20	(2007) Metallic Gaskets for Pipe Flanges - Ring-Joint, Spiral Wound, and Jacketed
ASME B16.5	(2009) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B31.3	(2010) Process Piping
ASME BPVC SEC IX	(2010) BPVC Section IX-Welding and Brazing Qualifications
ASME BPVC SEC V	(2010) BPVC Section V-Nondestructive Examination
ASME BPVC SEC VIII D1	(2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A182/A182M	(2011a) Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A193/A193M	(2012) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications

ASTM A194/A194M	(2011) Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A240/A240M	(2012) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A312/A312M	(2012) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A320/A320M	(2011a) Standard Specification for Alloy/Steel and Stainless Steel Bolting Materials for Low-Temperature Service
ASTM A36/A36M	(2008) Standard Specification for Carbon Structural Steel
ASTM A370	(2011a) Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM A376/A376M	(2006; R 2011) Standard Specification for Seamless Austenitic Steel Pipe for High-Temperature Central-Station Service
ASTM A403/A403M	(2011) Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings
ASTM E165	(2009) Standard Test Method for Liquid Penetrant Examination
ASTM E709	(2008) Standard Guide for Magnetic Particle Examination

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

MSS SP-58	(2009) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AS598	(2012) Aerospace Microscopic Sizing and Counting of Particulate Contamination for Fluid Power Systems

THE 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

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 to reflect only the submittals required for the project.

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

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.
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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.][information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation[; G][; 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. A nameplate plainly stamped in letters not less than 10 mm 3/8 inch high shall be permanently attached to vessel or vessel assembly structure at a conspicuous location. Attachment to shell or head portions or around the nozzle openings of vessel shall be by welding, brazing, soldering, or by tamper-resistant mechanical fasteners of suitable metal construction. Attachment by pressure sensitive adhesives of any type is not acceptable. Stamping shall 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. Manifolds shall be identified by a stainless steel plate or tag attached by stainless steel bands or clamps and shall show serial number, if any, symbols of the manufacturer, specification number, date of manufacture, design pressure, and test pressure. Vessels shall be code stamped in accordance with ASME BPVC SEC VIII D1. Asbestos and asbestos-containing products will not be allowed.

2.1.1 Piping for Manifolds

Piping for manifolds shall be 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. Stainless steel pipe in thicknesses up to and including Schedule 80S shall conform to ASTM A312/A312M, Grade TP 304L or ASTM A376/A376M, Grade TP 304; thicknesses greater than Schedule 80S shall conform to ASTM A376/A376M, Grade TP 304.

2.1.2 Fittings for Manifolds

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

2.1.3 Flanges for Manifolds

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

2.1.4 Bolts, Studs, and Nuts for Flanges

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

2.1.5 Flange Gaskets

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

2.1.6 Supports and Attachments

Structural steel for supports or structural attachments shall conform to requirements specified for vessel or to ASTM A36/A36M. Where legs of ASTM A36/A36M steel are attached to stainless steel vessels, pads of ASTM A240/A240M steel shall be used to make the attachment.

2.1.7 Vessels

Vessels shall be constructed of steels which meet the requirements for design pressure and temperatures. No steel shall be used 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. Supporting information shall be furnished 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, requirements of ASME BPVC SEC VIII D1 shall be adhered to, except as modified in this section.

2.2 SPECIAL REQUIREMENTS

2.2.1 Multiple-Layered or Banded Vessels

Longitudinally-welded seams in individual layers shall be spaced 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. Thickness of circumferential welds for attaching heads or flanges, and the combined thickness of circumferential welds for layers, shall not be 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 shall be ground flush before application of next layer.

2.2.1.1 Slag

Slag shall be removed after each weld layer in both longitudinal and circumferential weld joints, and each layer of weld shall be visually inspected for undercut, lack of fusion, irregularity of weld deposit, slag inclusions, and porosity. Corrections shall be made before next weld layer is deposited.

2.2.1.2 Post-Weld Heat Treatment

Post-weld heat treatment shall be accomplished in accordance with ASME BPVC SEC VIII D1. Heads shall be stress relieved after forming operations and attachments by welding have been completed, and before assembly to vessel. Inner shell shall be stress relieved 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, vessel shall conform to the following:

a. Multiple-layered shells in which layers are welded circumferentially in which each layer may be made of one or more plates shall have holes drilled radially from the outside of vessel to inner shell. Each layer plate shall have at least two vent holes of 6 mm 1/4 inch minimum diameter. Holes shall not penetrate inner shell of vessel. Drawings shall show such holes in detail.

b. After longitudinal seam of each layer has been welded, the layer shall be hammer tested 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. A gap of 1.5 mm 0.060 inch shall be limited to a length of 100 mm 4 inches; a gap of 1 mm 0.040 inch shall be limited to 150 mm 6 inches; a gap of 0.508 mm 0.020 inch shall be limited to 300 mm 12 inches. In event of more than one loose area circumferentially in any 600 mm 24 inch length, total of such areas shall 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, vessel shall conform to one of the following requirements, as applicable.

a. Tightness of layers having a nominal thickness of 10 mm 3/8 inch and under shall be established as specified.

b. Tightness of vessels with layers over 10 mm 3/8 inch nominal thickness, in which inner layer is expanded to outer layer, shall be determined 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. 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, shall be determined 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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Seamless cylinders shall be of a type and size suitable for manifolding together to meet gaseous-storage volume requirements. Seamless cylinders shall have two outlets, one at each end on longitudinal centerline; each outlet shall be a minimum of 50 mm 2 inches in diameter for connection to piping or manifold and for inspection purposes. Vessel connections for seamless vessels shall be [adapted for and connected to in accordance with ASME B16.5] [suitable for connection of stainless steel positive mechanical high-pressure threaded type fittings]. Connections shall be suitable for pressures specified for vessels. After fabrication, seamless cylinders shall be normalized or liquid-quenched and tempered.

2.3 DESIGN AND FABRICATION

Design and fabrication of vessels shall conform to ASME BPVC SEC VIII D1, except as modified herein. Vessels shall be welded cylinders or spheres, seamless cylinders, or cylinders of multiple-layered or banded construction. Vessels shall be suitable for stationary, aboveground [horizontal] [vertical] installation, exposed to atmospheric elements. Capacities of vessels shall be as shown.

2.3.1 Design Pressure

Vessels shall be designed for a pressure of [_____] kPa psig.

2.3.2 Design Temperature

Vessels shall be designed 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 shall 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 shall have a minimum diameter of 50 mm 2 inches. Nozzles and outlets shall be fully reinforced regardless of size. Flanged outlets shall conform to ASME B16.5 or to ASME BPVC SEC VIII D1. Nozzles or outlets shall be suitable for the pressures specified for vessels. Material for nozzles, outlets and flanges preferably shall be the same as that of the vessel, but may be of any other material that is compatible with vessel material. [Where shown, outlets shall be 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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Manholes and handholes shall conform 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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Drains and vents to facilitate cleaning of vessels shall be provided and shall be leakproof.

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.
****

Multiple-vessel assemblies shall be manifolded together to furnish required gaseous-storage volume. Manifold shall terminate at the piping connection point as shown. The total cross-sectional area of manifold piping in a system shall be not less than 1.5 times the cross-sectional area of the piping connection point.

2.3.5 Structural Attachments

Permanent structural attachments, including lifting lugs and erection brackets, shall not be welded to vessel parts subject to pressure stress, unless otherwise approved. If approved, such welds shall be full penetration and shall have welded layers inspected progressively by the magnetic particle method. No welding shall be performed 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.
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Shell and head thickness shall be calculated in conformance with

ASME BPVC SEC VIII D1.

2.3.7 Procedure for Welding Vessels and Manifolds

Welding procedures shall conform to requirements of ASME BPVC SEC IX and to requirements specified below. Information required by recommended Form QW-483, Article IV, of ASME BPVC SEC IX shall be submitted 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. Each welder shall be 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. An inert-gas shielded welding process with an inert-gas backup shall be used for the first pass of all manifold welds. Separate qualification tests shall be made on maximum joint thickness of each material and each procedure used in production of double-welded butt joints and single-welded joints. Procedures qualified for thickness greater than those specified shall be acceptable without requalification. Joint design used in test plates shall be the same as for joints used in production. A requalification test shall be made for any change in the nominal weld metal composition and for changes in any essential variables listed in ASME BPVC SEC IX. A separate qualification test shall be made for each joint design. For multiple-layered or banded vessels, the tension and guided-bend tests shall be performed on inner shell and outer layer thicknesses. For girth welds between multiple-layered shells and heads, the test specimen shall include head material as well as layered shell material. In addition to tests specified in ASME BPVC SEC IX, procedure qualification test plates shall be radiographed following the same heat-treating procedure used in production. Using radiographic procedures specified for production welds, radiographs shall conform to requirements specified.

2.3.7.1 Weld Layer Thickness

Individual layer thickness of production welds shall 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 shall be 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, ends of backing bar shall be welded to produce a continuous backing element.

2.3.8 Joint Efficiency

A joint efficiency not greater than 0.95 shall be used 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. A penetrometer thickness not more than 1 percent of total wall thickness being radiographed shall be used when radiographing adjacent layer. Joint efficiency for other buttwelded seams shall conform to ASME BPVC SEC VIII D1.

2.3.9 Pressure Relief Devices

All vessels, regardless of size or internal pressure, shall be provided 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

The Contracting Officer shall be notified [_____] days before the performance and fabrication tests are to be conducted. Tests shall be performed in the presence of the Contracting Officer.

2.4.1 Notched-Bar Impact Tests for Material

Materials for shells, heads, nozzles, and other vessel parts subject to stress due to pressure shall be impact tested 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

a. Test Plates for Welded Vessels: In addition to requirements of ASME BPVC SEC VIII D1, one set of impact specimens shall be taken from the head-to-shell weld with notch in adjacent head metal in heat-affected zone. Test specimens shall be taken from mid-length of test plates.

b. 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, the requirements for testing plates shall be met by testing at least one set of impact specimens for each 600 mm 2 feet of cylindrical length of each vessel.

c. Seamless Vessels: The requirements for testing impact specimens shall be met by testing one set of specimens from a test sample of the lot it represents. A lot shall consist 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. Test sample shall be at least 600 mm 24 inches long and shall be subjected to the same working, normalizing or quenching, and tempering and shall be heated with the lot of production vessels. Impact test specimens shall be cut 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 shall 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, a similar specimen shall be used, except that the dimension along the axis of the notch and the specified minimum impact value shall be reduced 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 shall have an impact value of not less than the specified value.

2.4.1.3 Additional Tests of Welded and Seamless Vessels

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

(1) Specimen shall be in accordance with ASTM A370 for Charpy Impact Test.

(2) Minimum values shall be as given below:

Size of Specimen	Base Metal and Heat-Affected Zone (joules)	Weld Metal (joules)
10 mm x 10 mm	41	34
10 mm x 7.5 mm	34	27
10 mm x 5 mm	27	22
10 mm x 2.5 mm	14	11

Size of Specimen	Base Metal and Heat-Affected Zone	Weld Metal
10 mm x 10 mm	30	25
10 mm x 7.5 mm	25	20
10 mm x 5 mm	20	16
10 mm x 2.5 mm	10	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 shall have an impact value of not less than the specified value.

b. For welded vessels, one set of Charpy Tests shall be made 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, tests shall be performed 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

Two tension tests and one bend test shall be made from each parent plate as rolled from a slab or ingot. Plates which are quenched and tempered by steel supplier shall be tested 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, one tension test shall be made 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

One impact specimen tension test shall be made from test sample for each lot. Test specimen shall be taken from the central 300 mm 12 inches of test sample.

2.4.3 Hydrostatic Testing

Hydrostatic testing shall be performed after fabrication and heat treatment. Pressure vessels and manifolds shall be hydrostatically tested in accordance with ASME BPVC SEC VIII D1, except that holding time at test pressure shall not be less than 6 hours.

2.5 INSPECTION AND REPAIR OF DEFECTS

2.5.1 Personnel Qualifications

Radiographic, liquid penetrant and magnetic particle inspections of buttwelded pipe joints and welded vessels listed below shall be performed by personnel qualified in accordance with applicable portion of ASME BPVC SEC V as appropriate. Certified test results shall be submitted 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 shall be radiographed 100 percent. Radiographic technique and interpretation shall conform to ASME B31.3, except as modified. The negatives and interpretation report shall be submitted for examination within 24 hours after taking radiographs. Unacceptable areas of joints shall be cut out, remade, and reradiographed. The negatives shall be accessible for examination by the Contracting Officer.

2.5.3 Radiography of Welded Vessels

Extent of radiography shall be based on joint efficiencies used for design purposes. Radiographic technique and interpretation shall conform to ASME BPVC SEC VIII D1. Radiographic film shall be the fine grain or extra fine type. Radiographic negatives and interpretation shall be submitted for approval at fabricator's plant. Unacceptable welds shall be repaired and reradiographed. A complete set of radiographs and records for each vessel or vessel part shall be 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, accessible surfaces of welds, including all layers of multiple-layered or banded vessels, shall be magnetic-particle inspected during fabrication in accordance with ASTM E709, using dc direct probe only. In addition, inspection of accessible outside surface of welds shall be made after hydrostatic testing. Swaged ends of seamless vessels shall be magnetic-particle inspected after forming and

heat treatment. Cracks shall be repaired. 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, shall be repaired.

2.5.5 Inspection for Laminations

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

2.5.6 Dye Penetrant Inspection

Piping and seal welds shall be liquid-penetrant inspected at the root and final weld layers. Cracks and linear indications, except minor inclusions, shall be eliminated. Inspection procedure shall be in conformance with ASTM E165.

2.5.7 Repair of Defects

Defects shall be repaired in accordance with approved procedures. Wherever a defect is removed and repair by welding is not required, affected area shall be blended into the surrounding surface so as to avoid sharp notches, crevices, or corners. After a defect is removed, and prior to making repairs, the area shall be examined by suitable methods to ensure that the defect has been eliminated. After repairs have been made, the repaired area shall be re-examined by the same methods that were originally required for the area. Any indication of a defect shall be 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

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NOTE: If this specification is used for the procurement of vessels, but not for installation, the time of final inspection will be revised.
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Internal surfaces of each vessel and manifold shall be cleaned until permissible contamination limits are complied with and then shall be dried and protected. Cleaning procedures as necessary to comply with permissible contamination limits specified shall be employed. Cleaning, except during fabrication, shall be performed at place of manufacture or at installation site. Cleaning solvents that contain chlorine shall not be used 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.
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Permissible contamination limits for vessels and manifolds shall 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

Filters shall remove 98 percent by weight of particles whose two smallest dimensions are greater than openings in filter media. Filters made by powder metallurgy processes shall not be used.

2.6.3.2 Clean Water

Water shall be color free and shall contain no visible suspended particles or hydrocarbons.

2.6.3.3 Dry Air

Air shall be oil-free air which has been 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 shall have been filtered through a 40-micrometer absolute-rated filter with an element constructed of stainless steel dutch twill weave. Filter shall be cleaned so as not to contaminate the system in excess of filter rating.

2.6.3.5 Hydrocarbon

Hydrocarbon shall be a combustible compound containing carbon and hydrogen.

2.6.3.6 Solid Particle

Solid particle shall be solid material which cannot be classified as a fiber. Size of a solid particle shall be determined by longest dimension.

2.6.3.7 Fiber

Fiber shall be a threadlike structure composed of any material.

2.6.3.8 White Metal

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

2.6.4 Cleaning Procedures

Cleaning procedures shall be as follows, and additional procedures shall be employed as necessary to comply with the permissible contamination limits.

2.6.4.1 Cleaning During Fabrication

During vessel fabrication, surfaces and welds of vessels and manifolds which will be exposed to gas shall be thoroughly cleaned to white metal. Wire brushes used on stainless steel shall be of stainless steel. Grinding discs that have been used on carbon steel shall not be used on stainless steel vessels. Descaling may be accomplished prior to welding of final seam. When performed after cleaning, stress relieving shall be performed using an inert gas within the vessel.

2.6.4.2 After Cleaning

After cleaning, surfaces shall be treated to inhibit rust.

2.6.5 Drying

Drying of vessels shall be by heating or vacuum evacuation. Manifolds shall be dried by purge with gaseous nitrogen or dry air at a minimum of 60 degrees C 140 degrees F. Vessels and manifolds shall be 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 shall be 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 a pressure of 804 Pa (0.238 inch of mercury absolute) 0.238 inch of mercury absolute shall be maintained for 5 minutes. Dry gas used for purging and drying shall be filtered through a 10-micron nominal rated filter.

2.6.6 Testing of Cleaned Vessels and Manifolds

Tests during or after cleaning shall be conducted so as not to contaminate vessels or manifolds. Should testing contaminate vessels and manifolds, recleaning shall be performed.

2.6.7 Inspection

Each vessel and manifold shall be inspected for compliance with permissible contamination limits specified herein. Certified results of such inspections shall be submitted for approval. Inspections, tests, and sampling shall be performed in the order listed below. Any vessel or manifold which is rejected in any one of these inspection procedures shall be recleaned or reworked 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, a 1-liter sample of effluent shall be examined by Millipore method or equivalent method in accordance with SAE AS598. For this purpose, rinse shall be performed 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 shall be cause for recleaning and reinspection.

2.6.7.2 Inspection No. 2, Visual

Vessels and manifolds shall be examined for evidence of corrosion products including rust, metal chips, scale, weld scale, oil, grease, paints, preservatives, decals, or other foreign matter. Special devices such as inspection mirrors or bore scopes shall be used to visually examine inaccessible areas of vessels or manifolds. Contamination in excess of permissible contamination limits shall be cause for recleaning and reinspection.

2.6.7.3 Inspection No. 3, Ultraviolet Light

Visual inspection with aid of an ultraviolet light shall be accomplished on accessible surfaces to determine the presence of petroleum type hydrocarbons. Wipe pads shall also be inspected by ultraviolet light. Inspectors shall be qualified to use the ultraviolet light. Contamination in excess of permissible contamination limits shall be cause for recleaning and reinspection. Ultraviolet light used for this inspection and light-intensity meter shall conform to the following:

a. Light source shall be 100-watt spot mercury and bulb 250 to 370 nanometers (2500 to 3700 Angstrom units) 2500 to 3700 Angstrom units.

b. Transformer shall meet the recommendations of bulb manufacturer.

c. Filter shall be approximately 127 mm 5 inches in diameter, convex and round.

d. Bulb shall be replaced 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

Wipe test shall be made at each end of each cleaned section of pipe and on interior surfaces of vessels and manifolds which are accessible with a probe. Clean filter paper shall be used. Interior surfaces are to be wiped on a random basis or as indicated by the results of visual

inspection. Test shall consist of a linear movement of filter paper over a distance approximately 600 mm 2 feet long when large areas are being tested. Smaller areas, such as manifold ends, shall receive a full circular wipe. Filter paper shall then be examined under clean-room conditions. Contamination in excess of permissible contamination limits shall be cause for recleaning and reinspection.

2.7 SEALING

2.7.1 Seals

Vessels and manifolds shall be sealed immediately after passing the cleaning inspections. Seals shall be tight enough to prevent contamination and shall be protected so that they will not be broken or warped. Tape for sealing procedures shall not leave any residue on connections when removed.

2.7.2 Flanged Openings

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

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Flanged openings shall be sealed 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. Stainless steel bolts shall be used in contact with stainless steels. Cadmium-plated bolts maybe used in contact with aluminum but shall not be used in contact with stainless steels. A bolt correctly torqued to correspond to particular blank flange and gasket design shall be placed in each bolt hole. Gaskets and flanges shall be cleaned as specified.

2.7.3 Threaded Openings

Threaded openings shall be sealed with appropriately cleaned caps or plugs made of corrosion-resisting steel.

2.8 CERTIFICATE

Certificate of inspection indicating conformance to requirements specified shall be attached to each item. Certificate shall show the date of inspection and the signature of the Contractor's inspector.

2.9 PRESSURIZING

Vessels shall be pressurized to 103 kPa 15 psig with nitrogen immediately following cleaning inspections and sealing of vessels. Vessels shall be maintained at positive pressure up to and during the time of final acceptance. Vessels shall be equipped with a shutoff valve and gauge for pressurizing. The gauge shall be capable of 103 kPa 15 psig minimum with 10 kPa 1.5 psig increments between 0 to 34 kPa 0 to 5 psig. A protective metal cover shall be provided around the gauge and valving. Complete loss of pressure shall be 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

Exterior surfaces of all vessels, including supports but excluding stainless steel surfaces, shall be cleaned and painted in the shop. Abraded or corroded spots shall be wire brushed and touched up with the same material as the paint coat.

2.10.2 Cleaning and Preparation of Surfaces

Exterior surfaces shall be cleaned before applying paint. Oil, grease, dirt, loose dust, loose mill scale, and other foreign substances shall be removed. Removal of oil and grease shall be accomplished 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. Cleaning shall be accomplished with clean cloths, fluid emulsions, steam, flame cleaning, high-speed power wire brushing, blast cleaning, or other approved methods. Use of chipping tools that produce cuts, burrs, and other forms of excessive roughness will not be permitted. 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

A primer coat of paint conforming to SSPC Paint 25 shall be applied to exterior surfaces of the vessel. Vessel shall be finished with two coats of gray enamel conforming to SSPC Paint 21. Paint shall be applied under dry and dust-free conditions when an ambient temperature is not below 4 degrees C 40 degrees F. Painting shall be done so as to produce an even film of uniform thickness. The three-coat paint system shall be applied so that their dry film thickness at any point shall be not 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 joints shall be thoroughly cleaned and painted.

PART 3 EXECUTION

3.1 FOUNDATIONS

Foundations shall be designed by the Contractor. Design shall be based on the soils investigation provided by the Government. Any additional information required shall be specified by the Contractor and obtained by the Government. Foundations for the pressure vessel [and manifold] shall be constructed of [21] [_____] MPa [3000] [_____] psi concrete, reinforced where necessary, and constructed in conformance with the applicable requirements of Section 03 30 00.00 10 CAST-IN-PLACE CONCRETE, except as shown or specified herein.

3.1.1 Excavation, Filling, and Grading

Excavating, filling, and grading shall conform to the applicable requirements of Section 31 00 00 EARTHWORK.

3.1.2 Anchor Bolts

Anchor bolts shall be set accurately and shall be of adequate length to install the pressure vessel. When embedded in concrete, anchor bolts shall

be provided with plates welded on the head and shall be protected 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

All tanks and equipment shall be installed in accordance with fabricator's instructions and recommendations. All vessels shall be bolted in place on concrete foundations. Care shall be exercised during the placement of vessel on foundation so as not to scratch or dent vessel, or crack foundation.

3.2.2 Piping

All interconnecting piping shall be assembled in accordance with fabricator's drawings and instructions. All piping shall conform to the requirements of ASME B31.3. Adequately support interconnecting piping to avoid producing large stresses on the pipe or the vessel nozzles. Pipe hangers and supports shall conform to MSS SP-58. Piping supports shall allow for movement of the pipe from thermal expansion or contraction. Pipe support spacing and installation shall conform to the requirements of MSS SP-69.

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 shall 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 shall be clean, dry nitrogen. Piping test pressure shall be not less than 1.2 nor more than 1.5 times the design pressure. The test pressure shall be continuously maintained for a minimum of 10 minutes, and the required test procedure shall be in accordance with ASME B31.3. To pass the pressure test, the piping system shall 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 shall conform to the requirements of paragraph PAINTING.

-- End of Section --