PIP VESLP001
Low-Pressure, Welded Vessel Specification
PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

This Practice is subject to revision at any time.

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1. Introduction

1.1 Purpose

This Practice provides requirements for the construction of low-pressure, welded vessels that generally must meet the philosophy and requirements of Section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code (Code), but do not require Code inspection or stamping. Vessels may be shop or field fabricated.

1.2 Scope

This Practice describes the basic requirements for the design, materials, fabrication, examination, inspection, and testing of aboveground, welded, cylindrical shell, single-wall vessels having an internal and external Maximum Allowable Working Pressure (MAWP) not exceeding 15 psig at the top of the vessel in the normal operating position. An additional specification may be required to define options covered herein and other specific requirements considering service (startup, normal operation, upset, shutdown), location, maintenance, etc. The documents listed in Section 2.1 should be used for a complete purchase specification.

This Practice is not intended for flat-bottom tanks or API-type field-erected storage tanks. Unless approved by Purchaser, this Practice is not to be used for low-pressure vessels that will contain “Lethal Substances” as defined in Code Paragraph UW-2 Footnote 1.

2. References

Applicable parts of the following Practices, industry codes and standards, and references are an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles are used herein where appropriate.

2.1 Process Industry Practices (PIP)

The latest edition issued at the date of contract award shall be used.

- PIP VECV1001 - Vessel/S&T Heat Exchanger Design Criteria ASME Code Section VIII, Divisions 1 and 2
- PIP VEDV1003 - Vessel Drawing/Data Sheet and Instructions
- PIP VEFV1100 - Vessel/S&T Heat Exchanger Standard Details
  - PIP VEFV1101 - Vessel Nameplate Bracket
  - PIP VEFV1102 - Vessel Tolerances
  - PIP VEFV1103 - Vessel Grounding Lug
  - PIP VEFV1105 - Vessel Saddles Supported on Concrete
  - PIP VEFV1106 - Vessel Saddles Supported on Structural Steel
  - PIP VEFV1117 - Vessel Manway Vertical Davit
  - PIP VEFV1118 - Vessel Manway Horizontal Davit
2.2 Industry Codes and Standards

For the following reference documents, if Code Table U-3 lists an edition or addenda different than the latest edition issued, the edition listed in Table U-3 shall be used. For the Code and documents not listed in Code Table U-3, the latest edition or addenda issued at the date of the contract award shall be used, although the latest edition or addenda may not have yet become mandatory.

- American Society of Civil Engineers (ASCE)
  - ASCE 7 - Minimum Design Loads for Buildings and Other Structures

- American Society of Mechanical Engineers (ASME)
  - ASME Boiler and Pressure Vessel Code
    - Section II - Materials, Part A, Ferrous Material Specifications
    - Section VIII, Division 1 - Pressure Vessels
    - Section IX - Welding and Brazing Qualifications
  - ASME B16.47 - Large Diameter Steel Flanges NPS 26 through NPS 60
  - ASME B16.5 - Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24
  - ASME B16.9 - Factory-Made Wrought Steel Buttwelding Fittings
  - ASME B46.1 - Surface Texture (Surface Roughness, Waviness, and Lay)
  - ASME SA-193 - Specification for Alloy Steel and Stainless Steel Bolting Materials for High-Temperature Service
  - ASME SA-194 - Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service
  - ASME SA-480 - Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip

- American Welding Society
  - ANSI/AWS A2.4 - Standard Symbols for Welding, Brazing and Nondestructive Examination

- International Conference of Building Officials
  - Uniform Building Code (UBC)

2.3 Other References

- “Stresses in Large Cylindrical Pressure Vessels on Two Saddle Supports,” L.P. Zick, Pressure Vessels and Piping: Design and Analysis, A Decade of Progress, Volume Two, 1972, p. 959.
3. **Definitions**

owner: The party who owns the facility wherein the vessel will be used.

**Code:** Section VIII, Division 1 ASME Boiler and Pressure Vessel Code

Construction: An all-inclusive term comprising materials, design, fabrication, examination, inspection, and testing

purchase order: Contract documents, drawings, specifications, or service-specific data provided by the Purchaser for a particular low-pressure vessel or group of low-pressure vessels. See PIP VEDV1003 for Vessel Drawing/Data Sheet and Instructions.

Manufacturer: The party entering into a contract with the Purchaser to construct a vessel in accordance with the purchase order. The Manufacturer shall possess an ASME Certificate of Authorization to construct “U”-stamped vessels.

Purchaser: The party who awards the contract to the Manufacturer. The Purchaser may be the owner or the owner’s authorized agent.

4. **Requirements**

4.1 **General**

4.1.1 All vessels shall be designed in accordance with:

a. The purchase order
b. This Practice
c. PIP VEFV1101, PIP VEFV1102, and PIP VEFV1103
d. Other standard details in PIP VEFV1100 as applicable
e. Purchaser’s data sheet, PIP VEDV1003

4.1.2 All aspects of the vessel construction, including materials, design, welding, and examination, shall be in accordance with the Code, except as specified herein.

4.1.3 Inspection and testing shall be in accordance with this Practice.

4.1.4 The Manufacturer shall be a valid ASME Code “U” Symbol stamp holder and shall perform the work in accordance with all aspects of their Code Quality Control System, except that inspection by the Authorized Inspector and Code stamping are not required.

4.1.5 All aspects of the work shall be in accordance with applicable local, county, state, and national rules and regulations.

4.1.6 Any differences between this Practice and laws or regulations of regulatory authorities shall be brought to the attention of Purchaser for resolution.
4.1.7 Alternative Design Proposals

4.1.7.1 A base proposal for construction of the vessel shall be provided in full compliance with the Purchaser’s request for quotation.

4.1.7.2 An alternative design proposal may be submitted if considered less costly and/or an improvement in the delivery schedule. However, the improvements in cost and schedule shall be realized without losing capability or shortening the anticipated life of the vessel.

4.1.7.3 If submitted, an alternative design proposal:
   a. Shall be accompanied by the base proposal and be clearly noted as an alternative design proposal.
   b. Shall be fully and clearly described and substantiated by calculations and sketches or drawings.
   c. Shall include a list of any specific exceptions to the Purchaser’s request for quotation or this Practice.
   d. Shall not be used unless approved in writing by the Purchaser.

4.2 Design

4.2.1 Design Pressure

4.2.1.1 Vessels shall be designed to withstand the specified internal design pressure plus any additional loadings (e.g., wind and seismic loadings) at both the maximum and minimum design metal temperatures.

4.2.1.2 If, on the Purchaser’s PIP VEDV1003 Data Sheet, the Purchaser requires determination of the MAWP, the MAWP shall be established considering both the maximum and minimum design metal temperatures.

Comment: If the MAWP exceeds 15 psig (103 kPa), Code stamping is required, which is outside the scope of this Practice.

4.2.1.3 The internal design pressure shall be established considering all specified loading conditions.

4.2.1.4 The internal design pressure shall not exceed 15 psig (103 kPa), at the top of the vessel.

4.2.1.5 Vessels shall be designed for pressure testing in the installed position in accordance with all provisions of Code Paragraph UG-99.

4.2.1.6 Code Paragraph UG-99(b), including Footnote 34, shall be met for a hydrostatic test. Code Paragraph UG-100 and Footnote 35 shall be met for pneumatic and hydro-pneumatic tests.

4.2.1.7 The test pressure or applicable Code paragraph number shall be as specified in the Purchaser’s PIP VEDV1003 Data Sheet.
4.2.2 Design Metal Temperature

4.2.2.1 Vessels shall have both maximum and minimum design metal temperature ratings. Both of these ratings shall be marked on the vessel nameplate.

4.2.2.2 The maximum design metal temperature shall be equal to or warmer than 150°F (66°C).

4.2.2.3 The minimum design metal temperature shall be equal to or colder than 30°F (-1°C).

4.2.3 Corrosion Allowance

4.2.3.1 The corrosion allowance specified in the Purchaser’s *PIP VEDV1003* Data Sheet shall be added to all pressure parts in contact with the service fluid.

4.2.3.2 Non-pressure internal parts that are welded in place shall include a corrosion allowance on all wetted surfaces of not less than 75% of that for pressure parts.

4.2.3.3 Non-pressure internal parts that are removable shall not require corrosion allowance unless specified in the Purchaser’s *PIP VEDV1003* Data Sheet or required by the Manufacturer’s design standards.

4.2.4 Compartmented Vessels

4.2.4.1 Components of compartmented vessels shall be designed for the most severe combinations of specified pressure, vacuum, temperature, and other loadings that may occur during operation and test conditions.

4.2.4.2 Design on the basis of simultaneous loading of internal pressure in adjacent compartments shall not be permitted.

4.2.5 Wind and Earthquake Loads

4.2.5.1 General

1. The vessel shall be self-supporting and designed for the wind or seismic conditions specified in the Purchaser’s *PIP VEDV1003* Data Sheet.

2. The vessel shall not be designed for simultaneous wind and earthquake loads.

3. The vessel, vessel supports, and anchor bolting shall be designed to withstand the greater of the wind or seismic loading acting simultaneously with other loadings imposed upon the vessel.

4. Load combinations shall be in accordance with *PIP VECV1001* Section 5.4.

5. References to ASCE 7 or UBC below may be superseded by jurisdictional regulation.
4.2.5.2 Wind Loads

1. Design wind loads shall be determined in accordance with ASCE 7, using data for Classification Category II structures.

2. The basic wind speed, exposure category, and topographic factor shall be as specified in the Purchaser’s PIP VEDV1003 Data Sheet.

3. For all horizontal vessels and for vertical vessels having a height-to-diameter ratio not greater than 1.0, the force coefficient, \( C_f \), shall be 0.5.

4. For vertical vessels having a height-to-diameter ratio greater than 1.0, the force coefficient value shall be 0.7.

5. Wind load shall be applied to the total projected area of the vessel including insulation, ladders, platforms, attached piping, and other appurtenances.

4.2.5.3 Earthquake Loads

If design for seismic conditions is required, the design loadings shall be in accordance with the ASCE 7 for the parameters specified in the Purchaser’s PIP VEDV1003 Data Sheet.

4.2.6 Minimum Thicknesses

4.2.6.1 Material thicknesses for shells and formed heads, exclusive of corrosion allowance, shall not be less than 3/16 inch (5 mm) for high-alloy steel and 1/4 inch (6 mm) for carbon and low-alloy steels.

4.2.6.2 Nozzle and manway neck thicknesses shall not be less than permitted by Code Paragraph UG-45.

4.2.6.3 If an agitator will be mounted on a nozzle or studding outlet in a formed head, the agitator manufacturer shall be consulted regarding the recommended minimum head thickness for proper support of the agitator installation configuration.

Comment: The head thickness based on Code formulas for pressure loadings and static local loadings analysis is often not sufficient to provide the rigidity and stress levels acceptable for the dynamic loadings that can be applied by an agitator.

4.2.6.4 Heads

1. Use of standard flanged and dished heads shall be permitted if the following conditions are met:

   a) The inside crown radius shall not be greater than the outside diameter of the skirt.

   b) The inside knuckle radius shall not be less than three times the head thickness.

   c) The minimum head thickness after forming shall be computed in accordance with Code rules.
2. To prevent internal pressure-induced buckling of large diameter, thin (ratio of spherical or crown radius-to-required head thickness greater than 300), formed, torispherical heads, a design check of the Code-required thickness shall be performed using a method approved by the Purchaser.

*Comment:* An acceptable method (among several that have been published) can be found in *Design Equations for Preventing Buckling in Fabricated Torispherical Shells Subjected to Internal Pressure*, Section 2.3. This check may reveal the need for a head thickness greater than the Code-required minimum thickness.

### 4.2.7 Vessel Connections

#### 4.2.7.1 Lap Joints

1. For lap-joint type flanges in stainless steel and nonferrous connections, carbon or low-alloy steel flanges may be substituted for solid stainless and nonferrous flanges.

2. Lap joint flanges equal to or less than NPS 24 shall be furnished in accordance with *ASME B16.5*.

3. Flanges for aluminum lap-joint stub ends shall be galvanized.

4. The nominal outside diameter of laps shall correspond with dimensions in *ASME B16.9* if used with *ASME B16.5* flanges.

### 4.2.8 Nozzles and Manways

#### 4.2.8.1 Nozzles

For nozzles equal to or smaller than NPS 8, the projection from the outside of the vessel wall to the nozzle face shall be 8 inches (200 mm) minimum.

#### 4.2.8.2 Manways

For nozzles larger than NPS 8 and for manways, the projection from the outside of the vessel wall to the nozzle face shall be 10 inches (250 mm) minimum.

#### 4.2.8.3 Unless otherwise specified by Purchaser, the nominal manway size shall be NPS 24 with a finished inside diameter not less than 23 inches (584 mm).

#### 4.2.8.4 Manways shall not be smaller than NPS 18 or have a finished inside diameter of less than 17 inches (430 mm).

#### 4.2.8.5 Manways larger than NPS 24 shall be provided to accommodate needs such as, but not limited to, installation of internals/catalyst, packing, maintenance requirements, long projection due to thick insulation, etc.

#### 4.2.8.6 External nozzle flanges for nozzle sizes equal to or less than NPS 24 shall be in accordance with *ASME B16.5*.

#### 4.2.8.7 Coupling ratings shall not be less than Class 6000, and sized not smaller than NPS 3/4, nor larger than NPS 2.
4.2.9 Vessel Supports

4.2.9.1 The type of vessel support shall be as specified in the Purchaser’s PIP VEDV1003 Data Sheet.

4.2.9.2 Allowable design stresses for all vessel support components shall be the same as specified in the Code for pressure parts, except as follows:

a. Stresses resulting from direct bending in anchor ring base plates shall not exceed 1.5 times the Code-allowable tensile stress values.

b. Compressive stresses in anchor ring gussets and other compression members shall not exceed 1.25 times the Code-allowable tensile stress values.

4.2.9.3 Skirt Supports

1. Support skirts for vertical vessels with bottom heads having a knuckle radius less than 6% of the head skirt inside diameter shall be configured as follows:

   a. Continuously welded to the straight flange (cylindrical portion) of the head

   b. The weld shall be sized to resist the maximum imposed loadings

   c. The skirt attachment shall be the lapped type (i.e., the skirt is lapped to the straight flange of the head).

2. Support skirts for vertical vessels with bottom heads having a knuckle radius equal to or greater than 6% of the head skirt inside diameter shall be configured as follows:

   a. Continuously welded to the head

   b. The weld shall be sized to resist the maximum imposed loadings

   c. The skirt attachment design shall be one of the following types:

      1) Butt type (i.e., skirt butted to knuckle portion of head such that the centerlines of the skirt plate and the head flange are the same nominal diameter or such that the outside diameters of the shell and skirt coincide)

      2) Lapped-type (i.e., skirt lapped to straight flange of head)

   Comment: See the Code Division 2, Figure 4.15.7 for illustrative weld attachment details and associated minimum weld sizes. Item 1 above is preferred over item 2.

3. All butt weld joints within the skirt shall be in accordance with the Code Table UW-12, Type No. 1.
4. Alignment tolerance at plate edges to be butt-welded shall be in accordance with Code Paragraph UW-33.

5. Unless specified in the Purchaser’s PIP VEDV1003 Data Sheet, the style of anchor ring assembly (e.g., single ring with gussets, single ring with chairs, double ring with gussets, etc.), and the type/degree of nondestructive examination of the skirt assembly welds shall be agreed between the Purchaser and the Manufacturer.

6. If the skirt diameter is sufficient, one or more access openings equal to or greater than 24 inches (610 mm) diameter shall be provided to accommodate inspection and/or maintenance work inside the skirt.

7. Unless specified in the Purchaser’s PIP VEDV1003 Data Sheet, other access opening geometries if needed shall be agreed between the Purchaser and Manufacturer.

8. Unless specified otherwise, vent openings in skirt supports are required.

9. All skirt openings shall be reinforced based on full area replacement criteria.

10. If the skirt is to be provided with insulation or fireproofing, the projection of sleeves through the skirt wall shall not be less than the insulation or fireproofing thickness.

11. Flange joints shall not be permitted within a skirt unless expressly approved by the Purchaser.

4.2.9.4 Leg Supports

Leg supports shall be limited to vessels that meet the following conditions:

a. Design temperature shall be 450°F (232°C) maximum.

b. Service shall be noncyclic and nonpulsating.

Comment: Vessels having agitators experience transient transverse forces due to dynamic bending moments from the agitator and sloshing of the liquid. Therefore, design of leg-supported vessels with agitators requires the application of experience-based engineering judgment to ensure that displacement stiffness and stress levels essential to satisfactory operation are provided.

c. Vessel height-to-diameter ratio shall be 5 maximum, where height is the distance from the base of the supports to the top tangent line of the vessel. The diameter is the outside diameter of the vessel, exclusive of any insulation.

Comment: Caution is advised for leg-supported vessels that could have excessive axial and/or bending loads.
on the legs or an overstress condition in the vessel wall at the points of attachment.

4.2.9.5 Saddle Supports

1. Vessels that will be horizontally installed shall be mounted on two saddle-type supports.
   
   *Comment:* See PIP VEFV1105 and PIP VEFV1106 for examples of standard saddle details that may be used.

2. Saddle supports shall extend over at least one-third (120 degrees) of the circumference of the vessel shell.

3. Wear plates shall be provided with radiused corners and shall be welded to the shell with a continuous fillet weld.

4. Wear plates shall be provided with two telltale holes. The holes shall be plugged with a Room Temperature Vulcanizing (RTV) silicone sealant.

5. The bottom of the supports shall extend 1 inch (25 mm) minimum below nozzles or other projecting vessel components.

6. One of the two saddles shall be designated as the fixed saddle with holes provided for the anchor bolts.

7. The other saddle shall be designated as the sliding saddle and slotted holes of sufficient length to permit the maximum anticipated expansion or contraction shall be provided.

8. Slide plates shall be furnished by Purchaser under all sliding saddles.

9. The effect of the saddles on the shell shall be analyzed using the method provided in *Stresses in Large Cylindrical Pressure Vessels on Two Saddle Supports*.

4.2.10 Anchor Bolting

4.2.10.1 Anchor bolts shall be 3/4 inch (M20) minimum diameter.

4.2.10.2 Allowable design tensile stresses for carbon steel anchor bolts, as calculated using the tensile stress area of the threaded portion, shall be 20,000 psi (138 MPa).

4.2.10.3 Anchor bolts for vertical vessels shall be selected in multiples of four bolts and shall straddle the natural centerlines of the vessel.

4.2.10.4 The anchor bolts shall be oriented as specified in the Purchaser’s PIP VEDV1003 Data Sheet.

4.2.10.5 Anchor bolting shall be furnished, finished, and installed by others.

4.2.10.6 Unless anchor bolts are stainless steel, bolts embedded in concrete foundations shall be hot dipped galvanized so the addition of a corrosion allowance is not required.
4.2.11 Lifting Lugs

4.2.11.1 Vessel Lifting Lugs

1. Shop-built vertical vessels shall be provided with lifting lugs designed to permit erecting the vessel from a horizontal position.

2. An impact factor of 1.5 minimum shall be applied to the design lift weight.

3. Unless otherwise specified or approved by Purchaser, two ear-type vessel lifting lugs shall be provided spaced 180 degrees apart and welded to the straight flange portion of the top head and shell.

Comment: Another common vessel lifting method is a single lug welded to a blind flange that is bolted to the nozzle in the center of the top head.

4. Welds across the bottom of the lifting lugs shall be omitted to allow drainage.

5. The crevice between the lifting lug and the top head dish surface shall be sealed by a bead of RTV silicone sealant after painting.

4.2.11.2 Removable vessel covers and manway covers shall be provided with suitable lifting lugs. See PIP VEFV1117 and PIP VEFV1118 for recommended lifting lug configurations.

4.3 Materials

4.3.1 Materials for pressure parts, vessel supports, and other nonpressure parts welded to pressure parts shall be in accordance with the Code.

4.3.2 Materials not completely defined in the Purchaser’s PIP VEDV1003 Data Sheet shall be in accordance with Section 4.3.1.

4.3.3 Formed heads fabricated from austenitic (i.e., types 304 and 316 only, including low-carbon and stabilized grades) or duplex stainless steel shall be solution annealed after forming in accordance with ASME SA-480.

4.3.4 Impact test exemptions shall be established in accordance with the Code.

4.3.5 The toughness of attachments welded to pressure-containing components shall be the same or greater as these components.

4.3.6 Bolting materials for pressure-resisting flanged joints shall be SA-193 Grade B7 bolts with SA-194 Grade 2 or 2H heavy hex nuts.

4.3.7 If stainless steel bolting is required, SA-193 Grade B8, Class 2 bolts with SA-194 Grade 8 or 8A heavy hex nuts shall be used.

Comment: Sections 4.3.6 and 4.3.7 constitute default minimums if bolt and nut materials are not stated in the Purchaser’s PIP VEDV1003 Data Sheet. Process environment and experience often dictate the use of other materials of construction.
4.3.8 Gaskets

4.3.8.1 Except for metal gaskets made integral by welding and nonmetallic (e.g., flexible graphite) tape gaskets with abutting ends suitably joined, gaskets, shall be seamless.

4.3.8.2 Service gaskets (e.g., for manways and blind flanged nozzles) shall be provided in accordance with the Purchaser’s PIP VEDV1003 Data Sheet.

4.3.8.3 Gaskets cut from sheet stock shall be at least 1/16 inch (1.5 mm) but not greater than 1/8 inch (3 mm) thick.

4.4 Fabrication

4.4.1 General

4.4.1.1 Plate layouts shall be arranged so that, to the maximum extent possible, longitudinal and circumferential weld seams clear all nozzles, manways, and their reinforcing pads by 2 inches (50 mm) minimum, measured from weld edge to weld edge.

4.4.1.2 Nozzles intended for use with a safety relief device or as vessel drains shall be trimmed flush inside the vessel wall.

4.4.1.3 Each vessel shall be provided with a grounding clip in accordance with PIP VEFV1103.

4.4.2 Welding

4.4.2.1 Deposited weld metal shall be essentially of the same mechanical, chemical, and toughness properties as the material joined, unless a different filler metal is used to join dissimilar materials.

4.4.2.2 Welded joints of Code Categories A, B, and butt-type Category C shall be Code Table UW-12, Type No. 1.

4.4.2.3 Butt welds with one plate edge offset in accordance with Code Figure UW-13.1(k) and permanent weld-joint backing strips shall not be permitted.

4.4.2.4 Non-butt joints connecting nozzles (including manways, couplings, sight glasses, and studding outlets) to the vessel wall shall be full penetration welds extending through the entire thickness of the vessel wall and through the inside edge of reinforcing plates if used.

4.4.2.5 Nozzles designated to extend beyond the inside surface of the vessel wall shall have a fillet weld at the inside corner.

4.4.2.6 For compartmented vessels having an intermediate formed head, the end of the intermediate head skirt shall be seal-welded to the shell of the compartment in accordance with Code Figure UW-13.1(f).

4.4.2.7 All welds, including those attaching non-pressure parts to pressure parts, shall be made by welders (or welding operators) and welding procedures qualified in accordance with Code Section IX.
4.4.2.8 Approval shall be obtained from Purchaser before any welding or preparation for welding is subcontracted to others.

4.4.2.9 The qualifications of the proposed welding subcontractor shall be provided to the Purchaser before approval can be granted for performing the work.

4.4.2.10 Manufacturer shall retain accountability for subcontracted fabrication work.

4.4.2.11 Welding on pressure resisting components and grinding (including cosmetic grinding) on pressure-resisting welds shall not be permitted after pressure testing unless approved in writing by Purchaser.

4.4.3 Flanges

4.4.3.1 Bolt holes in all fixed flanges and studding outlets shall straddle the natural centerlines.

4.4.3.2 For nozzles in heads, the bolt holes shall straddle centerlines parallel to or coincident with the natural vessel centerlines.

4.4.3.3 Bolt holes in flanges shall be 1/8 inch (3 mm) larger than the diameter of the bolts.

4.4.3.4 All gasket seating surfaces shall be plane and true.

4.4.3.5 If necessary, shop-fabricated flanges and lap rings shall be machined after welding, heat treatment, or other fabrication steps that can result in warpage or distortion from a plane and true surface.

4.4.3.6 Surface finish shall have 125 - 250 microinch (3.2 to 6.4 µm) R\text{a} roughness in accordance with ASME B46.1 with spiral or concentric circular serrations.

4.4.3.7 Surface finish for flanges in accordance with ASME B16.5 and ASME B16.47 shall be in accordance with the applicable ASME standard.

4.4.3.8 A means shall be provided for positioning (centering) the gasket during joint make-up.

4.4.3.9 No joint sealing compound or lubricant shall be used unless approved by Purchaser.

4.4.3.10 A light dusting of 3M™ Super 77™ or equal spray adhesive may be used if required to hold a gasket in place during assembly.

4.4.4 Tolerances and Clearances

4.4.4.1 Dimensional tolerances shall apply to the completed vessel after final pressure test and shall be in accordance with PIP VEFV1102.

4.4.4.2 The minimum distance from the toe of fillet welds that attach saddle supports or wear plates to the centerline of either a longitudinal or circumferential shell seam shall be $\sqrt{Rt}$, exclusive of corrosion.
allowance, where \( R \) equals the shell inside radius and \( t \) equals the shell thickness.

### 4.4.5 Weld Examination

4.4.5.1 As a minimum, weld seams in formed heads shall be radiographed in accordance with Code Paragraph UW-51 in the straight flange, knuckle region, and 2 inches (50 mm) into the spherical portion regardless of the joint efficiency used.

4.4.5.2 Radiographic examination of butt-welded seams shall not be required except as specified in Section 4.4.5.1.

4.4.5.3 Finished surfaces of welded pressure joints that will be inaccessible after assembly (e.g., those surfaces between lap joint flanges and associated nozzle necks, shells and lap-ring, or lap joint stub end attachment welds) shall be examined using either the magnetic particle or the liquid penetrant method in accordance with Code Appendix 6 or Appendix 8, respectively. Repairs shall be completed before testing or painting.

### 4.4.6 Postweld Heat Treatment

4.4.6.1 Alternative PWHT requirements of Code Table UCS-56.1 for carbon and low-alloy steels shall not be employed.

4.4.6.2 The equipment shall be adequately supported during PWHT to avoid distortion.

### 4.5 Pressure Testing

#### 4.5.1 General

4.5.1.1 Shop-built vertical vessels shall be tested in their operating position if practicable.

4.5.1.2 If a vertical vessel is shop-tested in the horizontal position, the Manufacturer shall be responsible for determining the need for and providing any temporary supports to prevent distortion or other damage to the vessel during the test.

4.5.1.3 Horizontal vessels shall be tested on their operating supports without additional temporary supports or shoring.

4.5.1.4 All supporting lugs, rings, saddles, legs, and other permanently attached supports shall be attached to the vessel before the test.

4.5.1.5 For vessels that consist of two or more compartments, each compartment shall be given a separate and individual test with atmospheric pressure in the adjacent compartments.

4.5.1.6 If the vessel will be pneumatically tested in the shop or field, refer to 7.2.2 of PIP VECV1001 for additional requirements and safety issues to be addressed.
4.5.2 Water Quality

4.5.2.1 Test water shall be clean and free of debris.

4.5.2.2 Brackish or untreated water shall not be permitted.

4.5.2.3 Potable water as delivered through municipal systems shall be permitted for testing carbon or chrome steel vessels or components.

4.5.2.4 Except as specified in Section 4.5.2.5, for vessels or components made of austenitic stainless steel materials, testing water shall contain 50 ppm chloride maximum.

4.5.2.5 For vessels or components made of austenitic stainless steel materials, testing water shall not exceed 50 ppm chloride content.

4.5.3 Inspection

4.5.3.1 The hydrostatic test pressure shall be maintained for one hour minimum.

4.5.3.2 Following the application of the hydrostatic test pressure, an inspection shall be made of all joints and connections.

4.5.3.3 During the inspection the hydrostatic pressure shall be maintained at or greater than two-thirds of the hydrostatic test pressure.

4.5.3.4 For the entire duration of the test, the vessel metal temperature shall be maintained above the Minimum Design Metal Temperature (MDMT) by at least 30°F (17°C).

4.5.3.5 Repairs to eliminate leaks revealed during pressure testing shall be tested by reapplying the originally specified hydrostatic test pressure.

4.5.4 Flanges and Gaskets

4.5.4.1 All blind flanges, gaskets, and bolting (or other types of blanking covers) necessary for testing shall be provided.

4.5.4.2 For connections not specified to be provided with blind flanges, the blind flanges and bolting (or other type covers) may be removed after testing and remain the property of the supplier.

4.5.4.3 If practicable, body flanges, manways, and nozzles specified to be provided with blind flanges shall be left undisturbed and assembled after testing.

4.5.4.4 Flanged joints specified to be provided with service gaskets (e.g., manways and blind flanged nozzles) that will not be disassembled after testing shall be tested with the specified service gasket.

4.5.4.5 If disassembly of flanged joints specified to be provided with service gaskets (e.g., manways and blind flanged nozzles) is necessary for shipping, draining, or other purposes, new gaskets shall be furnished in accordance with Section 4.4.3.2.

4.5.4.6 If the flanged joints described in Section 4.5.4.5 are shipped unassembled, new service gaskets for field installation shall be suitably packaged, marked, and shipped with the vessel.
4.5.4.7 If a flanged joint is to be disassembled after testing and has flanges in accordance with ASME B16.5, the test gasket shall be provided in accordance with the limitations in Section 4.4.3.4.

4.5.4.8 If a flanged joint is to be disassembled after testing, has non-standard flanges (i.e., not in accordance with ASME B16.5), and the service gasket is not specified, the test gasket shall be approved by Purchaser.

4.5.5 Painting

4.5.5.1 All required coatings shall be in accordance with the Purchaser’s PIP VEDV1003 Data Sheet.

4.5.5.2 Only surfaces that are required to be painted and that will be inaccessible after assembly (e.g., mating surfaces between lap-joint flanges and associated nozzle necks, shells, lap rings or stub ends; bolt holes; and welded joints) shall be painted before assembly and pressure testing.

Comment: The user is cautioned that painting/coating can mask leaks that would otherwise have been detected during the pressure test.

4.5.5.3 Except as specified in Section 4.5.5.2, vessels shall not be painted before the pressure test.

4.5.5.4 All PWHT vessels shall have the following notice painted on two sides of the shell and insulation covering, if present, in 3-inch (75 mm) letters visible in the installed position from grade:

POSTWELD HEAT TREATED - DO NOT BURN OR WELD

4.5.5.5 All vessels with nonmetallic linings shall have the following notice painted on two sides of the shell and insulation covering, if present, in 3-inch (75 mm) letters visible in the installed position from grade:

LINED VESSEL - DO NOT BURN OR WELD

4.6 Manufacturer’s Nameplate

4.6.1 Each vessel shall be provided with a Manufacturer’s nameplate(s) made of austenitic stainless steel and attached to an austenitic stainless steel nameplate bracket in accordance with PIP VEFV1101.

4.6.2 The nameplate shall include:

a. MAWP and associated Maximum Allowable Working Temperature
b. Design external pressure and associated temperature
c. MDMT at the MAWP
d. Purchaser’s vessel identification
e. Manufacturer’s name
f. Manufacturer’s serial number
g. Year built
4.7 Shipping Preparation

4.7.1 After completion of the hydrostatic test, the vessel interior shall be completely drained, thoroughly dried, and cleaned of foreign matter.

4.7.2 Body joints, manways, blind-flanged nozzles, plugged couplings, and other connections specified to be provided with service covers shall be shipped assembled if practicable.

4.7.3 For carbon and low-alloy steels, all exposed machined or threaded surfaces shall be cleaned with solvent and coated with one of the following temporary rust preventive greases or other equivalent products:
   a. Ashland Oil-Tectyl 858C
   b. Sanchem No-Ox-Id-A
   c. Exxon-Beacon 325
   d. Houghton-Rust Veto Heavy

4.7.4 All flange faces other than those furnished with permanent blinds shall be covered with 1/2 inch (13 mm) thick wood or 1/8 inch (3 mm) thick steel plate no smaller than the flange outside diameter.

4.7.5 Flange covers shall be secured with a minimum 25% complement of carbon steel bolts, but no less than four.

4.7.6 Welding stub ends shall be provided with bevel protectors.

4.7.7 All necessary precautions shall be taken in loading, blocking, and bracing the vessel to prevent damage during shipment.

4.8 Documentation

4.8.1 Certified fabrication drawings shall be provided for all vessels.

4.8.2 Fabrication drawings shall be complete and shall include all relevant design, materials, fabrication, examination, inspection, and testing requirements.

4.8.3 All welds shall be either detailed or identified by the standard welding symbols in accordance with ANSI/AWS A2.4.

4.8.4 Fabrication drawings shall include the following:
   a. Purchaser’s item number, purchase order number, and shop order number
   b. References to all applicable Practices, supplier specifications, and other standards
   c. Design specific gravity, maximum liquid level, and other operating loads
   d. Corrosion allowance (Specify as none if applicable.)
   e. Service-specific requirements
f. Test pressure shall be shown for both the operating position and the shop or field test position, if different.
   1. Horizontal position (referenced to top of vessel)
   2. Vertical position (for vertical vessels only, referenced to top of vessel). This may be a shop test, initial field test, or a future test in the operating position.

g. Estimated weight of vessel empty, maximum operating, and full of water

h. Capacity of vessel or each compartment (in gallons)
i. Surface preparation and painting or other protective coating requirements
j. Designations for nozzles, manways, and skirt openings as specified on Purchaser’s drawings.
k. For nozzles located normal to a cylindrical shell, the fabrication drawings shall include dimensions from the centerline (axis) of the shell to the nozzle faces.
l. The following notes as applicable:
   1. For all vessels: “Chlorides or substances that contain chlorine that will decompose to form chlorides (e.g., coatings to prevent adhesion of weld spatter) shall not be applied to any part of the vessel.”
   2. For stainless steel or nickel-alloy vessels: “Zinc-coated (galvanized or painted) components shall not be in contact (welded, bolted, or loose) with any alloy parts of the vessel.”
   3. For nickel or nickel-alloy vessels: “Substances containing sulfur (e.g., lubricants to aid machining) shall not be applied to alloy parts of the vessel.”

4.8.5 If reference is made to Manufacturer’s specifications, copies of the specifications shall be provided.
4.8.6 Facsimiles of stamps of vessel nameplates shall be provided.
4.8.7 The drawings shall be reviewed by Purchaser before the start of fabrication unless a release to proceed is obtained from Purchaser in writing.
4.8.8 Calculations shall be provided for each vessel in sufficient detail to demonstrate compliance with the requirements of this Practice and the referenced documents.
4.8.9 Material test reports or certificates of compliance shall be provided in accordance with Code requirements.
4.8.10 Heat treatment charts (time/temperature records) shall be provided.
4.8.11 Manufacturer’s Data Report Form, signed by the Manufacturer and the Inspector.