PIP VESFG001
Fiberglass Tank and 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.

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PUBLISHING HISTORY

March 1999  Issued
November 2000  Technical Correction
March 2007  Technical Revision
June 2011  Complete Revision

Not printed with State funds
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1. Introduction

1.1 Purpose

This Practice provides requirements for the construction of fiberglass vessels and tanks in accordance with ASME Boiler and Pressure Vessel Code Section X “Fiber-Reinforced Plastic Pressure Vessels” or ASME/ANSI RTP-1 “Reinforced Thermoset Plastic (RTP) Corrosion Resistant Equipment.”

1.2 Scope

This Practice describes the general requirements for the design, materials, fabrication, examination, inspection, testing, certification (ASME stamp and Supplier’s Data Report), and pressure relief of aboveground fiberglass reinforced polyester, vinyl ester, and epoxy tanks and vessels having internal or external pressure from full vacuum up to the limits of Code Section X. This Practice covers shop- and field-fabricated equipment, thermoplastic-lined equipment, and dual laminate equipment.

This Practice does not cover the following equipment items that are excluded from both ASME/ANSI RTP-1 and Code Section X:

a. Portable or movable containers
b. Hoods, ducts, and stacks
c. Fans and blowers
d. Vessel internals such as entrainment separators, chevron blades, packing support plates, and liquid distributor plates
e. Pipe or piping
f. Fully buried underground closed vessels

This Practice does not cover the following equipment items that are excluded from Code Section X:

a. Vessels having an inside diameter (ID), width, height, or cross-section diagonal of 6 inches (150 mm) or less, with no limitation on length or pressure. The 6-inch (150 mm) dimension excludes (150 mm) the thickness of any corrosion liner.
b. Vessels containing lethal substances as designated by the owner in accordance with Code Section X Paragraph RG-113.

This Practice does not cover the following equipment items that are excluded from ASME/ANSI RTP-1:

a. Vessels constructed of furan, epoxy, or phenolic resins
b. Vessels with non-glass structural reinforcements
c. Vessels having metallic liners

2. References

Applicable parts of the following Practices and references shall be considered 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)

- PIP STF05501 - Fixed Metal Ladders and Cages Details
- PIP STF05520 - Pipe Railing for Walking and Working Surfaces Details
- PIP STF05521 - Angle Railing for Walking and Working Surfaces Details
- PIP STF05535 - Vessel Platform Details

2.2 Industry Codes and Standards

- American Society of Mechanical Engineers (ASME)
  - ASME Boiler and Pressure Vessel Code
    - Section II – Materials, Parts A, B, C, D
      - SA-307 – Specification for Carbon Steel Bolts and Studs, 60,000psi Tensile Strength
      - SA-563 – Specification for Carbon and Alloy Steel Nuts
    - Section V - Nondestructive Examination
    - Section X - Fiber-Reinforced Plastic Pressure Vessels
  - ASME/ANSI RTP-1 - Reinforced Thermoset Plastic Corrosion Resistant Equipment
  - ASME B16.5 - Flanges and Flange Fittings Sizes NPS 1/2 through NPS 24
  - ASME B18.22.1 - Plain Washers

- American Society for Testing and Materials (ASTM)
  - ASTM D695 - Test Method for Compressive Properties of Rigid Plastics
  - ASTM D790 - Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
  - ASTM D2583 - Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor
  - ASTM D2584 - Test Method for Ignition Loss of Cured Reinforced Resins
  - ASTM D3299 - Standard Specification for Filament-Wound Glass-Fiber-Reinforced Polyester Chemical-Resistant Tanks

- ASTM D4097 - Standard Specification for Contact-Molded Glass-Fiber-Reinforced Thermoset Resin Chemical-Resistant Tanks

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

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

- National Bureau of Standards-Voluntary Product Standard
  - NBS PS15-69 - Custom Contact Molded Reinforced-Polyester Chemical-Resistant Process Equipment (Withdrawn)
2.3 Other References

- Association for Information and Image Management (AIIM)
  - AIIM MS32 - Standard Recommended Practice - Microrecording of Engineering Source Documents on 35 mm Microfilm
- Materials Technology Institute of the Chemical Process Industries, Inc. (MTI)
  - MTI Publication 50 - Users Guide to ASME Standards for Fiberglass Tanks and Vessels

3. Definitions

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

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

purchase order: Contract documents, drawings, specifications, or service-specific data provided by the purchaser for a particular fiberglass tank or vessel or group of tanks or vessels.

Supplier: The party entering into a contract with the purchaser to construct a vessel in accordance with the purchase order. The term “Fabricator” in ASME/ANSI RTP-1 refers to the producer of RTP equipment and is synonymous with “supplier” in this Practice. The supplier combines resin and reinforcing fibers to produce the final product.

User’s Basic Requirements Specification (UBRS): The comprehensive requirements data sheet provided by the purchaser in accordance with ASME/ANSI RTP-1 Table 1-1.

4. Requirements

4.1 General

4.1.1 All vessels and tanks shall be designed and constructed in accordance with the purchase order, UBRS, this Practice, and all applicable requirements of ASME/ANSI RTP-1 or Code Section X, including symbol stamping.

4.1.2 References in this Practice to ASME/ANSI RTP-1 and Code Section X apply based on the specified standard and are not interchangeable except as specifically indicated.

Comment: ASME/ANSI RTP-1 provides requirements for stationary vessels and tanks for the storage, accumulation, or processing of corrosive or other substances at pressures not exceeding 15 psig (0.103 MPa) external or internal) above any hydrostatic head.

Comment: Code Section X provides requirements for stationary vessels for the storage, accumulation, or processing of substances at pressures exceeding 15 psig (0.103 MPa) above any hydrostatic head. Code Section X provides upper pressure limitations depending on the type and class of construction, but the maximum internal pressure limit is 15000 psig (103.42 MPa).
4.1.3 The purchaser shall specify in the UBRS or purchase order which ASME code or standard is required.

4.1.4 **User’s Basic Requirements Specification (UBRS)**

4.1.4.1 The purchaser shall furnish a UBRS.

4.1.4.2 The purchaser’s UBRS shall provide the following:

a. Intended operating conditions of the vessel (i.e., basis for design)

b. Identification of the external environment to which the vessel shall be exposed

c. Intended function of the vessel

d. Mechanical loads that shall be imposed on the vessel

e. Specific installation requirements

f. Specific codes and laws applicable to the location where the vessel will be installed

4.1.4.3 The purchaser shall specify in the UBRS either the type of resin and corrosion liner required or define the intended contents to which the vessel shall be exposed.

4.1.4.4 While the UBRS is a requirement for ASME/ANSI RTP-1 stamped equipment, it shall also be utilized for Code Section X stamped equipment.

*Comment:* Examples of a completed UBRS can be found in *MTI Publication 50.*

4.1.5 The supplier shall be responsible for design, materials, fabrication, examination, inspection, testing, certification (ASME stamp and Supplier’s Data Report), and pressure relief of the tank(s) or vessel(s) in accordance with this Practice. Review of supplier’s documentation (e.g., fabrication drawings) by the purchaser shall not relieve supplier of this responsibility.

4.1.6 The supplier shall be responsible for conveying all purchaser requirements to any subcontractor of the supplier.

4.1.7 If a vessel or vessel component design is specified on the purchaser’s vessel drawings, the supplier shall not be relieved of the obligation and/or responsibility to be in accordance with the purchase order requirements.

4.1.8 Release for shipment by purchaser’s inspector shall not relieve the supplier of any responsibility for being in accordance with ASME/ANSI RTP-1 or Code Section X.

4.1.9 The supplier shall be ASME-accredited.

4.1.10 *Code Section X “RP”* and *ASME/ANSI RTP-1 “RTP”*-stamped vessels shall be registered with the National Board of Boiler and Pressure Vessel Inspectors (NB).

4.1.11 All aspects of the work and completed vessels shall be in accordance with applicable local, county, state, and federal rules and regulations. This shall
include, but is not limited to, the rules and standards established by EPA and
OSHA or other similar national standards.

4.1.12 Any differences between this Practice, the UBRS, and laws or regulations of
regulatory authorities shall be brought to the attention of purchaser for
resolution. Written clarifications shall be provided by the purchaser before
proceeding with any work.

4.1.13 Alternative Design Proposals

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

4.1.13.2 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 tank or
vessel.

4.1.13.3 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
      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 and Temperature

4.2.1.1 The design pressure and coincident maximum temperature shall be
determined by carefully considering all operating phases (including
liquid head) that the vessel or tank may experience during the
specified project life, such as:

   a. Initial startup
   b. Normal operations
   c. Temporary operations
   d. Emergency shutdown
   e. Emergency operations
   f. Normal shutdown
   g. Startup following a turnaround or emergency shutdown
   h. Cleaning, steam out, and decontamination
   i. Upset conditions
   j. Environmental restraints on relief venting
4.2.1.2 The UBRS shall specify the maximum and minimum operating pressures and temperatures.

4.2.1.3 The UBRS or purchase order documents shall specify any margins to be applied to the maximum operating pressure(s) and coincident temperature(s).

4.2.2 MAWP and Coincident Maximum Temperature

4.2.2.1 For both Code Section X and ASME/ANSI RTP-1 nameplates, the maximum allowable working pressure (MAWP) to be marked on the nameplate shall be defined as the maximum gauge pressure (in psi) permissible at the top of the completed vessel in its normal operating position while at the designated coincident temperature for that pressure.

4.2.2.2 The MAWP may be determined from either the design pressure or calculations based on the specified nominal component thickness (but reduced by the specified liner thickness).

4.2.3 Minimum Design Temperature and Coincident Pressure

4.2.3.1 The minimum design temperature and the coincident pressure to be marked on a Code Section X nameplate shall be determined by considering the operating phases such as those listed in Section 4.2.1.

4.2.3.2 The minimum design temperature shall be included on the UBRS.

4.2.3.3 If atmospheric temperatures govern during startup or normal operations, the lowest one-day mean atmospheric temperature at the installation site shall be considered.

4.2.4 Design Loads and Load Combinations

4.2.4.1 The loads listed in this Section shall be determined and specified in design calculations.

4.2.4.2 Design loads are defined and classified as follows:

a. Dead Load (L1)

The Dead Load is the installed weight of the vessel or tank including internals, catalyst or packing, platforms, insulation, linings, piping, and other permanent attachments.

b. Operating Live Load (L2)

The Operating Live Load is the weight of the liquid at the maximum operating level, including the load of liquid on the trays or held up in packing.

c. Pressure Load (L3)

The Pressure Load is the MAWP (internal or external at the coincident temperature) load, including the pressure drop through the vessel or tank. For vessels with more than one independent chamber, each chamber shall be designed and
constructed to withstand the most severe condition of coincident pressure and temperature in normal service.

d. **Thermal Load (L4)**

Thermal Loads are loads caused by restraining thermal expansion/interaction of the vessel or tank and/or its supports.

e. **Test Load (L5)**

The Test Load is the weight of the test medium (typically water). Design basis shall consider that the vessel or tank shall be tested in its normal operating position.

f. **Wind Load (L6)**

The Wind Load shall be determined in accordance with *ASCE 7, UBC*, or applicable local code.

g. **Seismic Load (L7)**

The Seismic Load shall be determined in accordance with *ASCE 7, UBC*, or applicable local code.

h. **Snow Load (L8)**

The Snow Load shall be determined in accordance with *ASCE 7, UBC*, or applicable local code.

i. **Piping and Superimposed Equipment Loads (L9)**

Loads caused by piping (other than the dead load) and superimposed equipment shall be considered as applicable.

j. **Dynamic Load (L10)**

Dynamic loads caused by the action of agitators, spargers, or other vibratory equipment shall be considered as applicable.

k. **Load Combinations**

Vessels, tanks, and their supports shall be designed to meet the most severe of the following load combinations:

1. Erected Condition with Full Wind Load
   
   \[ L_1 + L_6 \]

2. Design Condition with Full Wind Load
   
   \[ L_1 + L_2 + L_3 + L_4 + L_6 + L_8 + L_9 + L_{10} \]

3. Design Condition with Seismic Load
   
   \[ L_1 + L_2 + L_3 + L_4 + L_7 + L_8 + L_9 + L_{10} \]

4. Initial Hydrostatic Test Condition with Vessel in Normal Operating Position and 25% of Wind Load
   
   \[ L_1 + (F) L_3 + L_5 + (0.25)L_6 \]

   where: \( F \) is the minimum required increase over MAWP to be marked on the vessel and is equal to 1.1 for Section X vessels and 1.1 to 1.2 for RTP-1 vessels.
4.2.5 Component Design

4.2.5.1 Heads and Shells

1. The purchaser shall specify on the UBRS the principal dimensions of the shell and heads.
   a. Dimensions specified shall include diameter, height or length, minimum wall thickness (including liner thickness), and head shape.
   b. Thicknesses specified shall be the minimum required.

2. For ASME/ANSI RTP-1 vessels, thickness shall be 0.22 inches (5.6 mm) minimum, including the corrosion liner.

3. For Code Section X Class II vessels, thickness shall be 0.25 (6 mm) inches minimum, not including the corrosion liner.

4. For both ASME/ANSI RTP-1 and Code Section X vessels, corrosion liner thickness shall be 100 mils (2.5 mm) minimum and shall not be included in the structural calculations for heads and shells.

5. Top heads of vertical tanks, if specified, shall be designed to support a 250-pound (91 kg) person walking anywhere on the head, in addition to any external pressure.

6. Maximum deflection of the top heads of vertical tanks under all combinations of loadings shall be 1/2 percent of span at any location.

7. On any flat-sided vertical tank, the maximum deflection of any wall shall be 1/2 percent of span at any location.

8. If a tank shall be agitated by a vertical, top-entering agitator, the agitator shall not be supported from the tank head.

9. If a tank shall be agitated, the tank shell shall be reinforced with external circumferential stiffening ribs.

10. The shell of an open-top, vertical tank shall be provided with a reinforcing ring at the top of the tank shell. The ring shall be of sufficient rigidity to maintain the shape of the tank.

11. Dished heads subject to internal or external pressure or hydrostatic loads shall be reinforced in the knuckle in accordance with ASME/ANSI RTP-1, Figure 4-1(a), or Code Section X, Figure RD-1175.2.

12. Flat bottoms on tanks fabricated to ASME/ANSI RTP-1 shall be reinforced in the knuckle in accordance with ASME/ANSI RTP-1, Figure 4-2, and have a 1-1/2 inch (38 mm) minimum knuckle radius. In addition, flat bottoms shall be suitable for installation on flat, cushioned surfaces without the use of grout.

13. Shell joints shall be reinforced in accordance with ASME/ANSI RTP-1, Figure 4-3, or Code Section X, Figure 1175.2.
4.2.5.2 Nozzles and Reinforcements

1. Nozzles shall be in accordance with the UBRS and any requirements of the purchase order.

2. Unless otherwise specified, the design shall be in accordance with ASME/ANSI RTP-1, Figure 4-10, or Code Section X, Table RD-620.1.

3. Minimum nozzle size shall be 2 inches (50 mm).

4. Threaded connections, bulkhead fittings, or pad-type nozzles shall not be permitted.

5. All nozzles that are 4 inches (100 mm) and less shall be equipped with plate or conical gussets in accordance with ASME/ANSI RTP-1, Figure 4-13, or Code Section X, Figure RD-620.4.

   **Comment:** Code Section X requires gussets on nozzles 6 inches (150 mm) and less.

6. All manways and nozzles, except those providing clearance for connecting internal piping (i.e., dip pipe mounting nozzles), instrumentation, or other specified penetrating nozzles and internal appurtenances, shall be installed flush with the inside of the equipment in accordance with ASME/ANSI RTP-1, Figure 4-4, or Code Section X, Figure RD-620.5.

7. If penetrating nozzles are required, they shall be installed in accordance with ASME/ANSI RTP-1, Figure 4-5, or Code Section X, Figure RD-620.6.

8. For ASME/ANSI RTP-1 stamped equipment, the placement of nozzle installation and cutout reinforcement laminates shall be in accordance with ASME/ANSI RTP-1, Figure 4-12.

9. For Code Section X vessels, the placement of nozzle installation and cutout reinforcement laminates shall be in accordance with Code Section X Figures RD-620.5 and RD-620.6.

10. The reinforcement for nozzles and other vessel openings shall be external to the vessel wall, and the area of opening reinforcement shall be increased if necessary to limit shear stress to 200 psi (1.379 MPa).

11. All nozzles with internal projections shall have the ends capped or wrapped with the same number of surfacing veils present in the corrosion liner of the shell and heads.

12. All nozzle necks that extend inside the vessel shall not contain any woven roving.

13. If corrosion liners thicker than 100 mils (2.5 mm) are required, the increased thickness above 100 mils (2.5 mm) shall be added to the thickness given in ASME/ANSI RTP-1, Figure 4-10, or Code Section X, Table RD-620.1.
4.2.5.3 Nozzle Flanges

1. All flanges shall be flat-faced and molded integrally with nozzle stub in accordance with ASME/ANSI RTP-1, Figure 4-11(b), or Code Section X, Table RD-620.1.

2. Flange drilling, dimensions, and thickness shall be in accordance with ASME/ANSI RTP-1, Figure 4-10 or Code Section X, Table RD-620.1, for 50 psi (345 kPa) minimum rating, unless a higher rating is required.

3. Unless otherwise specified, bolt holes in flanged nozzles shall straddle natural equipment centerlines.

4. Bolt holes shall be spot faced on the back of the flange for ASME B18.22.1 Type A Narrow washers.

4.2.5.4 Manways

1. All vessels and tanks greater than 36 inches (900 mm inside diameter) shall have one manway minimum.

2. Tanks greater than 16 feet (4.87 m) inside diameter shall have two manways minimum – one in the shell and one in the roof.

3. Unless a vessel has an integrally molded thermoplastic liner and is a Code Section X Class I vessel, vessels and tanks less than 36 inches (900 mm) inside diameter shall have full-diameter body flanges for access.

4. Manways shall be 20 inches (500 mm) minimum inside diameter.

5. Manways that are 24 inches (600 mm) inside diameter shall be provided unless a smaller size is specified in the UBRS.

6. ASME/ANSI RTP-1 manway dimensions shall be in accordance with ASME/ANSI RTP-1, Table 4-2, and installed in accordance with ASME/ANSI RTP-1, Figure 4-4.

7. Code Section X manway dimensions shall be in accordance with Code Section X, Table RD-620.1 and be installed in accordance with Code Section X, Figure RD-620.5.

8. All manways shall be flush with the inside of the vessel or tank and be provided with studs, bolts, gasket, and cover.

9. All manway covers shall be provided with two handles for lifting.

10. The number and size of manways shall be indicated in the purchase order or UBRS.
4.2.5.5 Gaskets

1. Gasket type, thickness, and material shall be as specified on the UBRs or in the purchase order.

2. Unless otherwise specified, all gaskets shall be 1/8 inch (3 mm) thick, full-faced elastomeric type having a Shore A durometer hardness of 60 (plus or minus 5).

4.2.5.6 Bolting

1. Both interior and exterior bolting shall be as specified on the UBR or in the purchase order.

2. Bolts shall be provided in sizes less than and including 1 inch (M25) diameter.

3. Studs shall be used for bolt sizes greater than 1 inch (M25) diameter.

4. Bolts and studs shall be ASME SA-307 Grade B minimum.

5. Nuts shall be ASME SA-563 Grade A minimum or other ASME standard. Nuts shall be semi-finished heavy hex pattern.

4.2.5.7 Supports

1. The type of equipment support shall be in accordance with the UBR or as shown on the purchaser’s equipment drawings.

2. The supplier shall be responsible for proper design of the supports even if design details are shown on the purchaser’s equipment drawings.

3. Equipment supports shall be designed for all maximum coincident loading conditions.

4. If seismic and wind loads are specified, these loads shall be considered in the support design, but shall not act concurrently.

5. The loading and weight basis of the support design shall be included in the design calculations.

6. Flat-bottom tanks shall be installed with fully supporting foundations and shall be anchored. Anchor bolts shall be 1 inch (M25) diameter minimum.

   Comment: ASME/ANSI RTP-1 does not permit anchor bolts to be used to resist internal pressure in flat-bottom tanks.

7. Design of anchors shall be in accordance with ASME/ANSI RTP-1, Appendix NM-4, with holddown clips in accordance with ASME/ANSI RTP-1, Figure NM4-5.

8. Suspended vessels shall use design methods given in ASME/ANSI RTP-1, Appendix NM-5.

9. If horizontal tanks or vessels require saddles for support, a finite element analysis shall be performed to design the supports and check for excessive stresses in the shell and heads.
10. A Zick analysis shall not be used to design horizontal vessel support systems.

   Comment: The Zick analysis is not appropriate because of the different properties of fiberglass laminates versus metallic plates. Multiple saddles and additional stiffening are typically required.

11. Skirt supports shall be attached to the vessel in accordance with Figure 4-8 of ASME/ANSI RTP-1.

12. All skirts shall be provided with vent and access openings in accordance with fabrication detail PIP VESFG001-01.

13. Skirt holddown methods shall be in accordance with fabrication detail PIP VESFG001-02.

4.2.5.8 Body Flanges

1. If required, body flanges shall be designed in accordance with ASME/ANSI RTP-1, Appendix NM-2, or Code Section X, Paragraph RD-1176, and shall always contain woven roving.

2. Body flanges shall be flat and true to a tolerance in accordance with ASME/ANSI RTP-1, Table 4-14 and Paragraph 4-700, or Code Section X, Paragraph RD-620.3 and Figure RD-620.3.

4.2.5.9 Stiffening Rings

1. If provided, stiffening rings shall be a minimum of 3/16 inch (5 mm) thick and be constructed similar to ASME/ANSI RTP-1, Figure 4-7. Other shapes such as trapezoidal, triangular or flat ribs may be used.

2. The required moment of inertia for stiffening rings used to support the shell against external pressure shall be in accordance with ASME/ANSI RTP-1, Paragraph 3A-330, or Code Section X, Paragraph RD-1172.1.

3. Core materials used to help form the rib shape shall not be considered to increase the moment of inertia.

4.2.5.10 Internals

1. Unless otherwise specified, all internals shall be manufactured with the same materials as the equipment wall.

2. Metallic pipe for tubing or coils shall be in accordance with the UBRS and shall be suitable for cold bending.

3. Coils and other internal piping, trays, or other internals shall be supported to prevent vibration or breakage during shipping and operation.

4. Baffles for agitated tanks shall be the wedge type with sealed ends or the plate type with gussets. See fabrication detail PIP VESFG001-03 of this Practice for baffle construction.
5. Support ledges for packing supports or other heavy internals shall be integrally molded into the wall or shall utilize a plate clamped between body flanges. See fabrication detail PIP VESFG001-04, for internal support ledge construction.

6. Secondary bonded rings may be used to support lighter loads such as trays. The rings shall be well sealed and all cut edges shall be capped with surfacing veil.

7. All internals shall be covered with a full corrosion liner on the outside and all edges shall be capped with surfacing veil. A coating of resin only shall not be permitted.

8. Secondary bonded internals shall not contain woven roving, but shall be all mat construction.

9. For internal piping with butt joints, the joint edges shall be wrapped with surfacing veil before the butt joint overlay is attached.

10. Internal glued joints shall not be permitted.

4.2.5.11 Ladders, Platforms, and Handrails

1. If specified in the purchase order, ladders, platforms, and handrails shall be provided.

2. Design and material for ladders, platforms, and handrails shall be in accordance with PIP STF05501, PIP STF05520, PIP STF05521, and PIP STF05535.

3. All materials shall also be in accordance with OSHA regulations or equivalent national standard and any local building code, as required.

4.2.5.12 Attachments

All attachments furnished by the supplier shall be fitted to the equipment before inspection.

4.3 Materials

4.3.1 Resins

4.3.1.1 Resins specified on the UBRS or in the purchase order shall be used throughout the laminate.

4.3.1.2 If resins are not specified, a request shall be submitted to the purchaser to use selected resins that are suitable for the operating conditions and fluids shown on the UBRS or in the purchase order.

4.3.1.3 All resin shall be commercial grade, and selection shall be based on resin manufacturers’ test data as published in corrosion guides or actual field or laboratory tests.

4.3.1.4 Resin substitution shall not be allowed in any step of vessel fabrication.

4.3.1.5 The resin manufacturer’s current fabrication instructions for proper formulation and cure shall be followed.
4.3.1.6 If FDA compliance is required, only resins certified by the resin manufacturer to meet FDA requirements shall be used, and a post cure using hot air or steam followed by cleaning with water or steam shall be required.

4.3.2 Resin Fillers and Additives

4.3.2.1 Thixotropic Agents

1. Resins shall not contain fillers for viscosity control or fire retardancy except as recommended by the resin manufacturer and agreed by the purchaser.

2. Addition of thixotropic agents for viscosity control shall not exceed 2%.

3. If the chemical environment contains hypochlorites or attacks glass, thixotropic agents shall not be used in the corrosion liner or other surfaces that will be in contact with that environment.

4.3.2.2 Resin Putty

1. The use of resin putty shall be minimized and shall not be considered to provide any structural strength to the laminate.

2. Resin putty intended for use as filler material shall be made by mixing 5% (by weight) maximum of silica flour, carbon flour, or milled fibers with the resin specified.

3. Resin putty shall never be exposed to the process fluid and shall always be overlaid with laminate.

4. Resin putty shall be formulated to cure crack-free.

4.3.2.3 Styrene

1. Styrene shall be added as a diluent for viscosity control if required to improve workability and wet-out characteristics.

2. The amount of styrene added shall not exceed the resin manufacturer’s recommendations and shall not impair fire-retardant or chemical-resistant properties of the final product.

4.3.2.4 Ultraviolet (UV) Inhibitors

If the vessel is not to be pigmented, 1% (by weight) maximum of the resin manufacturer’s recommended UV inhibitor shall be added to the resin in the outer three plies of laminate.

4.3.2.5 Paraffin

For polyester and vinyl ester resins only, 0.6% (by weight) maximum of paraffin or wax shall be added to the resin-rich topcoat of non-mold surfaces to aid in curing and assure a tack-free surface.
4.3.3 Catalysts and Promoters

4.3.3.1 Proper curing of the resin shall be the supplier’s responsibility.

4.3.3.2 For both interior and exterior surfaces, all vessels shall be cured to 90% minimum of the minimum Barcol hardness specified by the resin manufacturer.

*Comment:* Use of a polyester veil or paraffin in the resin may lower the Barcol hardness below the resin manufacturer’s specifications.

4.3.3.3 The cure system for polyester and vinyl ester resins shall be MEKP/CoN or CHP/CoN.

4.3.3.4 BPO/DMA shall be used only if recommended by the resin manufacturer for the intended chemical service or if specified by the purchaser.

4.3.3.5 Silanes are to be used to achieve a strong bond between the glass fibers and the resin.

4.3.4 Reinforcements

4.3.4.1 All resins shall contain reinforcements of one or more of the types described in this Section.

4.3.4.2 A separately cured, unreinforced interior resin gel coat shall not be used.

4.3.4.3 Integrally bonded chopped strand mat and woven roving shall not be permitted in the laminate.

4.3.4.4 Glass Surfacing Veil

Glass surfacing veil shall be C glass, 10 mils thick, with a silane-type finish and a binder compatible with the lay-up resin.

4.3.4.5 Organic Surfacing Veil

Organic surfacing veil shall be apertured or non-apertured polyester veil, 12 to 16 mils thick, with a finish compatible with the lay-up resin.

4.3.4.6 Carbon Surfacing Veil

Carbon surfacing veil shall be 0.5 oz/yd² (16.8 gr/m²), 6 mils thick, with a finish compatible with the lay-up resin.

4.3.4.7 Chopped Strand Mat

Chopped strand mat shall be type E (electrical borosilicate) or ECR (electrical corrosion-resistant) glass; 0.75, 1, or 1.5 oz/ft² (236, 354, or 472 gr/m²), with a silane-type finish.

4.3.4.8 Woven Roving

Woven roving shall be E glass, nominal 24 oz/yd² (813 gr/m²), 5 by 4 square weave, with a silane-type finish.
4.3.4.9 Continuous Roving
Continuous roving used for filament winding or in chopper guns for spray-up shall be E or ECR glass with a silane-type finish.

4.3.4.10 Oriented Glass Fabric
Uniaxial or biaxial glass fabric used as structural reinforcement shall be E glass with a silane-type finish.

4.3.5 Thermoplastic Liners
4.3.5.1 If specified in lieu of or in addition to fiberglass corrosion liners, thermoplastic liner materials (i.e., TFE, FEP, PFA, MFA, PVDF, ECTFE, ETFE, PP, HDPE, PVC, or CPVC from 40 to 250 mils thick) shall be in accordance with ASTM requirements and ASME/ANSI RTP-1 Appendix M-12, Part M12B-200.

4.3.5.2 All thermoplastic welders shall be qualified in accordance with ASME/ANSI RTP-1, Appendix M-12, Part M12H-300.

4.3.5.3 Filler materials shall be in accordance with the same ASTM requirements as the parent material.

4.3.6 Core Materials
4.3.6.1 Core materials may be used to provide forms for molding ribs, head knuckles, or other parts. They may also be used as filler between the bottoms or shells of double-walled vessels.

4.3.6.2 Core materials shall not be considered part of the structural wall in the design other than in a purely compressive mode such as a filler in flat-bottom tank.

4.3.6.3 The cored bottom shall not be subject to bending loads from internal or external pressure.

4.3.6.4 Balsa wood, cardboard, urethane or glass foams, plastic fillers, fiberglass mats, or other materials compatible with the lay-up resin may be used as core materials.

4.3.6.5 Core materials shall always be covered by laminate and shall never be exposed to the chemical environment.

4.4 Fabrication
4.4.1 Laminates
4.4.1.1 Corrosion Liner
1. The corrosion liner shall be 100 mils (2.5 mm) thick minimum and consist of, as a minimum, 1 ply of surfacing veil and 2 or more plies of chopped strand mat totaling 3 oz/ft² (915 gr/m²).
2. Only C glass, polyester, or carbon surfacing veils shall be permitted in the corrosion liner.
3. Spray-up or chopped strand mat from a chopper gun shall not be permitted in the corrosion liner.
4. Colorants, thixotropic, or fire retardant additives shall not be permitted in the corrosion liner.

5. Paraffin used for surface cure and fillers may be used to increase abrasion resistance.

6. For vessels having a thermoplastic lining, the fiberglass corrosion liner can be omitted. However, a conductive layer shall be placed directly behind the thermoplastic liner to enable the entire liner surface to be spark tested.

4.4.1.2 Structural Layer

1. The structural layer shall consist of multiple plies of glass cloth, such as chopped strand mat and woven roving, in contact-molded construction or multiple cycles of filament winding roving interspersed with chopped strand mat and/or oriented glass cloth.

2. All filament-wound shells shall contain chopped strand interspersed between winding cycles. All shells, filament-wound and contact-molded, shall have an axial strength of 9000 psi (632kg/cm²) minimum.

3. Pigments shall not be added to the structural layer.

4. The structural layer shall not be applied until the corrosion liner has been allowed to gel so that resin will not be squeezed out of the corrosion liner during the fabrication of the structural layer.

5. A layer of chopped strand mat shall always be laid directly behind the corrosion liner as the start of the structural layer.

6. The resin used in the structural layer shall be the same as that used in the corrosion liner.

4.4.1.3 Exterior Layer

1. The exterior layer shall consist of either chopped strand mat, a gel coat, resin paint, or surfacing veil.

2. UV inhibitor or pigment shall be provided in the exterior layer. The exterior layer shall be the only part of the vessel wall that may be painted or pigmented.

3. Painting or pigmenting shall be performed after all internal inspections are completed.

4. For polyester and vinyl ester resin vessels, a paraffinated topcoat shall be applied unless resin paint is applied.

4.4.1.4 Cut Edges

1. For interior cut edges exposed to the chemical environment, the edges shall be capped with resin and the same number of surfacing veils as the corrosion liner.

2. If machining of flange faces is required, the faces shall be faced with surfacing mat. All other exterior machined surfaces or cut edges (e.g., bolt holes) shall be coated with resin only.
3. Under no circumstances shall the finished machined and resin coated flange thickness be less than that specified in the purchase order.

4.4.1.5 Joints and Secondary Bonds

1. All resin for capping cut edges and making joints, secondary bonds, and coatings (and elsewhere throughout the equipment) shall be the same resin used to construct the structural wall and corrosion liner.

2. Interior secondary bonds covering shell and head joints shall be 3 inches (75 mm) wide minimum on each side of the joint and shall consist of a minimum of 1 ply of surfacing veil and 3 plies of 1-1/2 oz/ft² (457 gr/m²) chopped strand mat.

3. If the corrosion liner thickness exceeds the thickness in Section 4.4.1.5.2, the interior lay-up shall match the corrosion liner.

4. Each successive ply shall overlap the preceding ply by 1/2 inch (12 mm) minimum beyond each side. The first ply shall be 3 inches (75 mm) wide minimum.

4.4.1.6 Lapping of Reinforcements

1. All edges of reinforcing material shall be lapped a minimum of 1 inch (25 mm) format and oriented cloth and 2 inches (50 mm) for woven roving.

2. Lapped edges of adjacent layers shall be staggered.

3. The laps in nozzle reinforcing pads shall be located 45 degrees minimum from the longitudinal axis of the vessel.

4.4.1.7 Tapering of Secondary Bonds

1. To minimize stress concentrations, all interior and exterior secondary bonds shall be tapered 6:1 minimum at the edges.

2. The material in the taper shall not be included in the required structural strength of the bond.

4.4.1.8 Thermoplastic Liners

1. Thermoplastic liners shall meet the requirements of ASME/ANSI RTP-I, Appendix M-12, except that Part M12G for shop qualification is not mandatory for Code Section X stamped vessels.

2. All provisions of ASME/ANSI RTP-I, Appendix M-12 shall be mandatory for ASME/ANSI RTP-I stamped equipment.

4.4.1.9 Mold Release Agents

1. Molds shall be prepared using a layer of polyester film, carnauba-based paste wax, or polyvinyl alcohol.

2. All mold release agents shall be removed before inspection and shipment.
4.4.2 Laminate Tolerances

4.4.2.1 Laminate thickness tolerances shall be in accordance with ASME/ANSI RTP-1, Subpart 2C, or Code Section X, Paragraphs RQ-130 or RQ-140.

4.4.2.2 An incorrect laminate sequence shall not be permitted even if the laminate thickness exceeds requirements.

4.4.2.3 The fiberglass corrosion liner thickness shall be 100 mils (2.5 mm) minimum.

4.4.3 Repairs

4.4.3.1 Minor defects in workmanship shall be repaired before stamping.

4.4.3.2 Before a repair is started, the repair method and extent of repair shall be approved by the purchaser and the Code Section X Authorized Inspector or the ASME/ANSI RTP-1 Certified Individual.

4.4.3.3 All repairs to ASME/ANSI RTP-1 vessels shall be in accordance with ASME/ANSI RTP-1, Appendix M-7.

4.4.3.4 For Code Section X Class II vessels, corrosion liner and structural layer repairs shall be in accordance with ASME/ANSI RTP-1, Appendix M-7.

4.4.3.5 Structural repairs to Code Section X Class I vessels shall not be permitted.

4.4.4 Post Curing

4.4.4.1 If the UBRS or purchase order requires post curing the vessel, the post curing temperature shall be 180°F minimum for 4 hours minimum.

4.4.4.2 Post curing shall be required for equipment containing food or pharmaceutical products, equipment using a BPO/DMA cure system, and equipment fabricated with epoxy resins.

4.4.4.3 Post curing by placing the vessel in a circulating hot air oven is preferred. Circulating hot air from external sources inside the vessel or using steam may also be used.

4.4.4.4 If steam is used for post curing, care shall be taken so that the steam sparge pipes do not impinge on the interior surface or inside any nozzle.

4.4.4.5 Steam sparge pipes shall project 12 inches (300 mm) minimum beyond the interior surface of the nozzle and 12 inches (300 mm) minimum from any wall.

4.4.4.6 Only low-pressure (less than 5 psig)(34.5 kPa) steam shall be used.

4.4.4.7 During the steam post curing process, the vessel shall be maintained at atmospheric pressure.

4.4.4.8 If hot air for the post cure is generated by fired heaters, a clean burning fuel such as propane or natural gas shall be used. Kerosene shall not be permitted.
4.4.5 Field Joints

4.4.5.1 If field joining of vessel or tank components is required, all the necessary materials shall be provided.

4.4.5.2 For stamped equipment, the supplier shall be responsible for the equipment until it has been completed, tested, inspected, and stamped in the field.

4.4.5.3 Field fabrication procedures shall be in accordance with the requirements of this Practice and ASME/ANSI RTP-1 or Code Section X.

4.4.6 Field Fabrication

4.4.6.1 Tanks with field-fabricated shells shall be in accordance with ASME/ANSI RTP-1, including a field hydrotest.

4.4.6.2 Tanks greater than 16 feet (4.87 m) diameter shall require a laminate proof test performed on nozzle cutouts.

4.4.6.3 Only an ASME/ANSI RTP-1-accredited shop with certificate scope permitting field fabrication shall be used.

4.4.6.4 Field fabrication of Code Section X vessels shall not be permitted.

4.4.7 Fabrication Tolerances

In addition to the mandatory fabrication tolerances given by ASME/ANSI RTP-1, Figure 4-9, or Code Section X, the recommended User’s fabrication tolerances given by ASME/ANSI RTP-1, Figure NM7-1, shall be required.

4.5 Inspections and Tests

The purchaser’s quality overview plan requirements are given on the Inspection and Testing Requirements Sheet PIP VESFG001-T. Inspectors and inspection and testing procedures shall be in accordance with this section.

4.5.1 Inspector Classifications

The following types of inspection individuals in accordance with ASME/ANSI RTP-1 and Code Section X shall participate in the inspections and tests:

a. Inspector

1) The Inspector for ASME/ANSI RTP-1 equipment shall be an individual who is mutually agreed between purchaser and supplier.

2) Unless otherwise specified, the Inspector shall be employed directly or be an independent person hired by the supplier.

3) The Inspector shall be designated on the UBRS.

4) The Inspector duties shall be in accordance with ASME/ANSI RTP-1, Paragraph 1-400 or Code Section X, Paragraph RG-330.
4.5.2 Resin Cure Tests

4.5.2.1 All resin cure tests shall be in accordance with ASME/ANSI RTP-1, Paragraph 6-910.

4.5.2.2 Barcol Hardness Tests

1. One week after manufacture, all fabricated equipment shall be cured to 90% minimum of the resin manufacturer’s recommended Barcol hardness for fully cured laminates.

   Comment: Post curing may be required to attain the required hardness.

   Comment: Barcol hardness values of laminates containing organic or carbon fiber surfacing veils can be 3 to 5 points less than those specified. Values measured when the vessel temperature is greater than 70°F can also be lower. Cooling of the surface may be necessary to obtain specified values. A light sanding of the surface to remove the paraffin layer may also be required to lower the readings.

2. Barcol hardness tests shall be performed in accordance with ASTM D2583 for Code Section X vessels or in accordance with ASME/ANSI RTP-1, Paragraph 6-910 for ASME/ANSI RTP-1 vessels.

4.5.2.3 Acetone Sensitivity Tests

1. For polyester and vinyl ester resin vessels, all potential air-inhibited cure surfaces shall be checked for acetone sensitivity.

2. A tacky surface after application of acetone indicates an under-cured laminate. To correct this nonconformity, the surface shall be re-coated with a paraffinated wax topcoat.

4.5.3 Laminate Thickness Checks

4.5.3.1 The thickness of laminates shall be checked in accordance with ASME/ANSI RTP-1, Paragraph 6-920, or Code Section X, Paragraph RG-141.

4.5.3.2 A spot check of all pressure containing laminates shall be performed.
4.5.3.3 Permissible thickness tolerances shall be in accordance with the applicable standard.

4.5.4 Laminate Visual Acceptance Checks

4.5.4.1 All laminates shall be checked visually in accordance with ASME/ANSI RTP-1, Paragraph 6-940, or Code Section X, Paragraph RG-141.

4.5.4.2 The acceptance criteria shall be in accordance with ASME/ANSI RTP-1, Table 6-1 for ASME/ANSI RTP-1 equipment or Code Section X, Appendix 6, Table 6-100.1 or Table 6-100.2 for structural laminates.

4.5.4.3 Unless the purchaser has declared the vessel to be in critical service, corrosion liners shall be in accordance with ASME/ANSI RTP-1, Table 6-1, for Level 2 laminates.

4.5.4.4 If critical service is declared on the UBRS, the laminates shall be in accordance with ASME/ANSI RTP-1, Table 6-1, for Level 1 laminates.

4.5.4.5 The maximum permissible air entrapment density for ASME/ANSI RTP-1, Table 6-1, Level 1 and Level 2 laminates shall be 10 bubbles per square inch (6.45 square centimeters) for the corrosion liner.

4.5.4.6 For ASME/ANSI RTP-1 structural laminates, the maximum density shall be 10 bubbles per square inch (6.45 square centimeters) for bubbles 1/16 inch (1.5 mm) and less or 4 bubbles per square inch (6.45 square centimeters) for bubbles greater than 1/16 inch (1.5 mm).

4.5.4.7 The criteria for foreign inclusions in the corrosion liner shall be a maximum dimension of 1/32 inch (0.75 mm) with a maximum density of 1 particle per square foot (929 square centimeters) for both Level 1 and Level 2 laminates.

4.5.4.8 Thermoplastic liners shall be in accordance with ASME/ANSI RTP-1, Appendix M-12, Table M12E-1, “Lining Visual Inspection Acceptance Criteria.”

4.5.5 Laminate Physical Property and Proof Tests

4.5.5.1 If specified in the UBRS, or if ASME/ANSI RTP-1 equipment is field-fabricated or designed for pressures 2 psig (13.7 kPa) and greater, the physical property tests of fully-cured specimens described in this Section shall be conducted by a qualified and experienced independent laboratory using ASTM test methods.

4.5.5.2 Test Specimen Preparation

1. Test specimens shall be a full thickness of the laminate as produced and shall not be machined on the surface.

2. Test specimens shall be marked with the purchaser’s equipment number and sample location so that results can be correlated to the specific production piece sampled.
3. Specimens prepared from shell cutouts less than 16 feet (4.87 m) diameter shall be cut in the axial direction of the cylinder to minimize specimen curvature.

4. Specimens prepared from filament-wound shells 16 feet (4.87 m) or greater in diameter shall be cut and tested in both the hoop and axial directions.

5. Specimens prepared from flat laminates shall have their long axis parallel to the warp of the woven roving.
   a. Depending on thickness, tensile test specimens shall be Type I or Type III, in accordance with ASTM D638, Figure 1.
   b. Flexural test specimens shall be Type I in accordance with ASTM D790. For thicknesses greater than 0.230 inch, specimen dimensions shall be interpolated to the nearest 0.062 inch (1.5 mm).
   c. Edge compressive test specimens shall be in accordance with ASTM D695, Paragraph 6.2.
      1) For thicknesses less than 0.525 inch, specimens may be plied to approximately 0.525 inch.
      2) The ends of compressive test specimens shall be milled flat and true at 90 degrees to the surface plane of the specimens.

6. Disposition of the test samples shall be at the direction of the purchaser’s inspector.

4.5.5.3 Specimen Testing and Reports

1. Tensile properties shall be determined on specimens in triplicate in accordance with ASTM D638, speed B (0.20 inch (5.08 mm) per minute).

2. A load extension plot shall be prepared and the chart speed recorded.

3. All flexural tests shall be performed with the “liner” face of the laminate in compression (under the loading nose).

4. If edge compression properties are required, three specimens shall be tested in accordance with ASTM D695.

5. Test reports shall be provided in duplicate to the purchaser.

6. Test reports shall include all pertinent details in accordance with the Report section of the applicable ASTM test method.

7. Test reports shall include load-elongation and load-deflection plots.
4.5.6 Laminate Reinforcement Content Tests

4.5.6.1 Reinforcing sequence shall be checked by visual means at nozzle cutouts and joint edges.

4.5.6.2 If a visual check is not practical, a burnout test shall be made on three specimens in accordance with ASTM D2584.

4.5.6.3 The guidelines given in ASME/ANSI RTP-I, Paragraph 6-930, shall be followed.

4.5.7 Hydrostatic Tests

4.5.7.1 Hydrostatic tests shall be performed on all liquid-filled equipment.

4.5.7.2 Flat sidewall deflection shall not exceed 1/2 percent of span during the hydrotest.

4.5.7.3 Test pressure shall be 1.1 times the design pressure at the top of vessel in the installed position.

4.5.7.4 All testing shall be in accordance with ASME/ANSI RTP-I, Paragraph 6-950, or Code Section X, Article RT-6.

4.5.7.5 All testing facilities and materials (e.g., blinds, bolting, and gaskets) shall be provided.

4.5.7.6 Test Water

1. Hydrostatic testing of vessels shall be performed with water that is clean and free of debris.

2. Potable water shall be used for fiberglass equipment.

3. Water that is brackish or untreated shall not be permitted.

4. Test water in contact with austenitic stainless steel internals shall have a maximum chloride content of 50 ppm.

5. If the test water will be in contact with stainless steel for more than 72 hours, the water shall be treated with an appropriate biocide to prevent biologically induced corrosion of stainless steel.

4.5.7.7 Before applying the test pressure, the test water and vessel material shall be permitted to equalize to approximately the same temperature.

4.5.7.8 Unless otherwise specified, the final hydrostatic test pressure shall be held for a minimum of one hour.

4.5.7.9 A horizontal vessel shall be tested while resting on its support saddles without additional supports or cribbing.

4.5.7.10 Tall vertical vessels shall be tested in the installed position in accordance with ASME/ANSI RTP-I or Code Section X. The vessels shall be adequately supported during the test to prevent damage.
4.5.7.11 If field assembly/erection of a vessel is required, the hydrostatic test shall take place at the owner’s site. A detailed test procedure shall be submitted to the purchaser for review before testing.

*Comment:* If a vessel is supported by lugs or ring supports in steelwork, a field hydrostatic test is typically required.

4.5.7.12 After completion of the hydrostatic test, the vessel shall be drained, dried (including drying internals), and closed as quickly as practicable.

4.5.7.13 Flanged Joints

1. Any flanged joint for which the service gasket is to be provided and which will not be disassembled after testing shall be tested with the specified service gasket.

2. If the joint is to be disassembled after testing and has flanges in accordance with ASME B16.5, the test gasket may be selected in accordance with the limitations in Sections 4.5.7.13.4 and 4.5.7.13.5.

3. If the service gasket is not specified and the joint is to be disassembled after testing and employs nonstandard flanges (i.e., other than in accordance with ASME B16.5), the test gasket shall be as specified by the purchaser.

4. The nominal thickness of sheet or laminate gaskets shall be 1/8 inch (3 mm) or greater.

5. Flanged joint assemblies specified to be furnished with service gaskets (e.g., main shell joints, manways, and blind flanged nozzles) and disassembled following tests shall be reassembled using new service gaskets. If such joints are shipped unassembled, new service gaskets for field installation shall be suitably packaged, marked, and shipped with the vessel.

6. Unless otherwise specified, joint sealing compound or gasket lubricant shall not be permitted.

4.5.8 Pneumatic Tests

4.5.8.1 In cases where a hydrostatic test is not feasible, vessels built to ASME/ANSI RTP-1 or Code Section X shall be pneumatically tested to 1.1 times the design pressure.

4.5.8.2 Because of the inherent danger of pneumatically testing a relatively non-ductile material, extreme caution shall be taken if conducting this test.

4.5.8.3 All pneumatically tested vessels shall be remotely monitored by acoustic emission examination during the test.

4.5.8.4 After the vessel has been brought up to the test pressure and held for 30 minutes minimum, the pressure shall be reduced to 80% of test pressure or less and all nozzles and manways joints shall be checked for leaks.
4.5.8.5 The purchase order shall specify if pneumatic testing is required in the field at the owner’s site. A detailed test procedure shall be submitted in writing for purchaser’s approval before performing the test.

4.5.9 Vacuum Tests

4.5.9.1 As required in ASME/ANSI RTP-1 and Code Section X, all vessels designed for vacuums less than 6 inches of water column (1.47 kPa) shall be vacuum tested as well as hydrostatically tested.

4.5.9.2 The vacuum test shall be performed after the hydrostatic test.

4.5.9.3 If the vessel is designed only for vacuum, it shall be vacuum tested with acoustic emission monitoring.

4.5.10 Acoustic Emission Tests

4.5.10.1 ASME/ANSI RTP-1 vessels designated in critical service and all Code Section X Class II vessels shall have an acoustic emission examination performed during the hydrostatic test.

4.5.10.2 The testing shall be conducted by a qualified independent testing agency approved by the purchaser.

4.5.10.3 The acceptance criteria shall be in accordance with ASME/ANSI RTP-1, Appendix M-8, or Code Section X, Article RT-6.

4.5.10.4 Test procedures and equipment shall be in accordance with Code Section V, Article T-11.

4.5.11 Sample Cutouts

4.5.11.1 If required by the purchase order, all cutouts from vessel laminates shall be marked to identify the equipment number and sample location and shall be retained for the purchaser’s inspection.

4.5.11.2 Cutouts shall be the property of the owner.

4.5.11.3 Cutouts shall be retained at the supplier’s facility for 6 months minimum after shipment, unless instructed otherwise by owner.

4.5.11.4 The extent to which cutouts shall be used for mechanical property testing shall be in accordance with the UBRS or the purchase order.

4.6 Supplier’s Nameplates

4.6.1 The completed equipment shall be provided with a nameplate in accordance with ASME/ANSI RTP-1, Paragraphs 1-530, 1-540, and 1-550, or Code Section X, Article RS-1.

4.6.2 Additionally, the following information shall be provided either on the ASME/ANSI RTP-1 or Code Section X nameplate or a separate nameplate:

a. Owner’s equipment item number

b. Initial test pressures

c. Purchase order number
d. Resin used  
e. Liner construction  
f. Capacity in gallons  
g. Estimated weights when empty, full of process fluid, and full of test water  

4.6.3 Nameplates shall be located in an accessible location.  
4.6.4 The nameplate location and information provided shall be shown on the dimensioned fabrication drawing.  
4.6.5 On insulated tanks, the nameplate shall be located on a bracket that extends 1 inch beyond the insulation thickness.  

4.7 Shipping  
4.7.1 Cleaning and Painting or Pigmentation  
4.7.1.1 The tank or vessel shall be cleaned inside and outside and shall be free of oil, grease, marking compounds, mold release agents, grinding dust, stray glass fibers, and general shop soil. The interior shall be dried after testing and cleaning.  
4.7.1.2 After all internal and exterior laminate quality inspections have been completed, the vessel shall be painted or pigmented with an exterior resin coat in accordance with the UBRS.  
4.7.1.3 Any exterior carbon steel surfaces (e.g., hold-down clips, ladders, platforms, and handrails) shall be prepared and painted or galvanized in accordance with the UBRS.  
4.7.1.4 To protect from rust, exterior alloy steel bolting shall be coated with a lubricant, galvanized or PTFE-coated.  

4.7.2 Preparation for Shipment  
4.7.2.1 Nozzle Covers  
1. Blind flanged connections, including manways, shall have the blinds attached with a full complement of new bolts. The bolts may have been used for the hydrostatic test.  
2. All nozzles shall be provided with covers.  
3. All flange faces other than those furnished with permanent blinds shall be covered with 1/2 inch (12 mm) thick wood or 1/8 inch (3 mm) thick steel plate no smaller than the flange outside diameter.  
4. The cover shall be secured with a 25% minimum (but not less than four) complement of bolts.  

4.7.2.2 Internals  
1. If any internals cannot be safely shipped in place, the internals shall be assemble in the vessel to assure the internals fit properly in accordance with any specified clearances or tolerances.
2. After the trial assembly is completed, the internals shall be removed, identified, tagged, and shipped separately.

4.7.2.3 **Accessories**

1. All bolting and other loose parts shall be suitably packaged and labeled with the purchase order number.

2. Uncoated bolts and nuts shall be coated with a suitable thread lubricant to prevent corrosion during transportation and storage.

3. The thread lubricant shall be easily removable with mineral spirits or a solvent.

4.7.3 **Handling and Lifting**

*Comment:* Impact or excessive distortion can cause cracking or crazing of the laminate structure.

4.7.3.1 The recommended handling and lifting recommendations in *ASME/ANSI RTP-1* shall be followed.

4.7.3.2 Vertical fiberglass vessels shall be provided with lifting and/or tailing lugs for moving or repositioning.

4.7.3.3 Vessels shall not be rolled, slid, dropped, or thrown.

4.7.3.4 All shop-built vessels and tanks shall be provided with metal lifting lugs designed for a shock factor of 1.58.

4.7.3.5 If lifting lugs are not provided, woven fabric rigger-slings of 3-inch (75 mm) width minimum shall be used for lifting cylindrical vessels in a horizontal position.

4.7.3.6 Open-end equipment (e.g., open top tanks) shall be provided with internal cross bracing or external structure to prevent damage from distortion during handling and transporting.

4.7.3.7 For lifting an uncrated and unskidded open-end vessel in a vertical position, a spreader bar shall be used to prevent damage from excessive distortion.

4.7.3.8 If a spreader bar is required for proper lifting, a stenciled notation to that effect shall be applied to the vessel in a prominent location before shipment.

4.7.3.9 Woven fabric rigger-slings of 3-inch (75 mm) minimum width and adequate strength shall be used for lifting fiberglass vessels. The slings shall be used in direct contact with the vessel.

4.7.3.10 Unpadded chains or cables shall not be wrapped around a fiberglass vessel for lifting.

4.7.3.11 Lifting cables and/or straps shall not be attached to or permitted to come in contact with nozzles, flanges, gussets, or accessories other than lifting lugs.

4.7.3.12 If a vessel is being lifted, a guideline shall be attached to prevent impact damage caused by swing contact with other objects.
4.7.4 Temporary Storage

4.7.4.1 As recommended in ASME/ANSI RTP-1, fiberglass vessels shall be placed on shipping cradles or dunnage resting only on firm level surfaces during storage or repositioning.

4.7.4.2 Vessels shall not be rested on stones, tools, chocks, or other small hard objects.

4.7.4.3 If stored outdoors, vessels shall be adequately tied down to prevent movement from wind or water flotation.

4.7.4.4 Closed vessels shall not be completely sealed.

4.7.4.5 If a large open-end vessel is stored in a horizontal position, bracing shall be provided at the open end to prevent excessive distortion. One cross brace with suitably padded end plates to distribute the load shall be installed perpendicular to the surface on which the vessel is resting.

4.7.5 Shipping Protection

4.7.5.1 Cylindrical vessels that are being shipped shall be protected in accordance with the recommendations of ASME/ANSI RTP-1.

4.7.5.2 Vessels shipped horizontally shall be mounted on padded cradles. The cradle saddles shall have 120 degrees minimum arc and be at least as wide in inches as the vessel measures in feet of diameter. The cradles shall be placed as close as possible to the top and bottom heads and/or other stiffened areas of the vessel.

4.7.5.3 Vessels shall be secured to the truck or railcar with padded banding straps that are properly fastened to the bed of the vehicle. Vessels shall also be blocked at the ends to prevent shifting in transit. The blocks shall be padded and bear only on the knuckle radius of the flat or dished heads.

4.7.5.4 Railcar transportation shall be avoided whenever possible. However, if railcar transportation is necessary, a cushioned end car shall be used.

4.7.5.5 Road trailers shall be of the “airride” suspension type.

4.7.5.6 Vessels being shipped in a vertical position shall be secured to a pallet or skid, then fastened to the bed of the vehicle with padded banding.

4.7.5.7 Small vessels being shipped in an enclosed trailer shall be completely crated with padded blocking between the vessel and the inside of the crate.

4.7.5.8 Vessels shall be secured to the vehicle with 1-1/2 inches (38 mm) or greater clearance between the vessel (including external fittings, nozzles, and other projections) and the bed of the truck or railcar.

4.7.5.9 Small vessels may be shipped on pallets or skids to permit handling by forklift truck.
4.7.5.10 If two or more separate units are shipped together, sufficient clearance shall be provided between units to prevent contact during transit.

4.8 Documentation

4.8.1 The documents specified in the purchaser’s Documentation Requirements Sheet, *PIP VESFG001-R*, shall be provided to the purchaser in accordance with quantities and dates indicated.

4.8.2 Reproducible materials shall be of suitable quality to be microfilmed, in accordance with *AIIM MS32*.

4.8.3 The final supplier’s data package shall be printed on 8-1/2 by 11-inch paper (or folded to 8-1/2 by 11-inch) and bound in data books.
SKIRT VENTS 2" (50 MM) I.D.  
(2 REQUIRED, SKIRTS < OR > 30" DIA (760 MM DIA)  
(4 REQUIRED, SKIRTS > 30" DIA (760 MM DIA)  

SKIRT ACCESS OPENINGS  
24" (600 MM) I.D. (2) REQUIRED FOR  
SKIRTS < OR > 42" DIA (1070 MM DIA)  
FOR SKIRTS < 42" DIA (1070 MM DIA) USE  
(2) HANDDOLES SIZE  
DEFINED BY PURCHASER  

100% REINFORCEMENT  
OF SKIRT OPENINGS  
WITH BANDING AND  
OVERLAYS  

SKIRT OPENINGS
SKIRT HOLD DOWN
SHEAR COLLAR WITH CHAIRS USED FOR EXCESSIVE OVERTURNING MOMENTS

ALTERNATE SKIRT HOLD DOWN
ANGLE CLIPS WITH HOLD DOWN DOGS ARE FOR MODERATE LOADS.

NOTE: THE METAL ANGLE CLIP MAY BE OVERWRAPPED WITH FIBERGLASS CLOTH OR FILAMENT WINDING IN LIEU OF BOLTING THROUGH SKIRT.

BUILD-UP SKIRT TO SATISFY COMPRESSION STRESS
THROUGH BOLTING
VESFGO01-3

PROCESS INDUSTRY PRACTICES
FABRICATION/INSTALLATION DETAILS

FIBERGLASS TANKS AND VESSELS
AGITATOR BAFFLE DETAILS

NOTE: BAFFLES MUST NOT BE ATTACHED TO TANK BOTTOM.

SECTION A-A
TYPE 2 WEDGE BAFFLE

TANK WALL
6 PLY MIN. MAT PLUS VEIL(S)

1

1

B

B = 1/12 TANK DIA.
NOTE: WEDGE BAFFLES MUST BE SEALED TOP AND BOTTOM.

SECTION B-B
TYPE 1 PLATE BAFFLE

TANK WALL
GUSSET PLATES LAMINATED TO BAFFLE AND TANK WALL

1 1/2" (38 MM)

SECTION C-C
TYPE 1 PLATE BAFFLE

TANK WALL
GUSSET PLATE

6 PLY MIN. MAT PLUS VEIL(S)

tg = 1/4" (6 MM) MIN.
SECONDARY BONDED LEDGE

USED FOR LIGHT LOADS

MONOLITHIC LEDGE

USED FOR MODERATE TO HIGH LOADS

FOR HIGH LOADS AN ADDITIONAL MID-SPAN BEAM SUPPORT MAY BE REQUIRED.
**Facility Name/Location:**

**Item Name:**

**Purchaser/Location:**

**Item Tag No.:**

**Job No.:**

**Service:**

**Purchaser Order No.:**

**Unit:**

**Supplier/Location:**

**P&ID No.:**

**Supplier Order/Serial Nos.:**

---

1. **Submittal of documentation is a condition of invoice payment. Refer to contract or documents. All data shall be provided before submission of final invoice.**

2. **Purchaser review of documentation shall not relieve supplier of responsibility.**

**Instructions**

1. Complete and return this form with quotation.
2. Submit “With Quote” documentation with quotation.
3. Unless submitted with quotation, drawings and data shall be mailed to _____.
4. Supplier shall submit documentation in compliance with documentation requirements sheet(s) as regards timing, quantity, and form of documentation.
5. Each copy of all data shall be certified and identified by project, purchase order or contract number, and item number.
6. All drawings and documents shall be black on white with clear image suitable for reproduction. Sepias and original film drawings shall not be folded for mailing.
7. Drawings and documents shall show information for this project only. Purchaser, at its sole discretion, may accept preprinted standard data if applicable information is clearly indicated and nonapplicable information is cross-hatched out.
8. If hard copy data books are required, data shall be provided on three-hole paper and bound in hard covers. Unless clarity is adversely affected, drawings shall be reduced to scale on 11-inch by 17-inch paper. If the clarity of reduced drawings is adversely affected, large drawings shall be folded and placed in heavy-duty, three-sided plastic covers and inserted into the binders.
9. Questions of a technical nature shall be directed to _____.
10. Identify supplier representative responsible for documentation:
    - **Name:**
    - **Title:**
    - **Phone:**

**Definitions**

1. **Approval:** Submitted for purchaser review and comment.
2. **Certified:** Certified correct by purchaser/supplier and incorporates comments by purchaser from approval copy.
3. **As Built:** Incorporates modifications made during fabrication.

**Remarks**

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<td>10. Fabrication Data Package (See Part A)</td>
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A. SUPPLIER’S DATA PACKAGE

The Supplier’s Data Package shall include:

1. Final certified assembly and fabrication detail drawings as described in this Appendix. (See Part B)
2. Supplier’s Design Report (See Part C)
3. Post cure charts (time/temperature record)
4. Pressure test charts (time/pressure/water temperature record)
5. Non-destructive examination records and reports
6. Nameplate facsimile
7. Copies of all material log sheets, including material certifications and lot numbers
8. Copies of all inspection checklists or travelers
9. Copies of any certified laminate or proof tests required
10. Description of non-conformities accepted by the User, if any
11. Required bolt preload for custom flanges
12. Any other documentation required in the UBRS

B. SUPPLIER’S DRAWING INFORMATION

The Supplier shall provide certified assembly and working drawings for all vessels and tanks. Supplier’s drawings shall have the same designation for nozzles, manways, skirt openings, and column trays as shown on Purchaser’s drawings. Drawings shall be complete and shall include, but not necessarily be limited to, the following information:

1. Maximum Allowable Working Pressure and coincident maximum design temperature (internal and external, if applicable) (see Section 4.2.2)
2. Minimum Design Temperature and coincident Maximum Allowable Working Pressure (see Section 4.2.2)
3. Reference to ASME RTP-1 or Section X, Edition, and Addenda. Include any Code Cases used and special service restrictions.
4. Special service notes (e.g., “for Critical Corrosive Service” followed by a description of the service)
5. National Board registration number (“RP” and “RTP”-stamped vessels)
6. Design specific gravity
7. Liner thickness and type
8. Secondary bonded joint details. All secondary bond overlays shall be detailed and identified by use of standard symbols described in a drawing legend.
9. Nondestructive examination requirements
10. Post curing requirements
11. Hydrostatic, pneumatic, or vacuum test pressures, as applicable
   a. Shop test in horizontal position (referenced to top of vessel)
   b. Shop test in vertical position (referenced to top of vessel) (except for horizontal vessels)
   c. Any Field in operating position (referenced to top of vessel)
12. Material specifications for all components and all attachments to components
13. Thickness and laminate sequences of all components.
14. All pertinent dimensions, including location of joints, knuckles, manways, nozzles and projections, vessel supports, insulation supports, and any other information necessary for a complete description of the vessel
15. Complete description of all vessel flanges (including both standard and custom-designed), pressure bolting, and gaskets
16. Legend describing laminate sequence symbology
B. SUPPLIER'S DRAWING INFORMATION (CONTINUED)

17. Sensitive leak tests, if any
18. Vessel support details
19. Surface preparation, painting, or other protective coating specifications
20. Estimated weight of vessel when empty, operating, and full of water
21. Design capacity of vessel (or each compartment) (in gallons or liters)
22. Full size reproductions of Supplier and ASME nameplates as stamped by Supplier.
23. Purchaser's vessel identification number(s) and title
24. Reference to Purchaser's specifications. Supplier shall include on the drawings a reference to all applicable codes, standards, and specifications (including all applicable PIP documents and any applicable Supplier standards). References shall include date of issue. When reference is made to Supplier's own standards, copies of such standards shall be included with the submitted working drawings.
25. Special cleaning instructions and purging instructions, if applicable
26. Extent of any laminate sample testing requirements
27. Details of any thermoplastic lining. Include thickness, joint configuration and location, and material specification, if applicable.
28. Wind and seismic zone design conditions
29. Recommended bolt torque for all flanges
30. Name of the Purchaser/Owner and Supplier
31. Design fill level of liquid contents in the vessel or tank
32. Installation name and location
33. Full details of all attachments
34. Operating conditions, if given
35. Special fabrication tolerances
36. Nozzle schedule. Include nozzle mark, nozzle service (if designated), reference to nozzle details on drawing, gusset type, and all dimensions shown on ASME/ANSI RTP-1, Figures 4-6, 4-8, 4-9, and 4-11, or Code Section X, Figures RD-620.1, RD-620.4, RD-620.5, and RD-620.6.
37. Special Notes:
   Supplier's drawings shall also include the following notes as applicable:
   a. Declaration of critical or lethal service (lethal services are prohibited in Code Section X)
   b. Laminate defect level and maximum density of entrapped air

C. SUPPLIER'S DESIGN REPORT

The Supplier's Design Report, in accordance with Paragraph 1 of ASME/ANSI RTP-1, or Paragraph RG-321 of Code Section X, shall contain at least the following data:
1. Design Calculations
2. Fabrication Drawings
3. Certification by a Registered Professional Engineer of the above two items for ASME/ANSI RTP-1 and Code Section X Class II vessels.
4. Final copy of the UBRS updated with all fabrication changes.

The following are required only in a Code Section X Supplier's Design Report:
1. Material manufacturer’s specification sheets for resin, fiber reinforcement, promoters, catalyst, and other components used in laminate construction.
3. Properly certified Form RP-2 for parts of the vessel fabricated by other suppliers.
4. Qualification Test Report for Class I vessels.
5. Records of Quality Control Test Reports.
1. Purchaser shall specify the extent of Purchaser's participation in the inspection and testing.
2. Purchaser reserves the right to witness all aspects of manufacturing, to review and reject manufacturing equipment, testing equipment, test procedures, and test results; and to reject product not meeting requirements.
3. Purchaser shall be given written notice ______ working days before inspection or test. If a test is rescheduled, the Purchaser shall be notified a minimum of ______ working days before the new test date.
4. Purchaser may perform additional testing, inspection, or both.
5. References are either to Code paragraphs or to applicable referenced standards. All additional requirements covered by the contract documents also apply.
6. If a work item is not checked, then documentation or notification to the Purchaser is not required. However, the work item itself is still required to be performed if specified elsewhere in the Code, PIP VESFG001, or other contract documents.
7. Contact Information:
Purchaser / Inspector: Phone number:
Supplier / Representative: Phone number:

**DEFINITIONS:**
Review = Supplier provides documentation for verifying performance of inspection or test
Witness = Purchaser has option to observe inspection or test
Inspect = Purchaser shall have access to physically conduct inspection
Hold Point = Purchaser shall provide authorization to perform inspection or test
Document = Supplier provides documentation of inspection or test results

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<th>Review</th>
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