Annex B
Tanks with High Pressure/Vacuum Ratings

1.0 General

This Annex provides guidance for those Purchasers specifying higher working pressures for 15' 6" diameter tanks of up to 6 psig. Tanks in this Annex have been designed in accordance with ASME Boiler and Pressure Vessels Section VIII Division 2 – Alternative Rules, known as *Design by Analysis*.

All requirements as outlined in the main body of this Standard shall be followed with the exceptions as noted in this Annex.

The guidelines presented here are ONLY for a 15' 6" diameter tank, with top deck, shell, head and skirt as specified in the ANNEX.

Tanks designed to the requirements of this Annex, will provide leak free zero point emissions provided that the Purchaser specifies a suitable venting strategy, device, proper set points, and the tank vent piping is adequately sized. For guidance on venting strategy, leakage, and set point selection please reference API 12R1.

NOTE: The Purchaser should select tank manufacturers that have a robust QA/QC program in place.

2.0 Terms and Definitions

2.1 Inside Diameter
The flush inside diameter of the tank, and the measurement used for volume calculations

2.2 Knuckle Radius (KR)
The radius of the curved part of the head where it meets the straight section of the head. The KR is 6% of the tank ID

2.3 Outside Diameter (OD)
The outside, or nominal dimension of the tank.

2.4 Overall Height (OAH)
The height of the tank measured from the weld line of the head to the shell and the roof to shell joint.

2.5 Straight Flange (SF)
The straight portion of the head measured from the tangent line to the edge of the head. Typically this will be 2 inches.

3.0 Materials

3.1 General

Materials listed in this Annex have been selected to provide adequate strength and reasonable service life. Other materials having mechanical properties equal to or greater than these listed may be used by agreement between the Purchaser and the Manufacturer. Where higher-strength materials are used, the minimum thicknesses called for in this specification shall not be reduced.

3.2 Plates

3.2.1 Plates shall conform to one of the following specifications:

a) ASTM A36/A36M
b) ASTM A516/516M, Grade 70

3.3 Heads

3.3.1 Heads shall conform to the following specification:

a) ASTM A516/516M, Grade 70

4.0 Design

4.1 Loads

4.1.1 A vacuum of up to -6.0 ounces per square inch.

4.1.2 A normal operating pressure of up to 80 ounces per square inch.

4.1.3 A maximum emergency pressure of 96 ounces per square inch.

4.1.4 The hydrostatic pressure from liquids inside the tank.

4.1.5 A wind loading from 140 mph 3-sec gust basic wind speed[1] acting on shell (uplift on tank roof not considered)

4.1.6 A seismic loading equivalent to design accelerations of SDS = 0.12 g and SD1 = 0.22 g (the maximum seismic acceleration possible without causing the tank to uplift[2]).

4.1.7 A snow load of 50 psf.

4.1.8 For larger loads than as specified in 4.1.5 and 4.1.6, the OWNER shall determine if anchorage is required and may modify the base ring for anchorage into a concrete foundation, and shall design the foundation to support these loads.

[1] See ASCE7-16 for definition from basic wind speed and wind loading calculation.
[2] Uplift occurs when the anchorage ratio J exceeds 0.785.

4.2 Load Combinations

4.2.1 A full tank of liquid (1.1 SG), the pressure stated in 4.1.3, and no wind.

4.2.2 460 mm (18 in.) of liquid (0.7 SG), the wind stated in 4.1.6, and no internal pressure.

4.2.3 A ground snow load as stated in 4.1.7 and a vacuum of 6 oz/in.2.

4.2.4 9144 mm (30 ft.) of liquid (1.1 SG), the seismic acceleration stated in 4.1.6, and no internal pressure.

4.3 Tank Uplift

The design of this tank does not have uplift as a result of internal pressure acting on the tank bottom. If the criteria listed in 4.1 are met, overturning uplift is not a concern, and the tank may be set on a level pad without the use of anchors provided the loading is within the loading criteria of 4.1.5 thru 4.1.7. For higher loads, see note 4.1.8.

4.4 Welding

Welding procedures and welders shall be qualified by the manufacturer in accordance with Section IX of the ASME Boiler and Pressure Vessel Code. The Purchaser is cautioned that the selection of a manufacturer to build tanks in this Annex should be carefully evaluated to ensure that the welding is free from defects and the workmanship is acceptable.

4.5 Weld Joint Efficiency

The tank designed under this ANNEX assumes a joint efficiency of 0.7. If the welds are not radiographed, testing of the tank may only be performed using water – pneumatic testing is prohibited. All radiographic examination shall conform to the requirements as outlined in API 650.

4.6 Bottom Design

4.6.1 Type

The tank bottom shall be a skirted ASME Flanged and Dished head. The head shall have an inner diameter of 4,724 mm (186 in.), a 51 mm (2 in.) straight flange, a knuckle radius of 283 mm (11.16 in.), and an overall height from bottom of head to top of flange of 856 mm (33.68 in.) See Figure 1.

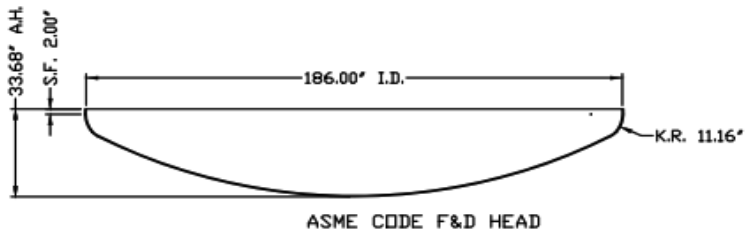


Figure 1: ASME Flanged and Dished Head.

4.6.2 **Bottom-to-Shell Attachments**

The tank bottom head shall be attached to the bottom shell course by full penetration groove welds, both inside and outside. The inside surfaces shall be flush.

4.6.3 **Tank Skirt**

The tank skirt shall be 9.5 mm (3/8 in.) thick. The skirt shall have a minimum of (4) ventilation / hand-holes c/w wildlife screen placed circumferentially around the skirt to allow for underside tank inspection and for any gases to escape that may be present in the case of a leak. The diameter of the hand holes shall be at least 304 mm (12 in.)

4.6.4 **Head to Skirt Attachment**

The tank skirt shall be attached to the flanged portion of the bottom head by a full fillet weld at the exterior of the tank. See Figure 2.

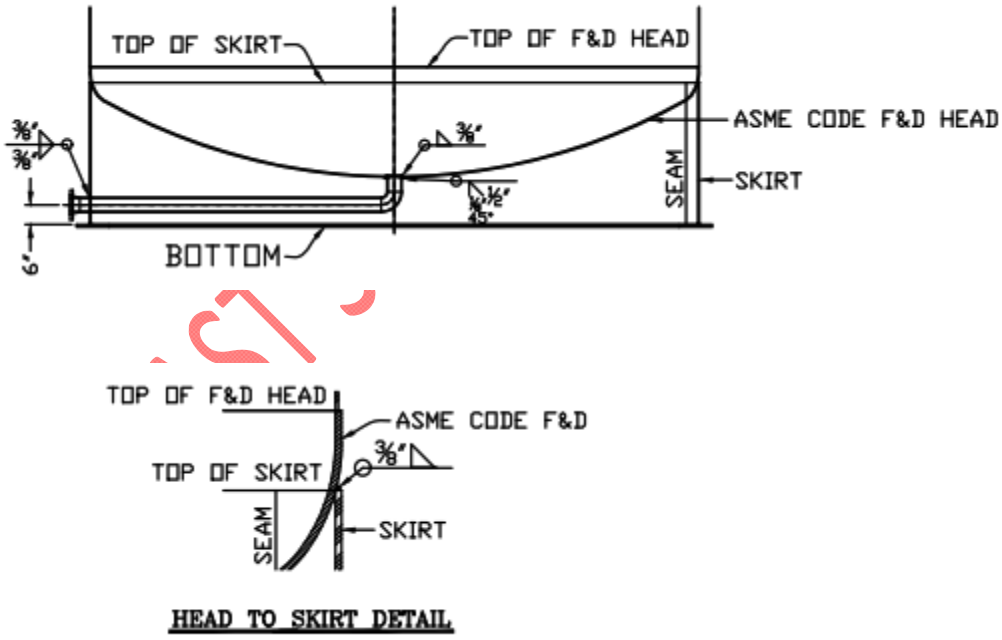


Figure 2: Skirt attachment Detail

4.6.5 Skirt Base Ring / Tank Support

The bottom of the tank skirt shall be fitted with a base ring. The base ring shall have an outer diameter of 4,928 mm (16 ft. 2in) and an inner diameter of 3,658 mm (12 ft.), that yields a width of 638 mm (25.1 in). See Figure 3.

The Base Ring shall be welded to the skirt with a continuous fillet weld both inside and outside the perimeter of the skirt.

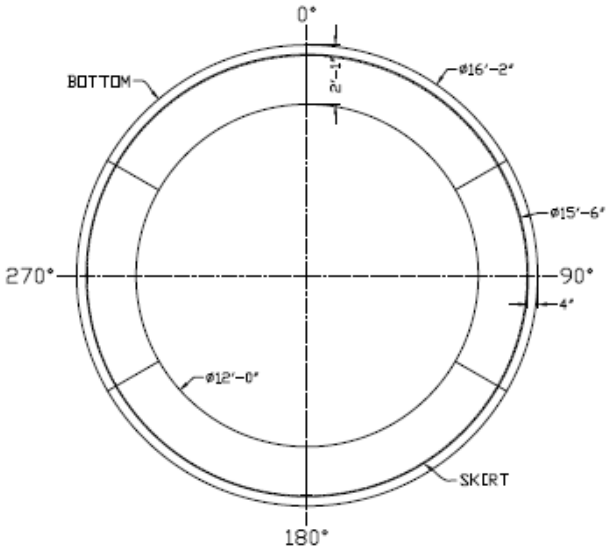


Figure 3: Skirt Base Ring

4.7 Shell Design

4.7.1 Thickness

The minimum nominal thickness of the shell plates shall be 6.3 mm (¼ in.) for the first shell course attached to the bottom head, and then 4.8 mm (3/16 in.) for the remaining shell courses. To minimize circumferential welds, the nominal width of shell plates shall be no less than 1.2 m (48 in.)

4.7.2 Shell Joints

Shell-plate joints shall be double-welded butt joints with complete penetration.

4.7.3 Re-Pads

All nozzle reinforcement pads, and poison pads welded to the shell shall have a ¼" weep hole near the bottom of the pad. The weep hole should be tapped to allow the pad to be pressure tested. The weep holes shall not be plugged and shall be packed with stiff grease for shipping to destination.

4.8 Roof Design

4.8.1 Type

The roof is non-frangible, and shall be of a self-supporting cone with a minimum slope of 4 in 12.

4.8.2 Thickness

The minimum nominal thickness of roof plates shall be 6.3 mm (¼ in.)

4.8.3 Roof Joints

Roof plate joints shall be double-welded butt joints with complete penetration.

4.8.4 Roof-to-Shell Attachment

The roof shall be attached to the tank shell course by a complete-joint-penetration groove weld or by full-fillet welds, both inside and outside.
A shell to roof stiffening chime band shall be installed between the upper shell course and the deck. The stiffening chime band should be rolled to same ID of the tank and shall not be less than 9.5 mm (3/8 in.) thick x 304mm (12 in.) width. See Figure 4.

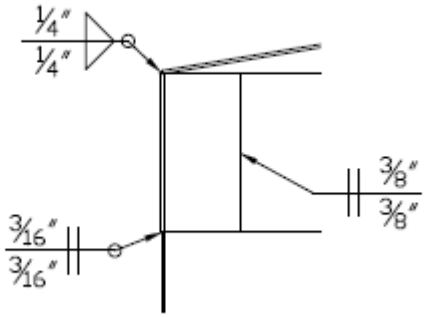
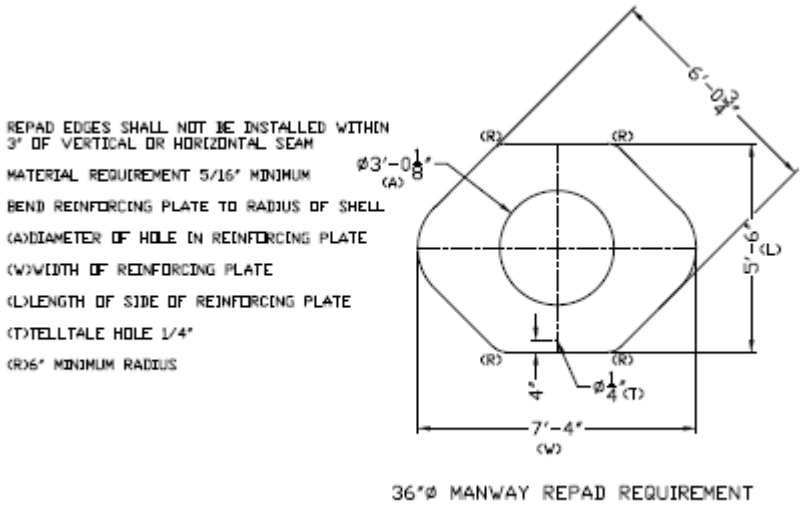


Figure 4: Roof to Stiffener Shell Detail

4.9 Appurtenance Design

4.9.1 Cleanout

Tanks shall be furnished with a round extended neck manway (cleanout) of diameter 914 mm (36 in.) ID. The manway shall be reinforced to the shell with a diamond reinforcing pad with minimum thickness of 8 mm (5/16 in.). See Figure 5.

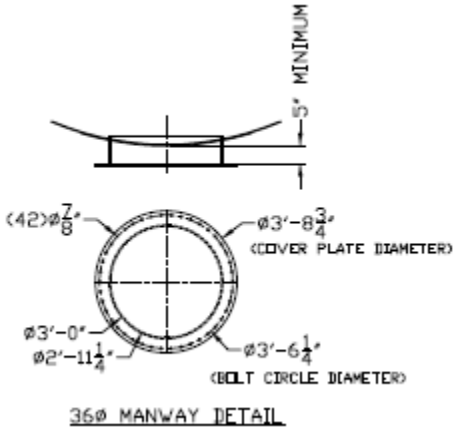


36"ø MANWAY REPAD REQUIREMENT

Figure 5: Cleanout Re-Pad details

The manway neck shall have a minimum 125 mm (5 in.) projection from the re-pad to allow for bolt installation. Bolt holes shall straddle the flange vertical centerline.
The design of the manway flange and cover plate shall follow guidance in API 650 Section 5.
Unless otherwise specified by the Purchaser, manway gaskets should be 1051 mm (41 3/8 in) OD by 914 mm (36 in) ID by 3 mm (1/8 in.) thick 1 piece Viton.

The manway cover shall be hinged to the manway flange or alternatively a davit arm installed to aid in removal. See Figure 6.



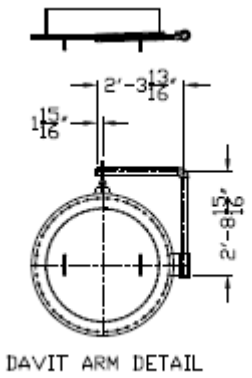


Figure 6: Manway Details

4.9.2 Connections

Unless otherwise specified by the Purchaser, tanks shall be provided with inlet and outlet connections as shown in Figure 8. Connections shall be raised face, Class 150, weld neck flanges and shall be attached to the tank member by full-fillet welds on both inside and outside surfaces.
Additional or fewer connections of other sizes or locations may be provided if agreed between the Purchaser and the Manufacturer. The nozzle neck shall be a minimum of standard weight pipe and attached by full-fillet welds, both inside and outside. The nozzle shall project a minimum of 150 mm (6 in.) from either the shell or short side of sloped surface (such as on the roof deck).

The Purchaser shall review the venting requirement of the tank, and ensure that the vent connection size is adequate for the intended use.

The sizes shown in this Annex are minimum connection sizes.

4.9.3 Lifting Lugs

Lifting lugs shall be attached to the top stiffening ring 180 degrees apart from one another. The lug shall be fabricated from material at least 19 mm (¾ in.) thick, and continuously welded to the tank stiffening ring. Tailing lugs shall be attached to the shell to aid with setting the tanks. A re-pad that is at least 9.5 mm (3/8 in.) thick shall be used to attach the tailing lug to the tank. The tailing lug shall be fabricated from material at least 19 mm (¾ in.) thick, and continuously welded to the repad. See Figure 7.

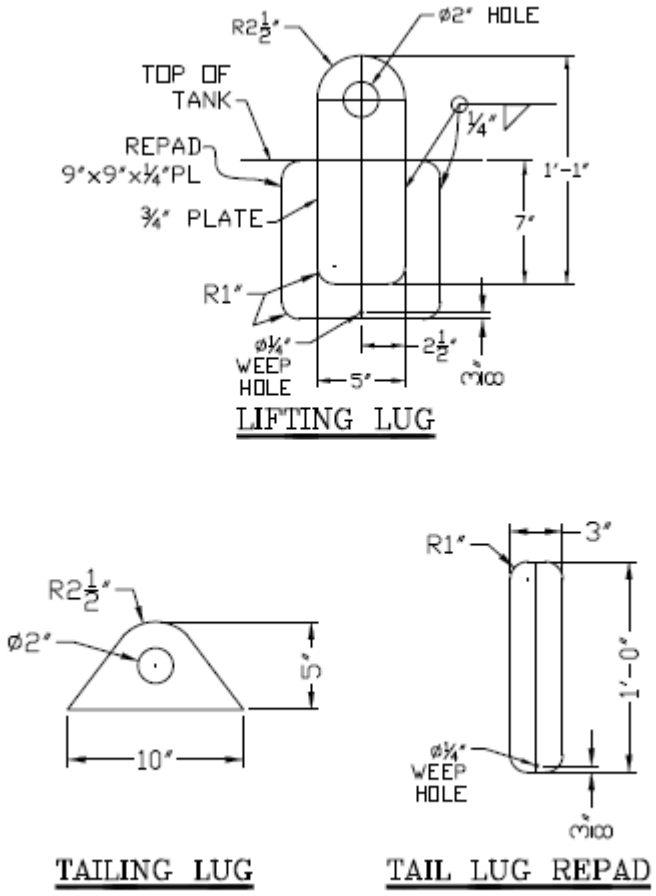


Figure 7: Lifting Lug/ Tailing Lug Detail

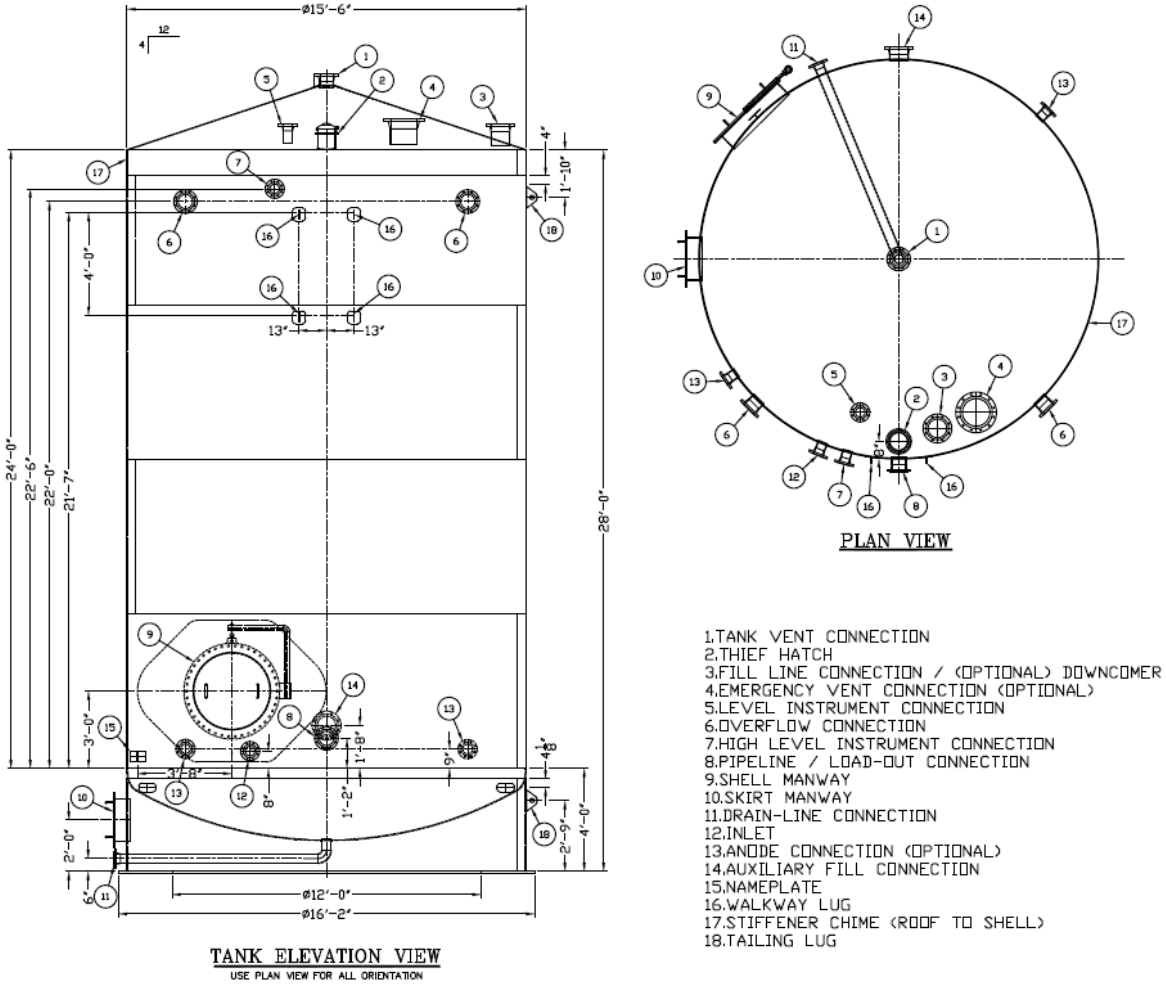


Figure 8: Overview of Tank Design and Appurtenances

5.0 Marking

When building a tank under this Annex, the API nameplate should identify the standard of construction as API 12F Edition Number (current addition) Annex B. The design pressure should be stamped on marked tag as 80 oz. and the vacuum should be stamped at -6.0 oz.

6.0 Testing

The tank shall be tested to a pressure of 1.2X design, or 96 osi. It is recommended that the tank be hydro tested rather than pneumatically tested to reduce the risk to personal in the test area. By agreement with the Purchaser, a tank may be pneumatically tested ONLY if the welds have been radiographed and any anomalies corrected prior to testing.