

Agenda Item:		650-1091
Title:	Update Fixed Roof Definitions	
Date:	05/16/22	
Contact:	Name:	R. Austin Pace
	Company:	Consolidated Fabrication and Constructors
	Phone:	219-746-4944
	E-mail:	Austin@Consfab.com
Purpose:	Add a clear definition for self-supported roofs.	
Source:	Inquiry	
Revision:	2	
Impact:	The business impact of this item is neutral	
Rationale:	<p>In INQ-650-D117 the inquirer wanted to know if self-supported cone roofs with rafters not welded to the roof plates and without a center column can be designed using the formulas from 5.10.5 for self-supported cone roofs. The answer is NO. The minimum thickness formulas in 5.10.5.1 are strictly for self-supported cone roofs supported only by the roof plates themselves. Any cone roofs which are supported by rafters or any other means need to be designed to 5.10.4. Similarly, the formulas for dome & umbrella roofs in 5.10.6.1 are strictly for dome & umbrella roofs supported only by the roof plate.</p>	
Proposal:	<p>5.1.5.9 Roof and Top Angle Joints</p> <p>d) At the option of the Manufacturer, for self-supporting roofs of the cone, dome, or umbrella type, the edges of the roof plates may be flanged horizontally to rest flat against the top angle to improve welding conditions.</p> <p>e) Except as specified for open-top tanks in 5.9, for tanks with frangible joints per 5.10.2.6, for unstiffened self-supporting roofs in 5.10.5, and 5.10.6, and for tanks with the flanged roof-to-shell detail described in Item f below, tank shells shall be supplied with top angles of not less than the following sizes:</p> <p>f) For tanks with a diameter less than or equal to 9 m (30 ft) and a supported cone roof (see 5.10.4), the top edge of the shell may be flanged in lieu of installing a top angle. The bend radius and the width of the flanged edge shall conform to the details of Figure 5.3a. This construction may be used for any tank with an unstiffened self-supporting roof (see 5.10.5 and 5.10.6) if the total cross-sectional area of the junction fulfills the stated area requirements for the construction of the top angle. No additional member, such as an angle or a bar, shall be added to the flanged roof to-shell detail.</p> <p>5.10.1 Definitions</p> <p>b) A self-supporting cone roof is a roof formed to approximately the surface of a right cone that is supported only at its periphery.</p> <p>c) A self-supporting dome roof is a roof formed to approximately a spherical surface that is supported only at its periphery.</p> <p>d) A self-supporting umbrella roof is a modified dome roof formed so that any horizontal section is a regular polygon with as many sides as there are roof plates that is supported only at its periphery.</p>	

e) An unstiffened self-supporting roof meets the requirements of 5.10.1 b, c, or d but is supported, beyond the periphery, by only the roof plates themselves.

5.10.2.2 Roof Plate Thickness: Roof plates shall have a nominal thickness of not less than 5 mm (3/16 in.) or 7-gauge sheet. Increased thickness may be required for supported cone roofs (see 5.10.4.4). Any required corrosion allowance for the plates of **unstiffened** self-supporting roofs shall be added to the calculated thickness unless otherwise specified by the Purchaser. Any corrosion allowance for the plates of supported roofs shall be added to the greater of the calculated thickness or the minimum thickness or [5 mm (3/16 in.) or 7-gauge sheet]. For frangible roof tanks, where a corrosion allowance is specified, the design must have frangible characteristics in the nominal (uncorroded) condition.

5.10.5 Unstiffened Self-Supporting Cone Roofs

~~NOTE Self-supporting roofs whose roof plates are stiffened by sections welded to the plates need not conform to the minimum thickness requirements, but the nominal thickness of the roof plates shall not be less than 4.8 mm (3/16 in.) when so designed by the Manufacturer, subject to the approval of the Purchaser.~~

5.10.6 Unstiffened Self-supporting Dome and Umbrella Roofs

~~NOTE Self-supporting roofs whose roof plates are stiffened by sections welded to the plates need not conform to the minimum thickness requirements, but the thickness of the roof plates shall not be less than 4.8 mm (3/16 in.) when so designed by the Manufacturer, subject to the approval of the Purchaser.~~

5.10.7 Top-angle Attachment for Unstiffened Self-Supporting Roofs

Information and certain restrictions on types of top-angle joints are provided in Item c of 5.1.5.9. Details of welding are provided in 7.2.

AL.5.6.5 Unstiffened Self-Supporting Cone Roofs

AL.5.6.6 Unstiffened Self-Supporting Dome and Umbrella Roofs

F.2.2 The required compression area at the roof-to-shell junction shall be calculated as in F.5.1, and the participating compression area at the junction shall be determined by Figure F.2. Full penetration butt welds shall be used to connect sections of the compression ring. For **unstiffened** self-supporting roofs, the compression area shall not be less than the cross-sectional area calculated in 5.10.5 or 5.10.6 as applicable. Materials for compression areas may be selected from API 650, Section 4, and need not meet toughness criteria of 4.2.9.

F.5.2 For **unstiffened** self-supporting roofs, the compression area shall not be less than the cross-sectional area calculated in 5.10.5 and 5.10.6.

F.6 Design of Roof Plates

F.6.1 Minimum thickness of supported and self-supporting cone roofs under internal pressure shall be calculated as follows:

NOTE 2 Calculated thickness (t) of roof plates shall not be less than that required under 5.10.4 for supported cone or less than that required under 5.10.5 for **unstiffened** self-supporting cone roofs.

F.6.2 Minimum thickness of self-supporting dome and umbrella roofs under internal pressure shall be calculated as follows:

NOTE 2 Calculated thickness (t) of roof plates shall not be less than that required under 5.10.6 for **unstiffened** self-supporting dome and umbrella roofs.

J.3.5 Roofs

J.3.5.1 General

Roofs for tanks constructed in accordance with this Annex shall be of the **unstiffened** self-supporting type and shall conform to either J.3.5.2 or J.3.5.3. Alternate designs meeting the requirements of 5.10.2.8 are permitted with Purchaser approval.

J.3.5.2 Cone Roofs

Unstiffened Self-supporting cone roofs shall be designed as specified in 5.10.5, except they may be provided with a flange that will permit butt-welded attachment to the shell (see J.3.1.4). Flanges shall be formed with a minimum inside corner radius of three times the roof thickness or 19 mm (3/4 in.), whichever is larger.

J.3.5.3 Dome and Umbrella Roofs

Unstiffened Self-supporting dome and umbrella roofs shall be designed as specified in 5.10.6, except they may be flanged as described in J.3.5.2. For dome roofs that are flanged, the radius of curvature shall not be limited to the maximum requirements given in 5.10.6; instead, the curvature shall be limited by the depth of the roof, including the crown and knuckle depth, as listed in Table J.1a and Table J.1b.

L.3 Specific Instructions

L.3.1 Line-by-Line Instructions

11. Open-Top and Fixed-Roof Data (see page 6 of the Data Sheet for Floating Roofs)
— Open Top?* (Yes/No) Specify “Yes” if tank has no fixed roof or has an external floating roof. Specify “No” for all other tanks.

NOTE The remaining entries in this line apply to fixed roofs ONLY:

Fixed Roof Type*: Enter description, such as supported cone with internal structure, supported cone with external structure, structurally-supported aluminum geodesic dome, self-supporting cone, self-supporting dome, self-supporting umbrella, **unstiffened** self-supporting cone, **unstiffened** self-supporting dome, **unstiffened** self-supporting umbrella, flanged only flat top, or other. See 5.10.1 or Annex G.

— Roof Support Columns*: Specify pipe or structural shape. If structural shape is specified, indicate the kind (e.g. wide flange, back-to-back channel, etc.). NOTE Pipe-type roof columns are preferred for internal floating roof tanks. In many cases the openings are 3/4 NPT threaded couplings that allow the user to plug the openings when the tank is in service, to minimize corrosion of the supports and reduce emission from the tank. The openings are needed to allow the free drainage and cleaning of the columns when the tank is out of service.

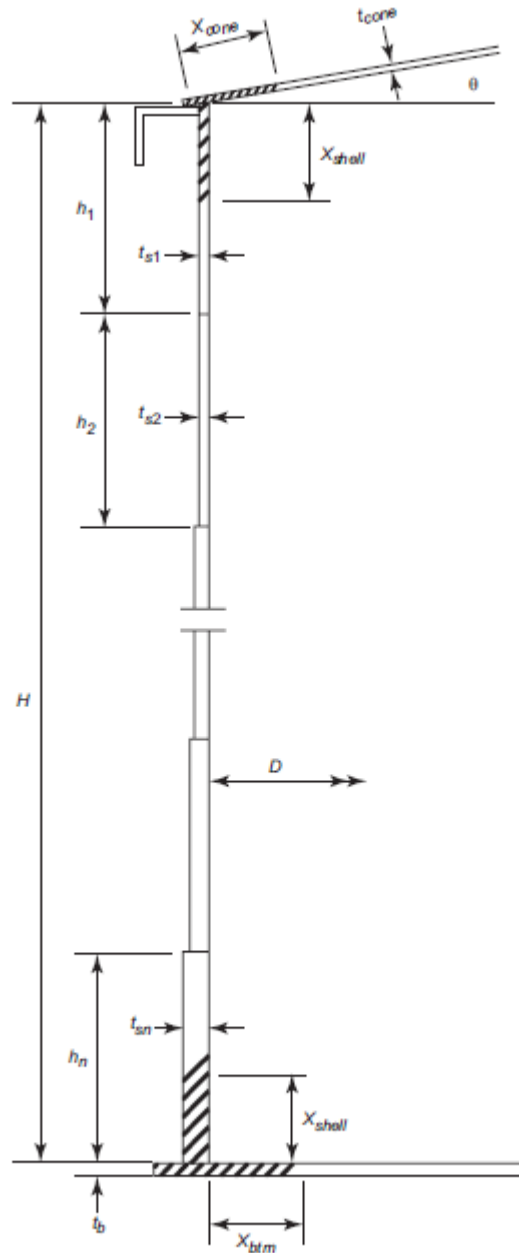
— Cone Slope*: Specify rise to run as a dimensionless ratio, e.g. “3/4:12”.

— Dome or Umbrella Radius*: See 5.10.6 for self-supporting approximate spherical radius of roof.

M.5 Self-Supporting Roofs

Table M.2a and Table M.2b shall be used to determine the material's modulus of elasticity at the maximum operating temperature.

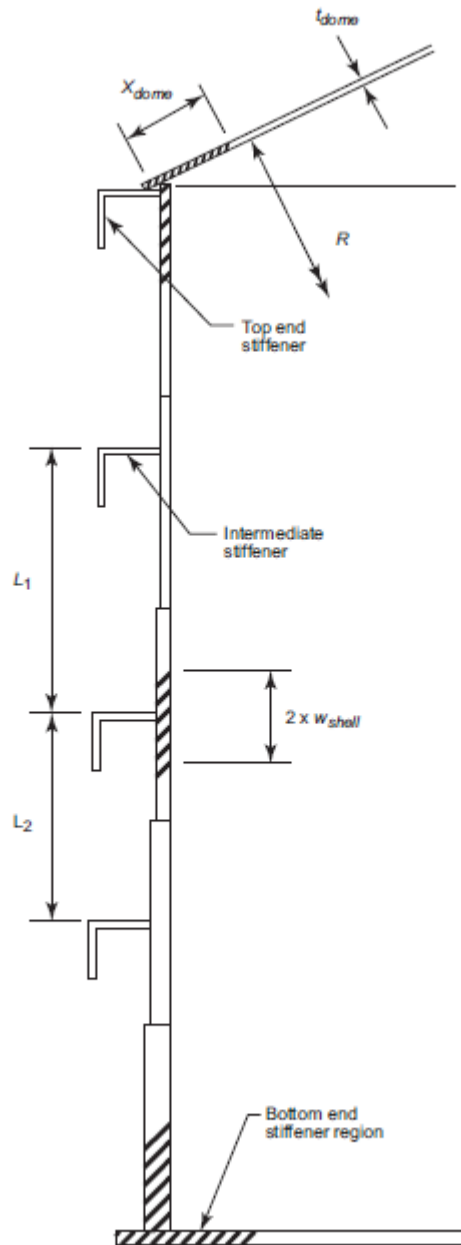
V.7.2 Unstiffened Self-Supporting Cone Roof



NOTE See Annex F, Figure F.2 for alternative configurations and associated limitations on structural section used for top stiffener.

Figure V.1a—Dimensions for Unstiffened Self-Supporting Cone Roof

V.7.3 Unstiffened Self-Supporting Dome or Umbrella Roof



NOTE See Annex F, Figure F2 for alternative configurations and associated limitations on structural section used for top stiffener.

Figure V.1b—Dimensions for Unstiffened Self-Supporting Dome Roof

V.10.2 External Pressure Calculations

- 1) Select roof type: Try an unstiffened self-supporting cone roof with a 20-degree slope from horizontal.