

Agenda Item: 650-1083

Title: Annex A Minimum Shell Thickness

Date: 13 November 2018

Contact: Name: Mark Baker
Company: Baker Consulting Group, Inc
Phone: (740) 504-1158
E-mail: mbaker@bakercgi.com

Purpose: To reassess the allowed minimum thickness of the Annex A and resolve conflict in the table A.2 and A.4 which shows 3/16" min thickness where the Annex would require 1/4" min.

Source: 4/2018 Inquiry

Revision: 1

Impact: Minor

Rationale: Align Annex A with the main body requirements and the requirements in Annex J.

Currently:

A.4.2 The nominal thickness of shell plates (including shell extensions for floating roofs) shall not be less than that listed in 5.6.1.1. The nominal thickness of shell plates refers to the tank shell as constructed. The nominal thicknesses given in 5.6.1.1 are based on erection requirements.

5.6.1.1 Note 4: states For diameters less than 15 m (50 ft) but greater than 3.2 m (10.5 ft), the nominal thickness of the lowest shell course shall not be less than 6 mm (1/4 in.).

Proposal:

Delete Tables: A.2a, A.2b, A.4a, A.4b Since they are not used.

Renumber Tables:

Table A.3a—Typical Sizes and Corresponding Nominal Capacities (m³) for Tanks with 2400-mm Courses (SI)

To:

Table A.2a—Typical Sizes and Corresponding Nominal Capacities (m³) for Tanks with 2400-mm Courses (SI)

Table A.3b—Typical Sizes and Corresponding Nominal Capacities (barrels) for Tanks with 96-in. Courses (USC)

To:

Table A.2b—Typical Sizes and Corresponding Nominal Capacities (barrels) for Tanks with 96-in. Courses (USC)

Table A.2a—Shell-Plate Thicknesses (mm) for Typical Sizes of Tanks with 1800-mm Courses (SI)

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12
Tank Diameter m	Tank Height (m) / Number of Courses in Completed Tank										Maximum Allowable Height for Diameter ^a m
	1.8 / 1	3.6 / 2	5.4 / 3	7.2 / 4	9 / 5	10.8 / 6	12.6 / 7	14.4 / 8	16.2 / 9	18 / 10	
3	5.0	5.0	5.0	5.0	5.0	5.0	—	—	—	—	—
4.5	5.0	5.0	5.0	5.0	5.0	5.0	—	—	—	—	—
6	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	—	—	—
7.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.3	—
9	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.7	6.3	—
10.5	5.0	5.0	5.0	5.0	5.0	5.0	5.1	5.9	6.6	7.4	—
12	5.0	5.0	5.0	5.0	5.0	5.0	5.9	6.7	7.6	8.4	—
13.5	5.0	5.0	5.0	5.0	5.0	5.6	6.6	7.6	8.5	9.5	—
15	6.0	6.0	6.0	6.0	6.0	6.6	7.3	8.4	9.5	10.6	—
18	6.0	6.0	6.0	6.0	6.2	7.5	8.8	10.1	11.4	—	17.8
21	6.0	6.0	6.0	6.0	7.3	8.8	10.3	11.8	—	—	15.3
24	6.0	6.0	6.0	6.6	8.3	10.0	11.7	—	—	—	13.4
27	6.0	6.0	6.0	7.4	9.3	11.3	—	—	—	—	11.9
30	6.0	6.0	6.0	8.2	10.4	12.5	—	—	—	—	10.8
36	8.0	8.0	8.0	9.9	12.5	—	—	—	—	—	9.0
42	8.0	8.0	8.5	11.5	—	—	—	—	—	—	7.8
48	8.0	8.0	9.7	—	—	—	—	—	—	—	6.9
54	8.0	8.0	10.9	—	—	—	—	—	—	—	6.1
60	8.0	8.0	12.2	—	—	—	—	—	—	—	5.5
66	10.0	10.0	—	—	—	—	—	—	—	—	5.1

^a Based on a maximum permissible shell-plate thickness of 13 mm, a maximum allowable design stress of 145 MPa, a joint efficiency of 0.85, and no corrosion allowance.

NOTE: The plate thicknesses shown in this table are based on a maximum allowable design stress of 145 MPa, a joint efficiency of 0.85, and no corrosion allowance (see A.4.1).

Table A.2b—Shell-Plate Thicknesses (in.) for Typical Sizes of Tanks with 72-in. Courses (USC)

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12
Tank Diameter ft	Tank Height (ft) / Number of Courses in Completed Tank										Maximum Allowable Height for Diameter ^a ft
	6 / 1	12 / 2	18 / 3	24 / 4	30 / 5	36 / 6	42 / 7	48 / 8	54 / 9	60 / 10	
10	3/16	3/16	3/16	3/16	3/16	3/16	—	—	—	—	—
15	3/16	3/16	3/16	3/16	3/16	3/16	—	—	—	—	—
20	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	—	—	—
25	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	0.20	0.22	—
30	3/16	3/16	3/16	3/16	3/16	3/16	3/16	0.21	0.24	0.26	—
35	3/16	3/16	3/16	3/16	3/16	3/16	0.21	0.24	0.27	0.30	—
40	3/16	3/16	3/16	3/16	3/16	0.21	0.24	0.28	0.31	0.35	—
45	3/16	3/16	3/16	3/16	3/16	0.23	0.27	0.31	0.35	0.38	—
50	1/4	1/4	1/4	1/4	1/4	0.26	0.30	0.35	0.39	0.43	—
60	1/4	1/4	1/4	1/4	0.26	0.31	0.36	0.41	0.47	—	58.2
70	1/4	1/4	1/4	1/4	0.30	0.36	0.42	0.48	—	—	50.0
80	1/4	1/4	1/4	0.27	0.34	0.41	0.48	—	—	—	43.9
90	1/4	1/4	1/4	0.31	0.38	0.46	—	—	—	—	39.1
100	1/4	1/4	1/4	0.34	0.43	—	—	—	—	—	35.3
120	5/16	5/16	5/16	0.41	—	—	—	—	—	—	29.6
140	5/16	5/16	0.35	0.47	—	—	—	—	—	—	25.5
160	5/16	5/16	0.40	—	—	—	—	—	—	—	22.5
180	5/16	5/16	0.45	—	—	—	—	—	—	—	20.1
200	5/16	0.32	0.50	—	—	—	—	—	—	—	18.2
220	3/8	3/8	—	—	—	—	—	—	—	—	16.6

^a Based on a maximum permissible shell-plate thickness of 1/2 in., a maximum allowable design stress of 21,000 lbf/in.², a joint efficiency of 0.85, and no corrosion allowance.

NOTE: The plate thicknesses shown in this table are based on a maximum allowable design stress of 21,000 lbf/in.², a joint efficiency of 0.85, and no corrosion allowance (see A.4.1).

Table A.4a—Shell-Plate Thicknesses (mm) for Typical Sizes of Tanks with 2400-mm Courses (SI)

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10
Tank Height Diameter m	Tank Height (m) / Number of Courses in Completed Tank								Maximum Allowable Height for Diameter ^a m
	2.4 / 1	4.8 / 2	7.2 / 3	9.6 / 4	12 / 5	14.4 / 6	16.8 / 7	19.2 / 8	
3	5.0	5.0	5.0	5.0	—	—	—	—	—
4.5	5.0	5.0	5.0	5.0	5.0	—	—	—	—
6	5.0	5.0	5.0	5.0	5.0	5.0	—	—	—
7.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	—
9	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	—
10.5	5.0	5.0	5.0	5.0	5.0	5.0	5.1	5.9	—
12	5.0	5.0	5.0	5.0	5.0	5.0	5.9	6.7	—
13.5	5.0	5.0	5.0	5.0	5.0	5.6	6.6	7.6	—
15	6.0	6.0	6.0	6.0	6.0	6.3	7.3	8.4	—
18	6.0	6.0	6.0	6.0	6.2	7.5	8.8	10.1	17.8
21	6.0	6.0	6.0	6.0	7.3	8.8	10.3	11.8	15.3
24	6.0	6.0	6.0	6.6	8.3	10.0	11.7	—	13.4
27	6.0	6.0	6.0	7.4	9.3	11.3	—	—	11.9
30	6.0	6.0	6.1	8.2	10.4	12.5	—	—	10.8
36	8.0	8.0	8.0	9.9	12.5	—	—	—	9.0
42	8.0	8.0	8.5	11.5	—	—	—	—	7.8
48	8.0	8.0	9.7	—	—	—	—	—	6.9
54	8.0	8.0	10.9	—	—	—	—	—	6.1
60	8.0	8.0	12.2	—	—	—	—	—	5.5
66	10.0	10.0	—	—	—	—	—	—	5.1

^a Based on a maximum permissible shell-plate thickness of 13 mm, a maximum allowable design stress of 145 MPa, a joint efficiency of 0.85, and no corrosion allowance.

NOTE The plate thicknesses shown in this table are based on a maximum allowable design stress of 145 MPa, a joint efficiency of 0.85, and no corrosion allowance (see A.4.1).

Table A.4b—Shell-Plate Thicknesses (in.) for Typical Sizes of Tanks with 96-in. Courses (USC)

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10
Tank Height Diameter ft	Tank Height (ft) / Number of Courses in Completed Tank								Maximum Allowable Height for Diameter ^a ft
	8 / 1	16 / 2	24 / 3	32 / 4	40 / 5	48 / 6	56 / 7	64 / 8	
10	3/16	3/16	3/16	3/16	—	—	—	—	—
15	3/16	3/16	3/16	3/16	3/16	—	—	—	—
20	3/16	3/16	3/16	3/16	3/16	3/16	—	—	—
25	3/16	3/16	3/16	3/16	3/16	3/16	0.20	0.23	—
30	3/16	3/16	3/16	3/16	3/16	0.21	0.24	0.28	—
35	3/16	3/16	3/16	3/16	0.20	0.24	0.28	0.33	—
40	3/16	3/16	3/16	3/16	0.23	0.28	0.32	0.37	—
45	3/16	3/16	3/16	0.21	0.26	0.31	0.36	0.42	—
50	1/4	1/4	1/4	0.25	0.29	0.35	0.40	0.46	—
60	1/4	1/4	1/4	0.27	0.34	0.41	0.48	—	58.2
70	1/4	1/4	1/4	0.32	0.40	0.48	—	—	50.0
80	1/4	1/4	0.27	0.37	0.46	—	—	—	43.9
90	1/4	1/4	0.31	0.41	—	—	—	—	39.1
100	1/4	1/4	0.34	0.46	—	—	—	—	35.3
120	5/16	5/16	0.41	—	—	—	—	—	29.6
140	5/16	5/16	0.47	—	—	—	—	—	25.5
160	5/16	0.35	—	—	—	—	—	—	22.5
180	5/16	0.40	—	—	—	—	—	—	20.1
200	5/16	0.44	—	—	—	—	—	—	18.2
220	3/8	0.48	—	—	—	—	—	—	16.6

^a Based on a maximum permissible shell-plate thickness of 1/2 in., a maximum allowable design stress of 21,000 lb/in.², a joint efficiency of 0.85, and no corrosion allowance.

NOTE The plate thicknesses shown in this table are based on a maximum allowable design stress of 21,000 lb/in.², a joint efficiency of 0.85, and no corrosion allowance (see A.4.1).

Table A.3a—Typical Sizes and Corresponding Nominal Capacities (m³) for Tanks with 2400-mm Courses (SI)

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
Tank Diameter m	Capacity per m of Height m ³	Tank Height (m) / Number of Courses in Completed Tank						
		4.8 / 2	7.2 / 3	9.6 / 4	12 / 5	14.4 / 6	16.8 / 7	19.2 / 8
3	7.07	34	51	68	—	—	—	—
4.5	15.9	76	115	153	191	—	—	—
6	28.3	136	204	272	339	407	—	—
7.5	44.2	212	318	424	530	636	742	848
9	63.6	305	458	610	763	916	1,069	1,221
10.5	86.6	416	623	831	1,039	1,247	1,455	1,663
12	113	543	814	1085	1,357	1,629	1,900	2,171
13.5	143	687	1,031	1373	1,718	2,061	2,405	2,748
15	177	848	1,272	1696	2,121	2,545	2,969	3,393
18	254	1,221	1,832	2442	3,054	3,664	4,275	4,358
<i>D = 17</i>								
21	346	1,663	2,494	3323	4,156	4,988	4,763	—
24	452	2,171	3,257	4341	5,429	5,474	<i>D = 19</i>	—
27	573	2,748	4,122	5494	6,871	<i>D = 22</i>	—	—
30	707	3,393	5,089	6782	<i>D = 27</i>	—	—	—
36	1,018	4,886	7,329	8712	—	—	—	—
<i>D = 34</i>								
42	1,385	6,650	9,975	—	—	—	—	—
48	1,810	8,686	11,966	—	—	—	—	—
54	2,290	10,993	<i>D = 46</i>	—	—	—	—	—
60	2,827	13,572	—	—	—	—	—	—
66	3,421	16,422	—	—	—	—	—	—

NOTE The nominal capacities given in this table were calculated using the following formula:

In SI units:

$$C = 0.785D^2H$$

where

C is the capacity of tank, in m³;

D is the diameter of tank, in m (see A.4.1);

H is the height of tank, in m (see A.4.1).

The capacities and diameters in italics (Columns 4 through 9) are the maximums for the tank heights given in the column heads, based on a maximum permissible shell-plate thickness of 13 mm, a maximum allowable design stress of 145 MPa, a joint efficiency of 0.85, and no corrosion allowance (see A.4.1).

Table A.3b—Typical Sizes and Corresponding Nominal Capacities (barrels) for Tanks with 96-in. Courses (USC)

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
Tank Diameter ft	Capacity per ft of Height barrels	Tank Height (ft) / Number of Courses in Completed Tank						
		16 / 2	24 / 3	32 / 4	40 / 5	48 / 6	56 / 7	64 / 8
10	14.0	225	335	450	—	—	—	—
15	31.5	505	755	1,010	1,260	—	—	—
20	56.0	900	1,340	1,790	2,240	2,690	—	—
25	87.4	1,400	2,100	2,800	3,500	4,200	4,900	5,600
30	126	2,020	3,020	4,030	5,040	6,040	7,050	8,060
35	171	2,740	4,110	5,480	6,850	8,230	9,600	10,980
40	224	3,580	5,370	7,160	8,950	10,740	12,540	14,340
45	283	4,530	6,800	9,060	11,340	13,600	15,880	18,140
50	350	5,600	8,400	11,200	14,000	16,800	19,600	22,400
60	504	8,060	12,100	16,130	20,160	24,190	28,220	26,130
<i>D = 54</i>								
70	685	10,960	16,450	21,950	27,440	32,930	30,140	—
80	895	14,320	21,500	28,670	35,840	35,810	<i>D = 62</i>	—
90	1,133	18,130	27,220	36,290	45,360	<i>D = 73</i>	—	—
100	1,399	22,380	33,600	44,800	<i>D = 88</i>	—	—	—
120	2,014	32,250	48,380	54,200	—	—	—	—
<i>D = 110</i>								
140	2,742	43,900	65,860	—	—	—	—	—
160	3,581	57,340	74,600	—	—	—	—	—
180	4,532	72,570	<i>D = 149</i>	—	—	—	—	—
200	5,595	89,600	—	—	—	—	—	—
220	6,770	108,410	—	—	—	—	—	—

NOTE The nominal capacities given in this table were calculated using the following formula:

In USC units:

$$C = 0.14D^2H$$

where

- C* is the capacity of tank, 42-gal barrels;
- D* is the diameter of tank, in ft (see A.4.1);
- H* is the height of tank, in ft (see A.4.1).

The capacities and diameters in italics (Columns 4 through 9) are the maximums for the tank heights given in the column heads, based on a maximum permissible shell-plate thickness of 1/2 in., a maximum allowable design stress of 21,000 lbf/in.², a joint efficiency of 0.85, and no corrosion allowance (see A.4.1).