JRS Presents.....

Minimum Thickness / Remaining Life App

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History with Ohio State University



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The National Board of Boiler and Pressure Vessel Inspectors

Field Aids

	Efficienc Stress V	1 - C	17.	1 114		Sectio	on IIIV	Vess	el																									
	Equation	n used:	t = (P	R) / (S	SE6	(P) of	r P = (SEt) /	(R + .6	ót)			Min tl	iicknes	S:	0.09	(3/32))																
								RESSU																										
t = minimum thickness	50			80																_	_	260							330	340	350	360	370	380
P = internal design pressure	6 0.009			0.014					0.023			0.028			0.033		0.037				0.044	0.046	0.047		0.051				0.058	0.060	0.061	0.063	0.065	0.067
S = max. allowable stress	7 0.010			0.016	0.018	0.020				0.029		0.033			0.039	0.041	0.043	0.045	0.047	0.049	0.051	0.053	0.055	0.057	0.059	0.061	0.063	0.065	0.067	0.070	0.072	0.074	0.076	0.078
R = inside radius of shell	8 0.012 0 0.012			0.019	0.021	0.023	0.026		0.030			0.037	0.040			0.047	0.049	0.051	0.054	0.056	0.058	0.061	0.063	0.065	0.068	0.070	0.072	0.075	0.077	0.079	0.082	0.084	0.086	0.089
E = lowest joint efficiency	9 0.013				0.024											0.053	0.055	0.058	0.060	0.063	0.066	0.068	0.071	0.074	0.076	0.079	0.082	0.084	0.087	0.089				0.100
D_{o}	10 0.015				0.026			0.035		0.041		0.047				0.058	0.061	0.064	0.067	0.070	0.073	0.076	0.079		0.085			0.093					0.108	
D	11 0.016		0.022						0.042	0.045		0.051		0.058	0.061	0.064	0.067	0.071	0.074	0.077	0.080	0.084	0.087		0.093			0.103		0.109			0.119	
D	12 0.018				0.032		0.039	0.042	0.046	0.049	0.053	0.056	0.060	0.063	0.067	0.070	0.074	0.077	0.081	0.084	0.088	_	0.095		0.102			0.112			0.123			
i	13 0.019 14 0.020	0.025	0.027	0.030	0.034	0.038	0.042	0.046	0.049	0.053	0.057	0.061	0.065	0.068	0.072	0.076	0.080	0.084	0.087	0.001			0.103		0.110			0.122						
a a	14 0.020 15 0.022	0.025	0.029	0.035	0.037	0.041	0.043	0.049	0.053	0.057	0.061	0.065	0.070	0.074	0.078	0.082	0.080	0.090		0.098			0.110		0.119		0.127	0.131			0.143			
$-\frac{t_{min}}{m}$	15 0.022 16 0.023	0.020	0.031	0.035	0.039	0.044	0.048	0.055	0.057	0.061	0.000	0.070	0.075	0.079	0.085	0.088	0.092			0.103			0.118					0.140			0.155		0.102	
() // e	10 0.025		0.035			0.047	0.051	0.050	0.065	0.005	0.070	0.075	0.079	0.084	0.089	0.093				0.112			0.120					0.150			0.104			
t	18 0.025			0.040		0.020	0.055	0.063	0.069	0.074	0.079	0.019	0.084	0.005	0.100								0.134		0.153		0.154			0.179				0.200
e	19 0.028			0.042			0.061	0.067	0.000	0.078	0.083	0.084	0.094		0.105		0.117	0.122					0.142		0.161			0.178						
r	20 0.029			0.047			0.064	0.070	0.076			0.093		0.105			0.123				0.146							0.187						
	20 0.025			0.049						0.086									0.141											0.209				
0	22 0.032				0.058				0.084										0.148											0.219			0.238	
f	23 0.034				0.060				0.087								0.141		0.155									0.215			0.235			
	24 0.035			0.056				0.084		0.098		0.112			0.133		0.147	0.154					0.189		0.203	0.210				0.238				-
v	25 0.037	0.044	0.051	0.058	0.066	0.073			0.095	0.102		0.117		-	0.139		0.153						0.197		0.212	0.219		0.234		0.248				0.278
e	26 0.038	0.046	0.053	0.061	0.068	0.076	0.084	0.091		0.106		0.122					0.160				0.190							0.243		0.258		0.273	0.281	0.289
S	27 0.039	0.047	0.055	0.063	0.071	0.079	0.087	0.095		0.110			0.134				0.166		0.181				0.213		0.229	0.237				0.268				0.300
S	28 0.041	0.049	0.057	0.065	0.074	0.082	0.090	0.098	0.106	0.115	0.123	0.131	0.139	0.147	0.155	0.164	0.172	0.180	0.188	0.196	0.205	0.213	0.221	0.229	0.237	0.245	0.254	0.262	0.270	0.278	0.286	0.294	0.303	0.311
e	29 0.042	0.051	0.059	0.068	0.076	0.085	0.093	0.102	0.110	0.119	0.127	0.136	0.144	0.153	0.161	0.169	0.178	0.186	0.195	0.203	0.212	0.220	0.229	0.237	0.246	0.254	0.263	0.271	0.280	0.288	0.297	0.305	0.313	0.322
1	30 0.044	0.053	0.061	0.070	0.079	0.088	0.096	0.105	0.114	0.123	0.131	0.140	0.149	0.158	0.167	0.175	0.184	0.193	0.202	0.210	0.219	0.228	0.237	0.245	0.254	0.263	0.272	0.280	0.289	0.298	0.307	0.316	0.324	0.333
	31 0.045	0.054	0.063	0.072	0.082	0.091	0.100	0.109	0.118	0.127	0.136	0.145	0.154	0.163	0.172	0.181	0.190	0.199	0.208	0.217	0.226	0.235	0.245	0.254	0.263	0.272	0.281	0.290	0.299	0.308	0.317	0.326	0.335	0.344
	32 0.047	0.056	0.065	0.075	0.084	0.093	0.103	0.112	0.122	0.131	0.140	0.150	0.159	0.168	0.178	0.187	0.196	0.206	0.215	0.224	0.234	0.243	0.252	0.262	0.271	0.280	0.290	0.299	0.309	0.318	0.327	0.337	0.346	0.355
	33 0.048	0.058	0.067	0.077	0.087	0.096	0.106	0.116	0.125	0.135	0.145	0.154	0.164	0.174	0.183	0.193	0.202	0.212	0.222	0.231	0.241	0.251	0.260	0.270	0.280	0.289	0.299	0.309	0.318	0.328	0.337	0.347	0.357	0.366
	34 0.050	0.060	0.070	0.079	0.089	0.099	0.109	0.119	0.129	0.139	0.149	0.159	0.169	0.179	0.189	0.199	0.209	0.219	0.228	0.238	0.248	0.258	0.268	0.278	0.288	0.298	0.308	0.318	0.328	0.338	0.348	0.358	0.368	0.377
	35 0.051	0.061	0.072	0.082	0.092	0.102	0.112	0.123	0.133	0.143	0.153	0.164	0.174	0.184	0.194	0.205	0.215	0.225	0.235	0.245	0.256	0.266	0.276	0.286	0.297	0.307	0.317	0.327	0.337	0.348	0.358	0.368	0.378	0.389



Main Screen Functions

📲 Verizon 奈	4:51	PM	1 100% 🔲			
≡	JR	5 🗞	RESET			
Minimum She	ell Thickness (i	<u>n.</u>)				
Minimum Hea	ad Thickness (i	<u>in.</u>)				
-	Type of head	Hemispherical	~			
	Material	Carbon Steel G	Grade 60 🗸 🗸			
		Stress value: 17100				
	MAWP (PSI)					
	Diameter (in.)					
Joint E	Efficiency (%)					
Minimum	Dree		Domaining			
Thickness	Pres Allo		Remaining Life			
7	8	9	ſ			
4	5	6	\checkmark			
1	2	3	CLR			
0	00	•	NEXT			

Example 1 – Routine Air Tank

📲 Verizon 🗢	4:39	PM	┩ 76% 🔲				
	JR	25 🐝 RES					
Minimum She	ell Thickness (i	<u>n.</u>)					
Minimum Hea	ad Thickness (i	i <u>n.</u>)					
-	Type of head	Hemispherical	~				
	Material	Carbon Steel G	Grade 60 🗸				
		Stress value: 17100					
	MAWP (PSI)						
	Diameter (in.)						
Joint E	Efficiency (%)						
Minimum Thickness	Pres Allo		Remaining Life				
7	8	9	ſ				
4	5	6	1				
1	2	3	CLR				
0	00	•	NEXT				

Example 1 – **Entering Actual Thickness**

📲 Verizon 🗢	8:20	AM	A 82% 🔲			
	JR	5 🍣	RESET			
Minimum She	ell Thickness (i	<u>n.</u>)				
			0.118			
Minimum Hea	ad Thickness (i	i <u>n.</u>)				
			0.094			
-	Type of head	Hemispherical	~			
	Material	Carbon Steel G	Grade 60 🗸 🗸			
		Stress value: 17100				
	MAWP (PSI)	200				
I	Diameter (in.)	20				
Joint E	Efficiency (%)	100				
Minimum Thickness	Pres Allo		Remaining Life			
7	8	9	ſ			
4	5	6	\checkmark			
1	2	3	CLR			
0	00	•	NEXT			

Example 1 – Determining **Remaining Life**

📶 Verizon 🗢	8:22	2 AM	1 81% 🔲 '
	JR	5 🐝	RESET
Calculate	d Pressure	Allowed	<u>(PSI)</u>
		337	.945
]
	, ,, .		
*This applicat	tion should not	be used to	increase MAWP
Current Thic	kness of Shell (ir	n.)	.2
Current Thicl	kness of Head (ir	n.)	.2
Minimum Thickness		sure	Remaining Life
7	8	9	<u>↑</u>
4	5	6	↓
1	2	3	CLR
0	00		NEXT

Unique or Irregular vessels

• Cases where vessels are constructed outside of ASME Code Section VIII Div. 1

OR

• They exceed parameters allowed by the code to use the standard formulas. For instance...





Unique or Irregular vessels

(15) UG-32 FORMED HEADS, AND SECTIONS, PRESSURE ON CONCAVE SIDE

(a) The minimum required thickness at the thinnest point after forming²² of ellipsoidal, torispherical, hemispherical, conical, and toriconical heads under pressure on the concave side (plus heads) shall be computed by the appropriate formulas in this paragraph,²³ except as permitted by Mandatory Appendix 32. Heads with bolting flanges shall meet the requirements of UG-35.1. In addition, provision shall be made for any of the loadings listed in UG-22. The provided thickness of the heads shall also meet the requirements of UG-16, except as permitted in Mandatory Appendix 32.

(b) The symbols defined below are used in the formulas of this paragraph:

- D = inside diameter of the head skirt; or inside length of the major axis of an ellipsoidal head; or inside diameter of a conical head at the point under consideration, measured perpendicular to the longitudinal axis
- D_i = inside diameter of the conical portion of a toriconical head at its point of tangency to the knuckle, measured perpendicular to the axis of the cone
- $= D 2r(1 \cos \alpha)$
- E = lowest efficiency of any joint in the head; for hemispherical heads this includes head-to-shell joint; for welded vessels, use the efficiency specified in UW-12
- L = inside spherical or crown radius. The value of L for ellipsoidal heads shall be obtained from Table UG-37.
- P = internal design pressure (see UG-21)
- r = inside knuckle radius

of 0.90D.

(d) Torispherical Heads With $t_s/L \ge 0.002$. The required thickness of a torispherical head for the case in which the knuckle radius is 6% of the inside crown radius and the inside crown radius equals the outside diameter of the skirt [see (i)] shall be determined by

$$t = \frac{0.885PL}{SE - 0.1P}$$
 or $P = \frac{SEt}{0.885L + 0.1t}$ (2)

NOTE: For torispherical heads with $t_s/L < 0.002$, the rules of 1-4(f) shall also be met.

Torispherical heads made of materials having a specified minimum tensile strength exceeding 70,000 psi (485 MPa) shall be designed using a value of S equal to 20,000 psi (138 MPa) at room temperature and reduced in proportion to the reduction in maximum allowable stress values at temperature for the material (see UG-23).

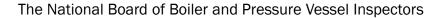
(e) Hemispherical Heads. When the thickness of a hemispherical head does not exceed 0.356L, or P does not exceed 0.665SE, the following formulas shall apply:

$$t = \frac{PL}{2SE - 0.2P} \quad \text{or} \quad P = \frac{2SEt}{L + 0.2t}$$
(3)

(f) Conical Heads and Sections (Without Transition Knuckle). The required thickness of conical heads or conical shell sections that have a half apex-angle α not greater than 30 deg shall be determined by

$$t = \frac{PD}{2\cos \alpha(SE - 0.6P)} \text{ or } P = \frac{2SEt \cos \alpha}{D + 1.2t \cos \alpha}$$
(4)





Example 2 – Irregular Vessels

📲 Verizon 🗢	8:41	AM	1 78% 🔲 '					
≡	JR	5 🍣	RESET					
Minimum She	ell Thickness (i	<u>n.</u>)						
Minimum Hea	ad Thickness (i	i <u>n.</u>)						
	Type of head	Hemispherical	~					
	Material	Carbon Steel G	Grade 60 🗸					
		Stress value: 17100						
	MAWP (PSI)							
	Diameter (in.)							
Joint E	Efficiency (%)	100						
Minimum Thickness	Pres		Remaining Life					
7	8	9	Ŷ					
4	5	6	\checkmark					
1	2	3	CLR					
0	00	•	NEXT					

If the vessel is determined to be below minimum thickness, the app will calculate the MAWP for the thickness provided.

This may be useful if the owner wishes to appeal to the state to use the vessel at a reduced pressure.





Example 3 – **Vessels below Minimum Thickness**

📲 Verizon 🗢	8:50	AM	1 77% 🔲 '			
	JR	5 🍣	RESET			
Minimum She	ell Thickness (i	<u>n.</u>)				
			0.118			
Minimum Hea	ad Thickness (i	i <u>n.</u>)				
			0.094			
-	Type of head	Hemispherical	~			
	Material	Carbon Steel G	Grade 60 🗸 🗸			
		Stress value: 17100				
	MAWP (PSI)	200				
I	Diameter (in.)	20				
Joint E	Efficiency (%)	100				
Minimum Thickness	Pres Allo		Remaining Life			
7	8	9	ſ			
4	5	6	\mathbf{h}			
1	2	3	CLR			
0	00	•	NEXT			

QR Code







The National Board of Boiler and Pressure Vessel Inspectors

Bigger stuff coming.....

POWERED BY NBB SEE YOU IN VEW ORLEANSII