Estimating Wall Thicknesses for Vessels and Piping

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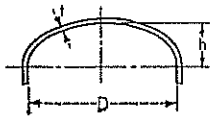
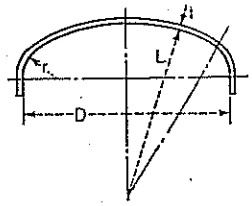
Problem: Given temperature, pressure and dimension of vessel or pipe, estimate the wall thickness.

1. From temperature, determine allowable stress for the material of construction from figure on last page, from Table 10-49 on page 10-110 of Perry's 7th edition, or Table 13.2 T&S.
2. Given the pressure and characteristic dimension of the pipe or vessel, determine the wall thickness:

Description	Wall Thickness	Pressure	Notes
Cylindrical Shell:	$t=\frac{PR}{SE-0.6P}$	$P=\frac{SEt}{R+0.6t}$	Circumferential stress(longitudinal joints) when t does not exceed $0.5R$ or P does not exceed $0.385SE$
Spherical Shell:	$t=\frac{PR}{2SE-0.2P}$	$P=\frac{2SEt}{R+0.2t}$	When t does not exceed $0.356R$ or P does not exceed $0.665SE$
Hemispherical Head:	$t=\frac{PL}{2SE-0.2P}$	$P=\frac{2SEt}{L+0.2t}$	When t does not exceed $0.356L$ or P does not exceed $0.665SE$. L = inside radius.
Ellipsoidal Head: 	$t=\frac{PD}{2SE-0.2P}$	$P=\frac{2SEt}{D+0.2t}$	For semi-ellipsoidal heads in which $h=D/4$.
	$t=\frac{PDK}{2SE-0.2P}$	$P=\frac{SEt}{DK+0.2t}$	For values of D/h from 2 to 6. $K=1/6\times\left[2+(D/2h)^2\right]$
Torispherical Head: 	$t=\frac{0.885PL}{SE-0.1P}$	$P=\frac{SEt}{0.885L+0.1t}$	For standard ASME heads in which min. knuckle radius = 6% of inside crown radius but is not less than $3t$. L must not exceed $D+2t$.
	$t=\frac{PLM}{2SE-0.2P}$	$P=\frac{2SEt}{LM+0.2t}$	For values of L/r from 1 to 16-2/3. $M=(1/4)\left(3+\sqrt{L/r}\right)$ r must be greater of $3t$ and $0.6\times(D+2t)$ L must not exceed $D=2t$
Pipes:	$t=\frac{PD_o}{2(SE+PY)}$	$P=\frac{2tSE}{D_o-2Yt}$	Equation 10-92 on page 10-103 of Perry's 7th.

NOTE: Need to add allowance for corrosion, erosion and any thread or groove depth. For standard corrosion add 2 mm.

Where: t is the shell or head thickness
P is the design pressure
R inside vessel radius for vessels
S allowable stress - see attached figure of Table 13.2 in T&S
D inside diameter of head skirt, or inside length of major axis of an elliptical head.
D_o outside diameter of pipe
h inside depth of an ellipsoidal head
r inside knuckle radius of a torispherical head.
L inside radius of hemispherical head or inside crown radius of a torispherical head.
Y coefficient from Table 10-50 of Perry's for ductile ferrous materials(see below), 0.4 for ductile non-ferrous materials, and zero for brittle materials such as cast iron.
E joint efficiency or quality factor - see Table 10-164 on page 10-109 of Perry's, or Table 13.3 in T&S. This accounts for various types of joint welds. For ideal case, use 1.0.

TABLE 10-50 Values of Coefficient Y When t Is Less Than D/6*

	Temperature, °C (°F)					
Materials	485 (900) and lower	510 (950)	540 (1000)	560 (1050)	595 (1100)	620 (1150) and higher
Ferritic steels	0.4	0.5	0.7	0.7	0.7	0.7
Austenitic steels	0.4	0.4	0.4	0.4	0.5	0.7
Other ductile metals	0.4	0.4	0.4	0.4	0.4	0.4
Cast iron	0.0					

*Extracted from ANSI B31.3—1980, with permission of the publisher, the American Society of Mechanical Engineers, New York.

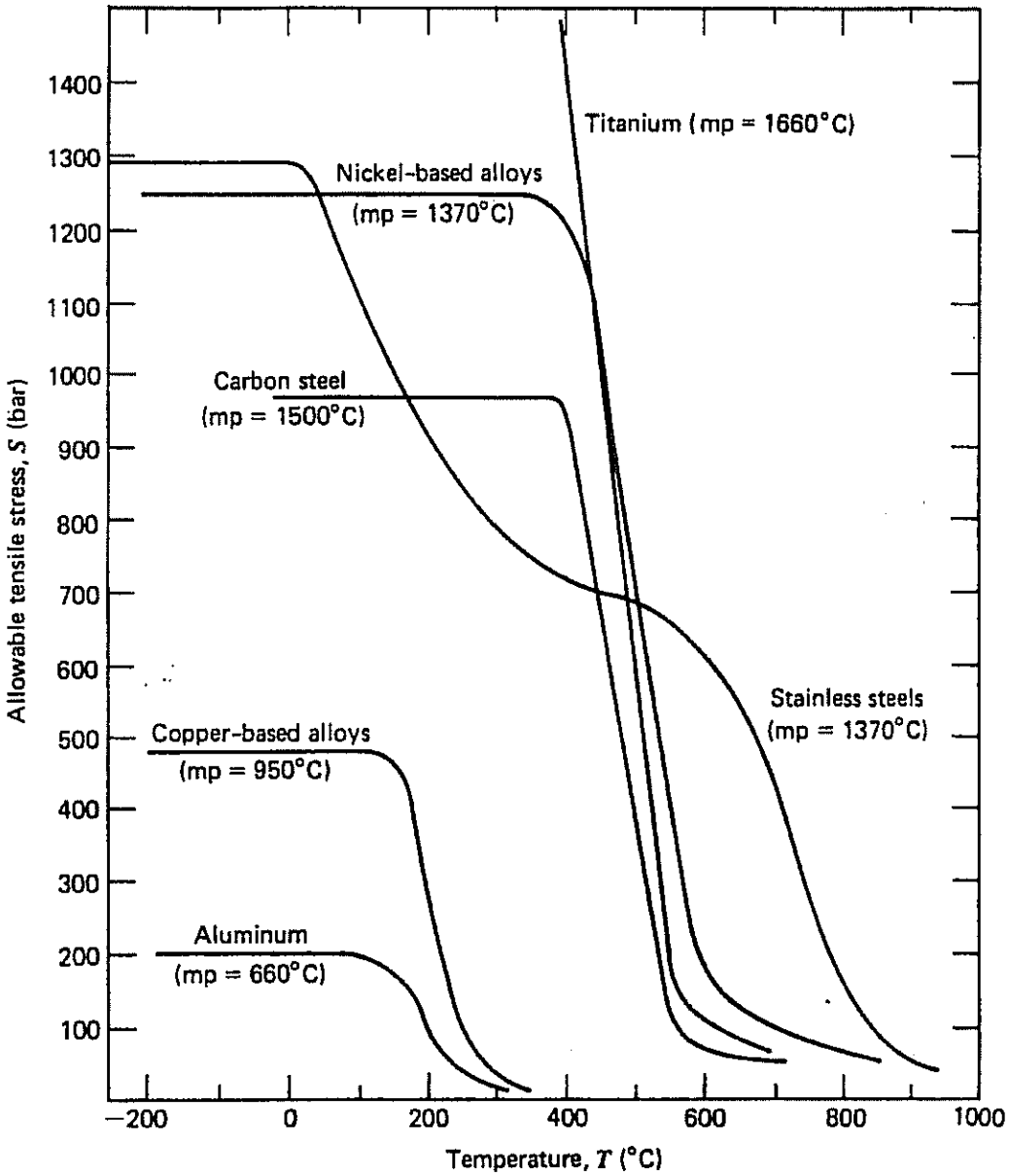


Figure 4-45 Stress-temperature relationships for important process metals and alloys.

Above figure from G. A. Ulrich, *A Guide to Chemical Engineering Process Design and Economics*, Wiley, New York, 1984.

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