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ASME Section VIII - Pressure Vessel Calculations

This ASME Section VIII - Pressure Vessel Calculations contains essential formulas, concepts and terms you'll need for success. Use it as a quick reference while studying and practicing problem-solving. If you're looking for a guided study approach to ensure exam success, explore our tutorial courses and practice exams at **PowerEngineering101.com**

Your success is our mission—let's get started!

ASME Section VIII-1 Pressure Vessel Calculations

Objective 1 Cylindrical shells

The calculations for pressure vessel cylindrical shells are similar to those we have already used in Section I, PG-27.2.2 Piping, Drums, Shells, and Headers. For pressure vessels, the formulas are in paragraph UG-27.

UG-27 Thickness of Shells under Internal Pressure

(a) The minimum required thickness of shells under internal pressure shall not be less than that computed by the following formulas, except as permitted by Mandatory Appendix 1 or Mandatory Appendix 32.

(1) Circumferential Stress (longitudinal joints)[1]
When the thickness does not exceed one half of the inside radius, or P does not exceed 0.385 SE, the following formulas shall apply:

$$t = \frac{PR}{SE - 0.6P} \quad \text{or} \quad P = \frac{SEt}{R + 0.6t}$$

E = joint efficiency for, or the efficiency of, appropriate joint in cylindrical shells, or the efficiency of ligaments between openings, whichever is less.
P = internal design pressure
R = inside radius of the shell course under consideration
S = maximum allowable stress value
t = minimum required thickness of shell

Note: These formulas are based on inside radius. When using outside radius, see Mandatory Appendix 1, Supplementary Design Formulas, para 1-1.

(2) Longitudinal stress (Longitudinal Joints)

[1] In a cylindrical vessel under internal pressure, the stress in the vessel wall acts in two directions: circumferential and longitudinal. For a given internal pressure, the stress is double the longitudinal stress. Therefore, the circumferential stress is the basis for the design formulas.

When the thickness does not exceed one-half of the inside radius, or P does not exceed 1.25SE, the following formulas shall apply:

$$t = \frac{PR}{2SE + 0.4P} \quad \text{or} \quad P = \frac{2SEt}{R - 0.4t}$$

Formulas using outside radius R_0

Appendix 1-1 Thickness of Cylindrical and Spherical Shells

$$t = \frac{PR_0}{SE + 0.4P} \quad \text{or} \quad P = \frac{SEt}{R_0 - 0.4t}$$

Appendix 1-2 Thick shells

(1) Circumferential Stress (Longitudinal Joints).

When the thickness of the cylindrical shell under internal design pressure exceeds one-half of the inside radius, or when P exceeds 0.385SE, the following equations shall apply. These equations may be used in lieu of those given in UG-27(c):

$$t = R\left(\exp\left[\frac{P}{SE}\right] - 1\right) = R_0\left(1 - \exp\left[\frac{-P}{SE}\right]\right)$$

$$P = SE\ \log_e\left(\frac{R + t}{R}\right) = SE\ \log_e\left(\frac{R_0}{R_0 - t}\right)$$

(2) Longitudinal Stress (Circumferential Joints).

When the thickness of the cylindrical shell under internal design pressure exceeds one-half of the inside radius, or when P exceeds 1.25SE, the following equations shall apply:

To find t, thickness

$$t = R\left(Z^{1/2} - 1\right) = R_0\left(\frac{Z^{1/2} - 1}{Z^{1/2}}\right) \text{ where } Z = \left(\frac{P}{SE} + 1\right)$$

To find P, the MAWP

$$P - SE\left(Z - 1\right) \text{ where } Z = \left(\frac{R + t}{R}\right)^2 = \left(\frac{R_0}{R}\right)^2 = \left(\frac{R_0}{R_0 - t}\right)^2$$

Formulas for pressure vessel heads

- Section VIII, UG-32 (c) Ellipsoidal Heads With ts/L ≥ 0.002. The required thickness or pressure of a dished head of semi ellipsoidal form, [in which half the minor axis (inside depth of the head minus the skirt) equals one-fourth of the inside diameter of the head skirt], shall be determined by:

$$t = \frac{PD}{2\,SE - 0.2\,P} \quad \text{or} \quad P = \frac{2\,SEt}{D + 0.2\,t}$$

- Section VIII, UG-32 (d) Torispherical Heads With ts/L ≥ 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 shall be determined by:

$$t = \frac{0.885\,PL}{SE - 0.1\,P} \quad \text{or} \quad P = \frac{SEt}{0.885\,L + 0.1\,t}$$

- Section VIII, UG-32(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:

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

- Appendix 1-3 Spherical Shells (for thick wall, hemispherical heads) When the thickness of a hemispherical head under internal design pressure exceeds 0.356R, use the following equations:

$$t = R\left[\exp\left(\frac{0.50\,P}{SE}\right) - 1\right] = R_0\left[1 - \exp\left(\frac{-0.50\,P}{SE}\right)\right]$$

$$P = 2\,SE\log_e\left(\frac{R + t}{R}\right) = 2\,SE\log_e\left(\frac{R_0}{R_0 - t}\right)$$

Objective 3 Unstayed Flat Heads and Covers UG-34

Section VIII, UG-32 (c) (2) The minimum required thickness of flat unstayed circular heads, covers and blind flanges shall be calculated by the following formula:

$$t = d\sqrt{CP/SE}$$