

Theoretical External Collapse Pressure for Piping (Method is not per ASME.)

Client:	Description:	Prepared By	Date	Rev.
Customer No.:	Item No.:			0
Owner No.:	Dwg. No.:			1
				2
				3
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The user is responsible for verifying that method and results are correct.

This method is not allowed for ASME vessels and pipes, except per ASME BPV Code, UG-28, F.

Method - 1 Theoretical External Pressure for Elastic Collapse:

"Elastic collapse occurs in the elastic region of the material's stress-strain curve. For thin-walled pipes, elastic collapse is the predominate mode of failure (i.e., those pipes with a T/D of 0.10 or less). ..."

Reference paper: Chemical Engineering, April 30, 1984, "Sizing Pipe for External Pressure", by M. Mikasinovic and P. A. Marcucci.

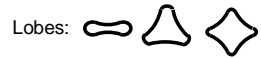
Elastic Collapse pressure given by Von Mises' Equation:

$$P_e = 1/3 [N^2 - 1 + (2N^2 - 1 - \mu) / (N^2 (2L / \pi D)^2 - 1)] (2E / (1 - \mu^2)) (T / D)^3 + (2E / (N^2 - 1)) * T / D / (N^2 (2L / \pi D)^2 + 1)^2 \quad \text{Eq. (1)}$$

Number of lobes, N, created during elastic collapse. Since N is a physical constant, it must be an integer.

Minimum N = 2 (Here, the pipe's cross-section would somewhat resemble a figure-8).

$$N = [(1 - \mu^2) / (3(T/D)^2) (2(\pi D / (2L))^4 - (\pi D / (2L))^2) + 5 (\pi D / (2L))^8 - 3(1 + \mu) (\pi D / (2L))^6]^{1/8} \quad \text{Eq. (11)}$$



This method has the following conditions: N >= 2, L/D <= 15, and 0.005 <= T/D <= 0.10

Design Temperature: 100 F, or 38 C ambient temp. = 70 F, or 21 C

Material data is per ASME B31.3 - 2006, Tables A-1 and A-1A

Example carbon steel pipe per Method 1

Basic allowable stress at design temp: S = 11.3 ksi = 78 MPa

Min. tensile stress, S_t = ...

Elastic modulus at design temp., E = 27.9 Msi = 192364 MPa

Min. yield stress, S_y = 18.0 ksi = 124.1 MPa

Poisson's ratio, μ = 0.300

Outside diameter User-defined D = 16.000 in. = 406.4 mm

Dimension units: Imperial

Nominal thickness User-defined T = 0.160 in. = 4.06 mm

T/D = 0.01 T/D is between 0.005 and 0.10. Thus the pipe shall be considered as thin-walled, and this method may be applied.

External pressure, P = 5.86 bar
85 psi = 586 kPa = 5.98 kg/cm² = 5.86 bar

Safety Factor, F_s = 3.0

L = Distance between stiffening elements (includes flanges, fittings, rings) L = 44.0 in. = 1117.6 mm

Maximum L/D = 15

L/D = 2.75

Calculate N per Eq. (11) above. Then, round N up to the next integer.

N = 3 = the number of lobes created at collapse.

External design pressure, P F_s = P_d = 255.0 psi = 1758 kPa = 17.93 kg/sqcm = 17.58 bar

Theoretical External Collapse Pressure per Eq. (1) above:

P_e = 262 psi = 1805 kPa = 18.4 kg/sqcm = 18.05 bar

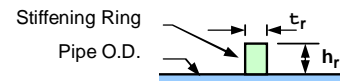
OK. Your external design pressure is less than theoretical collapse pressure.

Calculate stress in pipe at collapse, using a modified hoop stress formula,

$$S = P / (2 (T / D))$$

S = 13 ksi = 90 MPa

Continue below only if your design requires stiffening ring/s.



Stiffening ring may be sized for the above L/D since P_d does not exceed P_e, and L/D does not exceed 15:

Minimum required moment of inertia of stiffening ring, I = 1/28 D³ L P_d / E

I = 0.0588 in⁴ = 24474 mm⁴

Material is like the pipe. Modulus of elasticity, E = 27.9 x 10⁶ psi

Thickness, t_r = 0.500 in. = 12.7 mm

Height, h_r = 1.250 in. = 31.75 mm

Available moment of inertia, I_a = 1/12 t_r h_r³

I_a = 0.0814 in⁴ = 33881 mm⁴

Stiffening ring size is OK.