

Theoretical External Collapsing Pressure for Pipelines (Method is not per ASME.)

Client:	Description:	Prepared By	Date	Rev.
Customer No.:	Item No.:			0
Owner No.:	Dwg. No.:			1
				2
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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 - 2 Theoretical Critical Outer Hydraulic Pressure for *Elastic* and *Plastic* Instability:

This method is per book article by Adam Zanker: "The critical outer pressure that causes collapse of a nonpressurized tubular pipe may be governed by either elastic or plastic instability."

Reference 1: S. C. Haagsma and D. Schaap, "Collapsing of Submarine Lines Studied," Oil Gas J., pp. 87-95 (February 2, 1981).

Reference 2: S. P. Timoshenko and J. M. Gere, "Theory of Elastic Stability", 2nd ed., McGraw-Hill-Kogakusha, Tokyo.

Theoretical Outer Hydraulic Pressure for *Elastic* Instability:

$$P_e = 2E / [(1 - \mu^2) (D/T) ((D/T) - 1)^2] \quad \text{Eq. (1)}$$

Theoretical Outer Hydraulic Pressure for *Plastic* Instability:

$$P_p = 2S_y (T/D) \quad \text{Eq. (2)}$$

where: E = modulus of elasticity of pipe material, (Young's modulus), psi (MPa)

μ = Poisson's ratio

D = pipe outside diameter, in (mm)

T = pipe wall thickness, in. (mm)

S_y = yeild stress, psi (MPa)

Design Temperature: 200 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 2

Basic allowable stress at design temp: S = 8 ksi = 55 MPa

Min. tensile stress, S_t = ...

Elastic modulus (Young's) at design temp., E = 30.0 Msi = 206843 MPa

Min. yield stress, S_y = 12.0 ksi = 82.7 MPa

Poisson's ratio, μ = 0.300

Outside diameter NPS 12 (DN 300)

D = 12.750 in. = 323.85 mm

Dimension units: Imperial

Nominal thickness Sch 40 per ASME B36.10M

T = 0.406 in. = 10.31 mm

External pressure, P = 200 psi

Safety Factor, F_s = 3.0

200 psi = 1379 kPa = 14.06 kg/sqcm = 13.79 bar

External design pressure, $P F_s = P_d =$ 600.0 psi = 4137 kPa = 42.18 kg/sqcm = 41.37 bar

Theoretical Outer Hydraulic Pressure for *Elastic* Instability per Eq. (1) above:

$$P_e = 2E / [(1 - \mu^2) (D/T) ((D/T) - 1)^2] \quad P_e = \underline{\underline{\text{2271 psi = 15660 kPa = 159.69 kg/sqcm = 156.6 bar}}}$$

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

Theoretical Outer Hydraulic Pressure for *Plastic* Instability per Eq. (2) above:

$$P_p = 2S_y (T/D) \quad P_p = \underline{\underline{\text{764 psi = 5269 kPa = 53.73 kg/sqcm = 52.69 bar}}}$$

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

Compare P_e and P_p above.

"Elastic instability becomes dominant for very large values of D/T , i.e., in thin-walled pipes."

$D/T =$ 31