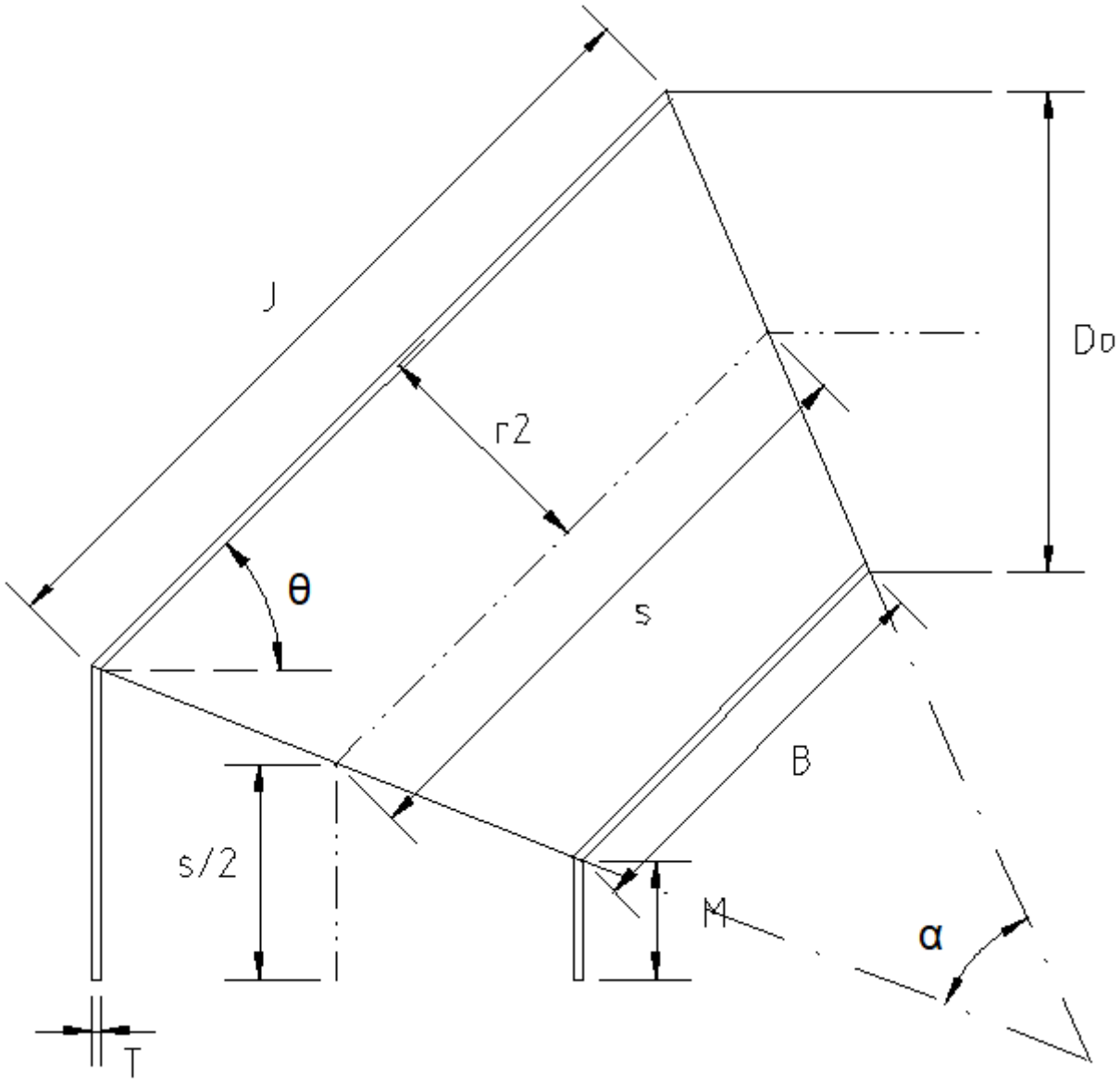
Allowable Pressure for Mitered Elbow

This application calculates the maximum allowable pressure in a mitred elbow. The methodology follows ASME B31.2 - 2019 Processing Piping Code (para 304.2.3).



ASTM A671-CC70, Cl. 12, 22, 32, 42 or 52/A516-70 Carbn Steel Pipe EFW 100%RT
Electric fusion welded pipe, 100% radiographed

Parameters

Design temperature

$T := 100\ \text{degF}$

Allowable stress at design temperature

$S := 23.30\ \text{ksi}$

$St := 70\ \text{ksi}$

$Sy := 38\ \text{ksi}$

Longitudinal weld joint quality

$E := 0.85$

Weld joint strength reduction

$W := 1$

Pipe size

NPS 18 (DN 450) thk = 0.344 in (8.74 mm)

Wall thickness

$T := 0.344\ \text{inch}$

Mech./corrosion allowance

$c := 0\ \text{inch}$

Pipe outsize diameter

$D_o := 18\ \text{inch}$

Pipe nominal thickness

$T_{nom} := 0.344\ \text{inch}$

Mean radius

$$r_2 := \frac{D_o - T_{nom}}{2} = 8.828\ \text{in}$$

Empirical value

$$A := \begin{cases} 1\ \text{inch} & T - c \le 0.5\ \text{inch} \\ 2 \cdot (T - c) & T - c > 0.5\ \text{inch} \ \textbf{and}\ T - c < 0.88\ \text{inch} \\ \frac{2}{3} \cdot \left(T - c\right) + 1.17\ \text{inch} & \text{otherwise} \end{cases}$$

$A = 1\ \text{in}$

Number of miter welds in 90 deg elbow

$N := 2$

Angle of direction change at miter joint $\alpha < 3\text{deg}$ can be treated as a straight line

$\alpha := 45\ \text{deg}$

Angle of miter cut

$\theta := \alpha / 2 = 22.500\ \text{arcdeg}$

Factor for bend radius x nominal size

$f := 1.5$

Bend radius (normally 1.5 x nominal size)

$$R_1 := 1.5 \cdot D_o = 27.000\ \text{in}$$

para 304.2.3

$$Min\_R_1 := \frac{A}{\tan(\theta)} + \frac{D_o}{2} = 11.414\ \text{in}$$

$$check\_1 := \begin{cases} \text{sprintf}\left("\text{Increase radius factor so R1 is at least \%2.3f inches}", \min\left(\frac{Min\_R_1}{\text{inch}}, 2\right)\right) & R_1 < Min\_R_1 \\ \text{"Radius factor is large enough"} & \text{otherwise} \end{cases}$$

check_1 = "Radius factor is large enough"

Long edge length of a segment

$$J := 2 \cdot \left(R_1 + D_o/2\right) \cdot \tan(\theta) = 29.823\ \text{in}$$

Centerline length of a miter segment

$$s := \tan(\theta) \cdot R_1 \cdot 2 = 22.368\ \text{in}$$

Short edge length of a segment

$$B := 2 \cdot \left(R_1 - D_o/2\right) \cdot \tan(\theta) = 14.912\ \text{in}$$

$$check\_2 := \begin{cases} \text{"See welding specialist about B"} & \min(2\text{inch}, 10 \cdot T) > B \\ \text{"B must allow space for good welds"} & \text{otherwise} \end{cases}$$

check_2 = "B must allow space for good welds"

One-half segment length at long edge

$$J/2 = 14.912\ \text{in}$$

One-half segment at centerline

$$s/2 = 11.184\ \text{in}$$

One-half segment length at short edge

$$B/2 = 7.456\ \text{in}$$

Distance the dimension M shall extend below the end of the elbow arc

$$M := \max\left(2.5 \cdot \left(r_2 \cdot T\right)^{\frac{1}{2}}, \tan(\theta) \cdot \left(R_1 - r_2\right)\right) = 7.527\ \text{in}$$

$$M_1 := \max(M - B/2, 0\ \text{inch}) = 0.071\ \text{in}$$

Equation 4a

$$P_{m\_1} := S \cdot E \cdot W \cdot \frac{T - c}{r_2} \cdot \frac{T - c}{T - c + 0.643 \cdot \tan(\theta) \cdot \left(r_2 \cdot (T - c)\right)^{\frac{1}{2}}}$$

$$P_{m\_1} = 328.507\ \text{psi}$$

Equation 4b

$$P_{m\_2} := S \cdot E \cdot W \cdot \frac{T - c}{r_2} \cdot \frac{R_1 - r_2}{R_1 - 0.5 \cdot r_2} = 620.918 \ \frac{lbf}{in^2}$$

$$P_{m\_2} = 620.918 \ psi$$

Equation 4c

$$P_{m\_3} := S \cdot E \cdot W \cdot \frac{T - c}{r_2} \cdot \frac{T - c}{T - c + 1.25 \cdot \tan(\theta) \cdot \left(r_2 \cdot (T - c)\right)^{\frac{1}{2}}}$$

$$P_{m\_3} = 213.016 \ psi$$

Maximum Allowable Internal Pressure

Closely spaced miter elbow

$$\min\left(P_{m\_1}, P_{m\_2}\right) = 328.507 \ \frac{lbf}{in^2}$$

Single miter elbow or widely spaced miter elbow

$$\begin{cases} P_{m\_1} & \theta \leq 22.5 \ arcdeg \\ P_{m\_3} & \text{otherwise} \end{cases} = 328.507 \ \frac{lbf}{in^2}$$