## Caesar II Determines

| | | | |
|---|---|---|---|
| Design Code | ASME B31.4 | Pipeline Material | API 5L Gr. X60 |
| Design Pressure | $P := 4.75MPa$ | Design Temperature | $T_1 := 50\ ^\circ C$ |
| Outside Diameter | $D_o := 914.4mm$ | Wall Thickness | $t_n := 13.7mm$ |
| Young Modulus | $E := 201790MPa$ | Poisson's Ratio | $\nu := 0.3$ |
| Coefficient of Thermal Expansion | $\alpha := 0.000340$ | Axial Force @ node no. 2210 (from C II file) | $F_a := 3760.735kN$ |

### Thermal Force

Inside Diameter $D_i := D_o - 2 \times t_n = 887 \cdot mm$

$Area1 := \frac{\pi}{4} \times \left(D_o^2 - D_i^2\right) = 38765.965 \cdot mm^2$

$Thermal\_Force := E \cdot \alpha \cdot Area1$

$Thermal\_Force = 2659.68 \cdot kN$

### Bourdon Force

$Area2 := \frac{\pi}{4} \times D_i^2 = 617926.928 \cdot mm^2$

$Bourdon\_Force := (1 - 2 \cdot \nu) \times P \times Area2$

$Bourdon\_Force = 1174.06 \cdot kN$

### Determines the stress equation based on

$Limiting\_Force := Thermal\_Force + Bourdon\_Force = 3833.74 \cdot kN$

Delta = Limiting Force + Local Axial Force

$Delta := Limiting\_Force + F_a = 7594.47 \cdot kN$

$$\frac{|Delta|}{|Limiting\_Force|} = 1.981$$

$$Stress\_Equation := \begin{cases} \text{"Fully Restrained"} & \text{if } \frac{|Delta|}{|Limiting\_Force|} \le 0.025 \\ \text{"Unrestrained"} & \text{otherwise} \end{cases}$$

$Stress\_Equation = \text{"Unrestrained"}$

| Node | Axial Stress N./sq.mm. | Bending Stress N./sq.mm. | Torsion Stress N./sq.mm. | Hoop Stress N./sq.mm. | OCTAHEDRAL Stress N./sq.mm. | SIF/Index In-Plane | SIF/Index Out-Plane | Code Stress N./sq.mm. | Allowable Stress N./sq.mm. | Ratio % | Piping Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2162 | -21.26 | 12.94 | 0 | 158.52 | 0 | 1 | 1 | 158.52 | 0 | 0 | B31.4/U |
| 2210 | -21.26 | 12.54 | 0 | 158.52 | 0 | 1 | 1 | 158.52 | 0 | 0 | B31.4/U |
| | | | | | | | | | | | |
| 2210 | -21.3 | 12.54 | 0 | 158.52 | 196.98 | 1 | 1 | 158.52 | 297.85 | 53.22 | B31.4/R |
| 2211 | -21.3 | 4.14 | 0 | 158.52 | 191.04 | 1 | 1 | 158.52 | 297.85 | 53.22 | B31.4/R |

| Node | Axial Force N. | Shear Force N. | Bending Moment N.m. | Torsion Moment N.m. | FX N. | FY N. | FZ N. | MX N.m. | MY N.m. | MZ N.m. | Element Name |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2210 | 3760735 | 17002 | 107846 | -36 | 3760346 | 54304 | -16405 | -506 | -8 | -107845 | |
| 2211 | -3760735 | 17002 | 35633 | 36 | -3760346 | -54304 | 16405 | 191 | -6 | 35633 | |
| | | | | | | | | | | | |
| 2162 | 3759284 | 7828 | 111317 | -36 | 3759005 | 43471 | -16399 | -521 | -10 | -111316 | |
| 2210 | -3759189 | 27808 | 107846 | 36 | -3759005 | -43471 | 16399 | 506 | 8 | 107845 | |