

Caesar II Determines

Design Code	ASME B31.4	Pipeline Material	API 5L Gr. X60
Design Pressure	$P := 4.75 \text{ MPa}$	Design Temperature	$T_{\max} := 50 \text{ }^{\circ}\text{C}$
Outside Diameter	$D_o := 914.4 \text{ mm}$	Wall Thickness	$t_n := 13.7 \text{ mm}$
Young Modulus	$E := 201790 \text{ MPa}$	Poisson's Ratio	$\nu := 0.3$
Coefficient of Thermal Expansion	$\alpha := 0.000340 \cdot \Delta^{\circ}\text{C}^{-1}$	Axial Force (from C II file)	$F_a := 3760.735 \text{ kN}$
Installation Temperature	$T_i := 21 \text{ }^{\circ}\text{C}$		

Thermal Force

$$\text{Inside Diameter } D_i := D_o - 2 \times t_n = 887 \cdot \text{mm}$$
$$\text{Area1} := \frac{\pi}{4} \times (D_o^2 - D_i^2) = 38765.97 \cdot \text{mm}^2$$
$$\text{Thermal_Force} := E \times \alpha \cdot (T_{\max} - T_i) \times \text{Area1}$$
$$\text{Thermal_Force} = 77130.68 \cdot \text{kN}$$

Bourdon Force

$$\text{Area2} := \frac{\pi}{4} \times D_i^2 = 617926.93 \cdot \text{mm}^2$$
$$\text{Bourdon_Force} := (1 - 2 \cdot \nu) \times P \times \text{Area2}$$
$$\text{Bourdon_Force} = 1174.06 \cdot \text{kN}$$

Determines the stress equation based on

$$\text{Limiting_Force} := \text{Thermal_Force} + \text{Bourdon_Force} = 78304.74 \cdot \text{kN}$$

$$\text{Delta} = \text{Limiting Force} + \text{Local Axial Force}$$
$$\text{Delta} := \text{Limiting_Force} + F_a = 82065.48 \cdot \text{kN}$$

$$\frac{|\text{Delta}|}{|\text{Limiting_Force}|} = 1.048$$

$$\text{Stress_Equation} := \begin{cases} \text{"Fully Restrained"} & \text{if } \frac{|\text{Delta}|}{|\text{Limiting_Force}|} \leq 0.025 \\ \text{"Unrestrained"} & \text{otherwise} \end{cases}$$

$$\text{Stress_Equation} = \text{"Unrestrained"}$$

But the C-II output report shows **Fully-Restrained Stress Equation**

Node	Axial Stress N/sq.mm.	Bending Stress N/sq.m m.	Torsion Stress N/sq.mm.	Hoop Stress N/sq.m m.	OCTAHEDRAL Stress N/sq.mm.	SIF/Ind ex In- Plane	SIF/Ind ex Out- Plane	Code Stress N/sq.m m.	Allowabl e Stress N/sq.m m.	Ratio %	Piping Code
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	