Restrained Pipeline Anchor Force with Pressure and Temperature

Axial stress in a fully restrained (buried) pipeline from temperature and internal pressure (Poisson effect), and the force on the anchor at its end.

Method: Axial stress of a fully restrained pipe: σ_L = ν σ_h − EαΔT (thin-wall hoop stress)

Input parameters

Unit system: SI

Parameter	Value	Unit
Pipe outside diameter	323.90	mm
Wall thickness	9.5300	mm
Internal pressure (gauge)	70.000	bar
Temperature rise above the installation temperature	40.000	K
Elastic modulus	203.00	GPa
Thermal expansion coefficient	11.700	µm/(m·K)
Poisson's ratio	0.30000	

Calculated results

Parameter	Value	Unit
Hoop stress	111.96	MPa
Axial stress in the restrained section (negative = compression)	-61.417	MPa
Thermal part of the anchor force	894.18	kN
Pressure part (end cap minus Poisson)	194.78	kN
Anchor force at the end of the restrained section	1,089.0	kN
Steel cross-section	9,412.0	mm²

Notes for this case

• A long buried pipeline is held by the soil and cannot change length. Heating would lengthen it by αΔT and pressure would shorten it by the Poisson effect of the hoop stress (ν σ_h/E), so the axial stress is σ_L = ν σ_h − EαΔT. Where the pipe leaves the ground or turns, the anchor must hold the difference between the restrained pipe and a free pipe: the thermal force A_s EαΔT plus the pressure end force p A_i less the Poisson part ν σ_h A_s. The hoop stress uses the thin-wall formula on the inside diameter.

Formula and method

$$\sigma_h = \frac{pD_i}{2t}, \quad \sigma_L = \nu\sigma_h - E\alpha\Delta T, \quad F = A_s E\alpha\Delta T + pA_i - \nu\sigma_h A_s$$

Variables

D_o	Pipe outside diameter	m
t	Wall thickness	m
p	Internal pressure (gauge)	Pa
ΔT	Temperature rise above the installation temperature	K
E	Elastic modulus	Pa
α	Thermal expansion coefficient	1/K
ν	Poisson's ratio	-
σ_h	Hoop stress	Pa
σ_L	Axial stress in the restrained section (negative = compression)	Pa

F_T	Thermal part of the anchor force	N
F_p	Pressure part (end cap minus Poisson)	N
F	Anchor force at the end of the restrained section	N
A_s	Steel cross-section	m²

Method and standards

Restrained pipe.

Assumptions and limits

- Fully restrained straight pipe; linear elastic; thin-wall hoop stress.

References

Axial stress of a fully restrained pipe: σ_L = ν σ_h − EαΔT (thin-wall hoop stress)

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/mechanical/piping/pipeline-anchor-force-pressure

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Reopens the calculator with the inputs of this report.