Thermal Stress and Force in a Restrained Bar or Pipe

Axial thermal stress and end force in a bar or pipe that is fully restrained while heated or cooled, and the free expansion it would have had.

Method: σ = E α ΔT

Input parameters

Unit system: SI

Parameter	Value	Unit
Young's modulus	200.00	GPa
Mean coefficient of thermal expansion	12.000	µm/(m·K)
Temperature change	100.00	K
Cross-section area of the metal	5,000.0	mm²
Length between restraints	10.000	m
Yield strength at temperature (0 = not checked) Optional: the page warns when the thermal stress exceeds it.	0	MPa

Calculated results

Parameter	Value	Unit
Thermal stress E α ΔT (positive = compressive, from heating; negative = tensile, from cooling)	240.00	MPa
Force on the restraints	1,200.0	kN
Free thermal expansion if unrestrained	12.000	mm

Notes for this case

- Sign: compression is positive (heating) and tension negative (cooling), the reverse of the tension-positive convention.
- Rigid restraints and elastic behaviour; real anchors and supports yield a little, and a long slender member may buckle before reaching this stress.

Formula and method

$$\sigma = E \alpha \Delta T$$
$$F = \sigma A$$
$$\delta = \alpha \Delta T L$$

Variables

E	Young's modulus	Pa
α	coefficient of thermal expansion	1/K
ΔT	temperature change	K
A	metal cross-section	m²
L	length	m
S_y	yield strength at temperature (optional check)	Pa
σ	thermal stress, positive in compression (heating)	Pa
F	force on the restraints	N
δ	free expansion	m

Method and standards

A member prevented from expanding carries the strain it would have had, α ΔT, as elastic strain: stress is E α ΔT, independent of length.

Assumptions and limits

- Fully rigid restraints; elastic material; uniform temperature.
- Sign: σ is positive in compression (heating) and negative in tension (cooling).
- Elastic only: if σ exceeds the yield strength (enter it to be warned), the member yields. Buckling of slender members is not checked.

References

- $\sigma = E \alpha \Delta T$

Report details

Report reference	FCC-ZWQX-N1SH (the same inputs always give the same reference)
Generated	17 November 2026, 19:50 UTC
Calculator	Thermal Stress and Force in a Restrained Bar or Pipe
Method last reviewed	12 November 2026
Software release	FireCAD Calc, release of 17 November 2026
Release checks	3 reference cases of this calculator, computed independently, are checked on every release

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

This calculator online

https://calc.firecad.com/mechanical/strength-of-materials/restrained-thermal-stress

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.