Pipe Thermal Expansion and Offset Leg

Thermal expansion of a pipe run between cold and hot temperatures, and the length of offset leg that absorbs it by the guided-cantilever method.

Method: ASME B31.1 Appendix B (expansion data, input); Guided-cantilever method (M.W. Kellogg, Design of Piping Systems)

Input parameters

Unit system: SI

Parameter	Value	Unit
Length of the pipe run	100.00	m
Mean coefficient of linear expansion Mean value between the two temperatures from your piping code's expansion table (ASME B31.1 Appendix B). Carbon steel is about 12–14 µm/(m·K), austenitic stainless about 17–18.	12.600	µm/(m·K)
Installation (cold) temperature	20.000	°C
Operating (hot) temperature	184.00	°C
Pipe outside diameter (for the leg)	168.30	mm
Modulus of elasticity Carbon steel about 200 000 MPa cold; your code may ask for the cold or the hot value.	200,000	MPa
Allowable expansion stress range From your piping code for the material and temperatures (ASME B31.1 §102.3.2). Enter the code value.	150.00	MPa

Calculated results

Parameter	Value	Unit
Thermal expansion of the run	206.64	mm
Offset leg to absorb it (guided cantilever)	11.794	m
Expansion per unit length	0.002066	

Formula and method

$$\Delta L = \alpha\, L\, (T_h - T_c) \qquad L_o = \sqrt{\frac{3\, E\, D_o\, \Delta L}{S_A}}$$

Variables

L	length of the pipe run	m
α	mean coefficient of linear expansion	1/K
T_c	installation (cold) temperature	K
T_h	operating (hot) temperature	K
D_o	pipe outside diameter	m
E	modulus of elasticity	Pa
S_A	allowable expansion stress range	Pa
ΔL	thermal expansion of the run	m
L_o	offset leg to absorb it	m
$\Delta L / L$	expansion per unit length	–

Method and standards

Linear thermal expansion with a mean coefficient between the two temperatures, taken from the expansion table of your piping code (ASME B31.1 Appendix B). The offset leg follows the guided-cantilever method of M.W. Kellogg (Design of Piping Systems): a

leg fixed at both ends, bent by a lateral movement ΔL, has a bending stress 3·E·D·ΔL/L².

Assumptions and limits

- The guided-cantilever method is conservative and ignores the flexibility of bends and of the run itself.
- Stress intensification at fittings, sustained loads and anchor forces are not checked.
- Allowable stress range and modulus are your code values.
- A cold service (T_h below T_c) gives a negative ΔL (contraction); the leg uses the magnitude |ΔL|.

References

• ASME B31.1 Appendix B (expansion data, input)
• Guided-cantilever method (M.W. Kellogg, Design of Piping Systems)

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

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Reopens the calculator with the inputs of this report.