Important Thermal Stress Formulas PDF

Formulas
Examples
with Units

List of 18
Important Thermal Stress Formulas

1) Actual Stress and Strain Formulas

1.1) Actual Expansion when Support Yields Formula

Evaluate Formula

Formula

$$AE = \alpha_L \cdot L_{bar} \cdot \Delta T - \delta$$

Example with Units

$$6\,\text{mm} = 0.0005\,\text{K}^{-1} \cdot 2000\,\text{mm} \cdot 10\,\text{K} - 4\,\text{mm}$$

1.2) Actual Strain given Support Yields for Value of Actual Expansion Formula

Evaluate Formula

Formula

$$\varepsilon_A = \frac{AE}{L_{bar}}$$

Example with Units

$$0.003 = \frac{6\,\text{mm}}{2000\,\text{mm}}$$

1.3) Actual Strain when Support Yields Formula

Evaluate Formula

Formula

$$\varepsilon_A = \frac{\alpha_L \cdot \Delta T \cdot L_{bar} - \delta}{L_{bar}}$$

Example with Units

$$0.003 = \frac{0.0005\,\text{K}^{-1} \cdot 10\,\text{K} \cdot 2000\,\text{mm} - 4\,\text{mm}}{2000\,\text{mm}}$$

1.4) Actual Stress given Support Yields for Value of Actual Strain Formula

Evaluate Formula

Formula

$$\sigma_{a'} = \varepsilon_A \cdot E_{bar}$$

Example with Units

$$0.693\,\text{MPa} = 0.0033 \cdot 210\,\text{MPa}$$

1.5) Actual Stress when Support Yields Formula

Evaluate Formula

Formula

$$\sigma_{a'} = \frac{\left(\alpha_L \cdot \Delta T \cdot L_{bar} - \delta\right) \cdot E_{bar}}{L_{bar}}$$

Example with Units

$$0.63\,\text{MPa} = \frac{\left(0.0005\,\text{K}^{-1} \cdot 10\,\text{K} \cdot 2000\,\text{mm} - 4\,\text{mm}\right) \cdot 210\,\text{MPa}}{2000\,\text{mm}}$$

2) Thermal Stress and Strain Formulas

2.1) Extension of Rod if Rod is Free to Extend Formula

Evaluate Formula

Formula

$$\Delta L_{Bar} = l_0 \cdot \alpha_T \cdot \Delta T_{rise}$$

Example with Units

$$7.225\,\mathrm{mm} = 5000\,\mathrm{mm} \cdot 17\mathrm{E}{-6}\,{}^{\circ}\mathrm{C}^{-1} \cdot 85\,\mathrm{K}$$

2.2) Thermal Strain Formula

Evaluate Formula

Formula

$$\varepsilon = \frac{\Delta L}{l_0}$$

Example with Units

$$0.2 = \frac{1000\,\mathrm{mm}}{5000\,\mathrm{mm}}$$

2.3) Thermal Strain given Coefficient of Linear Expansion Formula

Evaluate Formula

Formula

$$\varepsilon_c = \alpha_L \cdot \Delta T_{rise}$$

Example with Units

$$0.0425 = 0.0005\,\mathrm{K}^{-1} \cdot 85\,\mathrm{K}$$

2.4) Thermal Strain given Thermal Stress Formula

Evaluate Formula

Formula

$$\varepsilon_s = \frac{\sigma_{th}}{E}$$

Example with Units

$$0.4348 = \frac{0.01\,\mathrm{MPa}}{0.023\,\mathrm{MPa}}$$

2.5) Thermal Stress given Coefficient of Linear Expansion Formula

Evaluate Formula

Formula

$$\sigma_c = \alpha_L \cdot \Delta T_{rise} \cdot E$$

Example with Units

$$0.001\,\mathrm{MPa} = 0.0005\,\mathrm{K}^{-1} \cdot 85\,\mathrm{K} \cdot 0.023\,\mathrm{MPa}$$

2.6) Thermal Stress given Thermal Strain Formula

Evaluate Formula

Formula

$$\sigma_s = \varepsilon \cdot E$$

Example with Units

$$0.0046\,\mathrm{MPa} = 0.2 \cdot 0.023\,\mathrm{MPa}$$

3) Thermal Stress in Composite Bars Formulas

3.1) Actual Expansion of Copper Formula

Evaluate Formula

Formula

$$AE_c = \alpha_T \cdot \Delta T_{rise} \cdot L_{bar} - \frac{\sigma_{c'}}{E} \cdot L_{bar}$$

Example with Units

$$-434779.7187\,\mathrm{mm} = 17\mathrm{E}{-6}\,{}^{\circ}\mathrm{C}^{-1} \cdot 85\,\mathrm{K} \cdot 2000\,\mathrm{mm} - \frac{5\,\mathrm{MPa}}{0.023\,\mathrm{MPa}} \cdot 2000\,\mathrm{mm}$$

3.2) Actual Expansion of Steel Formula

Evaluate Formula

Formula

$$L = \alpha_T \cdot \Delta T_{rise} \cdot L_{bar} + \frac{\sigma_t}{E} \cdot L_{bar}$$

Example with Units

$$15046.3683\,\text{mm} = 17\text{E-}6\,{}^\circ\text{C}^{-1} \cdot 85\,\text{K} \cdot 2000\,\text{mm} + \frac{0.173000\,\text{MPa}}{0.023\,\text{MPa}} \cdot 2000\,\text{mm}$$

3.3) Contraction due to Compressive Stress Induced in Brass Formula

Evaluate Formula

Formula

$$L_c = \frac{\sigma_{c'}}{E} \cdot L_{bar}$$

Example with Units

$$434782.6087\,\text{mm} = \frac{5\,\text{MPa}}{0.023\,\text{MPa}} \cdot 2000\,\text{mm}$$

3.4) Expansion due to tensile stress in steel Formula

Evaluate Formula

Formula

$$\alpha_s = \frac{\sigma}{E} \cdot L_{bar}$$

Example with Units

$$1043.4783\,\text{mm} = \frac{0.012\,\text{MPa}}{0.023\,\text{MPa}} \cdot 2000\,\text{mm}$$

3.5) Free Expansion of Copper Formula

Evaluate Formula

Formula

$$\Delta L_{cu} = \alpha_T \cdot \Delta T_{rise} \cdot L_{bar}$$

Example with Units

$$2.89\,\text{mm} = 17\text{E-}6\,{}^\circ\text{C}^{-1} \cdot 85\,\text{K} \cdot 2000\,\text{mm}$$

3.6) Free Expansion of Steel Formula

Evaluate Formula

Formula

$$\Delta L_s = \alpha_T \cdot \Delta T_{rise} \cdot L_{bar}$$

Example with Units

$$2.89\,\text{mm} = 17\text{E-}6\,{}^\circ\text{C}^{-1} \cdot 85\,\text{K} \cdot 2000\,\text{mm}$$

3.7) Load on Brass or Steel Formula

Evaluate Formula

Formula

$$W_{load} = \sigma \cdot A$$

Example with Units

$$0.768\,\text{kN} = 0.012\,\text{MPa} \cdot 64000\,\text{mm}^2$$

Variables used in list of Thermal Stress Formulas above

- **A** Cross Sectional Area of Bar *(Square Millimeter)*
- **AE** Actual Expansion *(Millimeter)*
- AE_c Actual Expansion of Copper *(Millimeter)*
- **E** Young's Modulus Bar *(Megapascal)*
- E_{bar} Modulus of Elasticity of Bar *(Megapascal)*
- **L** Actual Expansion of Steel *(Millimeter)*
- l_0 Initial Length *(Millimeter)*
- L_{bar} Length of Bar *(Millimeter)*
- L_c Contraction Due to Compressive Stress in Brass *(Millimeter)*
- W_{load} Load *(Kilonewton)*
- α_L Coefficient of Linear Expansion *(Per Kelvin)*
- α_s Expansion of Steel under Tensile Stress *(Millimeter)*
- α_T Coefficient of Thermal Expansion *(Per Degree Celsius)*
- δ Yield Amount (Length) *(Millimeter)*
- ΔL Prevented Extension *(Millimeter)*
- ΔL_{Bar} Increase in Bar Length *(Millimeter)*
- ΔL_{cu} Free Expansion of Copper *(Millimeter)*
- ΔL_s Free Expansion of Steel *(Millimeter)*
- ΔT Change in Temperature *(Kelvin)*
- ΔT_{rise} Temperature Rise *(Kelvin)*
- ε Thermal Strain
- ε_A Actual Strain
- ε_c Thermal Strain given Coef. of Linear Expansion
- ε_s Thermal Strain given Thermal Stress
- σ Stress in Bar *(Megapascal)*
- σ_a' Actual Stress With Support Yield *(Megapascal)*
- σ_c Thermal Stress given Coef. of Linear Expansion *(Megapascal)*
- σ_c' Compressive Stress on Bar *(Megapascal)*

Constants, Functions, Measurements used in list of Thermal Stress Formulas above

- Measurement: **Length** in Millimeter (mm)
  Length Unit Conversion
- Measurement: **Area** in Square Millimeter (mm²)
  Area Unit Conversion
- Measurement: **Pressure** in Megapascal (MPa)
  Pressure Unit Conversion
- Measurement: **Force** in Kilonewton (kN)
  Force Unit Conversion
- Measurement: **Temperature Difference** in Kelvin (K)
  Temperature Difference Unit Conversion
- Measurement: **Temperature Coefficient of Resistance** in Per Degree Celsius ($°C^{-1}$)
  Temperature Coefficient of Resistance Unit Conversion
- Measurement: **Coefficient of Linear Expansion** in Per Kelvin (K^{-1})
  Coefficient of Linear Expansion Unit Conversion
- Measurement: **Stress** in Megapascal (MPa)
  Stress Unit Conversion

- σ_s Thermal Stress Given Thermal Strain *(Megapascal)*
- σ_t Tensile Stress *(Megapascal)*
- σ_{th} Thermal Stress *(Megapascal)*

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