Important Jacketed Reaction Vessel Formulas PDF

Formulas
Examples
with Units

List of 21
Important Jacketed Reaction Vessel Formulas

1) Channel Jacket Thickness Formula

Evaluate Formula

Formula

$$t_c = d \cdot \left(\sqrt{\frac{0.12 \cdot p_j}{f_j}} \right) + c$$

Example with Units

$$11.2409\,\text{mm} = 72.3\,\text{mm} \cdot \left(\sqrt{\frac{0.12 \cdot 0.105\,\text{N/mm}^2}{120\,\text{N/mm}^2}} \right) + 10.5\,\text{mm}$$

2) Combined Moment of Inertia of Shell and Stiffener per Unit Length Formula

Evaluate Formula

Formula

$$I_{required} = \frac{D_o^{\,2} \cdot L_{eff} \cdot \left(t_{jacketedreaction} + \frac{A_s}{L_{eff}} \right) \cdot f_j}{12 \cdot E}$$

Example with Units

$$1.2E{+}14\,\text{mm}^4\text{/mm} = \frac{550\,\text{mm}^{\,2} \cdot 330\,\text{mm} \cdot \left(15\,\text{mm} + \frac{1640\,\text{mm}^2}{330\,\text{mm}} \right) \cdot 120\,\text{N/mm}^2}{12 \cdot 170000\,\text{N/mm}^2}$$

3) Cross Sectional Area of Stiffening Ring Formula

Evaluate Formula

Formula

$$A_s = W_s \cdot T_s$$

Example with Units

$$1640\,\text{mm}^2 = 40\,\text{mm} \cdot 41\,\text{mm}$$

4) Depth of Torisperical Head Formula

Evaluate Formula

Formula

$$h_o = R_c - \sqrt{\left(R_c - \frac{D_o}{2} \right) \cdot \left(R_c + \frac{D_o}{2} - 2 \cdot R_k \right)}$$

Example with Units

$$73.1009\,\text{mm} = 1401\,\text{mm} - \sqrt{\left(1401\,\text{mm} - \frac{550\,\text{mm}}{2} \right) \cdot \left(1401\,\text{mm} + \frac{550\,\text{mm}}{2} - 2 \cdot 55\,\text{mm} \right)}$$

5) Design of Shell Thickness Subjected to Internal Pressure Formula

Evaluate Formula

Formula

$$t_{jacketedreaction} = \frac{p \cdot D_i}{\left(2 \cdot f_j \cdot J \right) - \left(p \right)} + c$$

Example with Units

$$14.3333\,\text{mm} = \frac{0.52\,\text{N/mm}^2 \cdot 1500\,\text{mm}}{\left(2 \cdot 120\,\text{N/mm}^2 \cdot 0.85 \right) - \left(0.52\,\text{N/mm}^2 \right)} + 10.5\,\text{mm}$$

6) Dished Head Thickness Formula

Evaluate Formula

Formula

$$t_{hdished} = \left(\frac{p \cdot R_c \cdot W}{2 \cdot f_j \cdot J} \right) + c$$

Example with Units

$$81.9235\,\text{mm} = \left(\frac{0.52\,\text{N/mm}^2 \cdot 1401\,\text{mm} \cdot 20}{2 \cdot 120\,\text{N/mm}^2 \cdot 0.85} \right) + 10.5\,\text{mm}$$

7) Jacket Width Formula

Evaluate Formula

Formula

$$w_j = \frac{D_{ij} - OD_{Vessel}}{2}$$

Example with Units

$$50\,\text{mm} = \frac{1100\,\text{mm} - 1000\,\text{mm}}{2}$$

8) Length of Shell for Jacket Formula

Evaluate Formula

Formula

$$L_{jacket} = L_s + \frac{1}{3} \cdot h_o$$

Example with Units

$$520.3333\,\text{mm} = 497\,\text{mm} + \frac{1}{3} \cdot 70\,\text{mm}$$

9) Length of Shell under Combined Moment of Inertia Formula

Evaluate Formula

Formula

$$L = 1.1 \cdot \sqrt{D_o \cdot t_{vessel}}$$

Example with Units

$$89.3644\,\text{mm} = 1.1 \cdot \sqrt{550\,\text{mm} \cdot 12\,\text{mm}}$$

10) Maximum Axial Stress in Coil at Junction with Shell Formula

Evaluate Formula

Formula

$$f_{ac} = \frac{p_j \cdot d_i}{\left(4 \cdot t_{coil} \cdot J_{coil}\right) + \left(2.5 \cdot t \cdot J\right)}$$

Example with Units

$$0.0125\,\text{N/mm²} = \frac{0.105\,\text{N/mm²} \cdot 54\,\text{mm}}{\left(4 \cdot 11.2\,\text{mm} \cdot 0.6\right) + \left(2.5 \cdot 200\,\text{mm} \cdot 0.85\right)}$$

11) Maximum Equivalent Stress at Junction with Shell Formula

Evaluate Formula

Formula

$$f_e = \left(\sqrt{\left(f_{as}\right)^2 + \left(f_{cs}\right)^2 + \left(f_{cc}\right)^2 - \left(\left(f_{as} \cdot f_{cs}\right) + \left(f_{as} \cdot f_{cc}\right) + \left(f_{cc} \cdot f_{cs}\right)\right)}\right)$$

Example with Units

$$2.0057\,\text{N/mm²} = \left(\sqrt{\left(1.20\,\text{N/mm²}\right)^2 + \left(2.70\,\text{N/mm²}\right)^2 + \left(0.421875\,\text{N/mm²}\right)^2 - \left(\left(1.20\,\text{N/mm²} \cdot 2.70\,\text{N/mm²}\right) + \left(1.20\,\text{N/mm²} \cdot 0.421875\,\text{N/mm²}\right) + \left(0.421875\,\text{N/mm²} \cdot 2.70\,\text{N/m}\right.\right.$$

12) Maximum Hoop Stress in Coil at Junction with Shell Formula

Evaluate Formula

Formula

$$f_{cc} = \frac{p_j \cdot d_i}{2 \cdot t_{coil} \cdot J_{coil}}$$

Example with Units

$$0.4219\,\text{N/mm²} = \frac{0.105\,\text{N/mm²} \cdot 54\,\text{mm}}{2 \cdot 11.2\,\text{mm} \cdot 0.6}$$

13) Required Plate Thickness for Dimple Jacket Formula

Evaluate Formula

Formula

$$t_{j\,(minimum)} = \text{Maximum}_{Pitch} \cdot \sqrt{\frac{p_j}{3 \cdot f_j}}$$

Example with Units

$$0.1537\,\text{mm} = 9\,\text{mm} \cdot \sqrt{\frac{0.105\,\text{N/mm²}}{3 \cdot 120\,\text{N/mm²}}}$$

14) Required Thickness for Jacket Closer Member with Jacket Width Formula

Evaluate Formula

Formula

$$t_{rc} = 0.886 \cdot w_j \cdot \sqrt{\frac{p_j}{f_j}}$$

Example with Units

$$1.3104\,\text{mm} = 0.886 \cdot 50\,\text{mm} \cdot \sqrt{\frac{0.105\,\text{N/mm²}}{120\,\text{N/mm²}}}$$

15) Shell Thickness for Critical External Pressure Formula

Evaluate Formula

Formula

$$p_c = \frac{2.42 \cdot E}{\left(1 - \left(u\right)^2\right)^{\frac{3}{4}}} \cdot \left(\frac{\left(\frac{t_{vessel}}{D_o}\right)^{\frac{5}{2}}}{\left(\frac{L}{D_o}\right) - 0.45 \cdot \left(\frac{t_{vessel}}{D_o}\right)^{\frac{1}{2}}}\right)$$

Example with Units

$$319.5295\,\text{N/mm²} = \frac{2.42 \cdot 170000\,\text{N/mm²}}{\left(1 - \left(0.3\right)^2\right)^{\frac{3}{4}}} \cdot \left(\frac{\left(\frac{12\,\text{mm}}{550\,\text{mm}}\right)^{\frac{5}{2}}}{\left(\frac{90\,\text{mm}}{550\,\text{mm}}\right) - 0.45 \cdot \left(\frac{12\,\text{mm}}{550\,\text{mm}}\right)^{\frac{1}{2}}}\right)$$

16) Thickness of Bottom Head subjected to Pressure Formula

Evaluate Formula

Formula

$$t_h = 4.4 \cdot R_c \cdot \left(3 \cdot \left(1 - \left(u\right)^2\right)\right)^{\frac{1}{4}} \cdot \sqrt{\frac{p}{2 \cdot E}}$$

Example with Units

$$9.7993\,\text{mm} = 4.4 \cdot 1401\,\text{mm} \cdot \left(3 \cdot \left(1 - \left(0.3\right)^2\right)\right)^{\frac{1}{4}} \cdot \sqrt{\frac{0.52\,\text{N/mm²}}{2 \cdot 170000\,\text{N/mm²}}}$$

17) Thickness of Half Coil Jacket Formula

Evaluate Formula

Formula

$$t_{coil} = \frac{p_j \cdot d_i}{\left(2 \cdot f_j \cdot J\right)} + c$$

Example with Units

$$10.5278\,\text{mm} = \frac{0.105\,\text{N/mm²} \cdot 54\,\text{mm}}{\left(2 \cdot 120\,\text{N/mm²} \cdot 0.85\right)} + 10.5\,\text{mm}$$

18) Thickness of Jacket Shell for Internal Pressure Formula

Evaluate Formula

Formula

$$t_{rj} = \frac{p_j \cdot D_i}{\left(2 \cdot f_j \cdot J\right) - p_j}$$

Example with Units

$$0.7725\,\text{mm} = \frac{0.105\,\text{N/mm²} \cdot 1500\,\text{mm}}{\left(2 \cdot 120\,\text{N/mm²} \cdot 0.85\right) - 0.105\,\text{N/mm²}}$$

19) Total Axial Stress in Vessel Shell Formula

Evaluate Formula

Formula

$$f_{as} = \left(\frac{p \cdot D_i}{4 \cdot t \cdot J}\right) + \left(\frac{p_j \cdot d_i}{2 \cdot t \cdot J}\right) + \frac{2 \cdot \Delta p \cdot \left(d_o\right)^2}{3 \cdot t^2}$$

Example with Units

$$1.1885\,\text{N/mm}^2 = \left(\frac{0.52\,\text{N/mm}^2 \cdot 1500\,\text{mm}}{4 \cdot 200\,\text{mm} \cdot 0.85}\right) + \left(\frac{0.105\,\text{N/mm}^2 \cdot 54\,\text{mm}}{2 \cdot 200\,\text{mm} \cdot 0.85}\right) + \frac{2 \cdot 0.4\,\text{N/mm}^2 \cdot \left(61\,\text{mm}\right)^2}{3 \cdot 200\,\text{mm}^2}$$

20) Total Hoop Stress in Shell Formula

Evaluate Formula

Formula

$$f_{cs} = \frac{p_{shell} \cdot D_i}{2 \cdot t \cdot J} + \frac{p_j \cdot d_i}{\left(4 \cdot t_{coil} \cdot J_{coil}\right) + \left(2.5 \cdot t \cdot J\right)}$$

Example with Units

$$2.7037\,\text{N/mm}^2 = \frac{0.61\,\text{N/mm}^2 \cdot 1500\,\text{mm}}{2 \cdot 200\,\text{mm} \cdot 0.85} + \frac{0.105\,\text{N/mm}^2 \cdot 54\,\text{mm}}{\left(4 \cdot 11.2\,\text{mm} \cdot 0.6\right) + \left(2.5 \cdot 200\,\text{mm} \cdot 0.85\right)}$$

21) Vessel Wall Thickness for Channel Type Jacket Formula

Evaluate Formula

Formula

$$t_{vessel} = d \cdot \sqrt{\frac{0.167 \cdot p_j}{f_j}} + c$$

Example with Units

$$11.374\,\text{mm} = 72.3\,\text{mm} \cdot \sqrt{\frac{0.167 \cdot 0.105\,\text{N/mm}^2}{120\,\text{N/mm}^2}} + 10.5\,\text{mm}$$

Variables used in list of Jacketed Reaction Vessel Formulas above

- A_s Cross Sectional Area of Stiffening Ring *(Square Millimeter)*
- **c** Corrosion Allowance *(Millimeter)*
- **d** Design Length of Channel Section *(Millimeter)*
- d_i Internal Diameter of Half Coil *(Millimeter)*
- D_i Internal Diameter of Shell *(Millimeter)*
- D_{ij} Inside Diameter of Jacket *(Millimeter)*
- d_o Outer Diameter of Half Coil *(Millimeter)*
- D_o Vessel Shell Outer Diameter *(Millimeter)*
- **E** Modulus of Elasticity Jacketed Reaction Vessel *(Newton per Square Millimeter)*
- f_{ac} Maximum Axial Stress in Coil at Junction *(Newton per Square Millimeter)*
- f_{as} Total Axial Stress *(Newton per Square Millimeter)*
- f_{cc} Maximum Hoop Stress in Coil at Junction with Shell *(Newton per Square Millimeter)*
- f_{cs} Total Hoop Stress *(Newton per Square Millimeter)*
- f_e Maximum Equivalent Stress at Junction with Shell *(Newton per Square Millimeter)*
- f_j Allowable Stress for Jacket Material *(Newton per Square Millimeter)*
- h_o Depth of Head *(Millimeter)*
- $I_{required}$ Combined Moment of Inertia of Shell and Stiffener *(Millimeter⁴ per Millimeter)*
- **J** Joint Efficiency for Shell
- J_{coil} Weld Joint Efficiency Factor for Coil
- **L** Length of Shell *(Millimeter)*
- L_{eff} Effective Length Between Stiffeners *(Millimeter)*
- L_{jacket} Length of Shell for Jacket *(Millimeter)*
- L_s Length of Straight Side Jacket *(Millimeter)*
- $Maximum_{Pitch}$ Maximum Pitch between Steam Weld Centre Lines *(Millimeter)*
- OD_{Vessel} Outer Diameter of Vessel *(Millimeter)*
- **p** Internal Pressure in Vessel *(Newton per Square Millimeter)*
- p_c Critical External Pressure *(Newton per Square Millimeter)*
- p_j Design Jacket Pressure *(Newton per Square Millimeter)*
- p_{shell} Design Pressure Shell *(Newton per Square Millimeter)*
- R_c Crown Radius for Jacketed Reaction Vessel *(Millimeter)*
- R_k Knuckle Radius *(Millimeter)*
- **t** Shell Thickness *(Millimeter)*
- t_c Channel Wall Thickness *(Millimeter)*
- t_{coil} Thickness of Half Coil Jacket *(Millimeter)*
- t_h Head Thickness *(Millimeter)*
- $t_{hdished}$ Dished Head Thickness *(Millimeter)*
- $t_{j\ (minimum)}$ Required Thickness of Dimple Jacket *(Millimeter)*
- $t_{jacketedreaction}$ Shell Thickness for Jackted Reaction Vessel *(Millimeter)*
- t_{rc} Required Thickness for Jacket Closer Member *(Millimeter)*
- t_{rj} Required Thickness of Jacket *(Millimeter)*
- T_s Thickness of Stiffener *(Millimeter)*
- t_{vessel} Vessel Thickness *(Millimeter)*
- **u** Poisson Ratio
- **W** Stress Intensification Factor
- w_j Jacket Width *(Millimeter)*

Constants, Functions, Measurements used in list of Jacketed Reaction Vessel Formulas above

- Functions: **sqrt**, sqrt(Number)
  A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.
- Measurement: **Length** in Millimeter (mm)
  Length Unit Conversion
- Measurement: **Area** in Square Millimeter (mm²)
  Area Unit Conversion
- Measurement: **Pressure** in Newton per Square Millimeter (N/mm²)
  Pressure Unit Conversion
- Measurement: **Moment of Inertia per Unit Length** in Millimeter⁴ per Millimeter (mm⁴/mm)
  Moment of Inertia per Unit Length Unit Conversion
- Measurement: **Stress** in Newton per Square Millimeter (N/mm²)
  Stress Unit Conversion

- W_s Width of Stiffener *(Millimeter)*
- Δp Maximum difference between Coil and Shell Pressure *(Newton per Square Millimeter)*

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