Important Boiling Formulas PDF

Formulas
Examples
with Units

List of 13
Important Boiling Formulas

1) Convective Processes Heat Transfer Coefficient Formula

Evaluate Formula

Formula

$$Q = h_t \cdot \left(T_w - T_{aw} \right)$$

Example with Units

$$69.432\,\text{W/m}^2 = 13.2\,\text{W/m}^2\text{*K} \cdot \left(305\,\text{K} - 299.74\,\text{K} \right)$$

2) Critical heat flux to nucleate pool boiling Formula

Evaluate Formula

Formula

$$Q_c = 0.18 \cdot \Delta H \cdot \rho_v \cdot \left(\frac{Y \cdot [g] \cdot \left(\rho_l - \rho_v \right)}{\rho_v^{\,2}} \right)^{0.25}$$

Example with Units

$$332.8425\,\text{W/m}^2 = 0.18 \cdot 500\,\text{J/mol} \cdot 0.5\,\text{kg/m}^3 \cdot \left(\frac{21.8\,\text{N/m} \cdot 9.8066\,\text{m/s}^2 \cdot \left(4\,\text{kg/m}^3 - 0.5\,\text{kg/m}^3 \right)}{0.5\,\text{kg/m}^3{}^2} \right)^{0.25}$$

3) Emissivity given heat transfer coefficient by radiation Formula

Evaluate Formula

Formula

$$\varepsilon = \frac{h_r}{[\text{Stefan-BoltZ}] \cdot \left(\frac{T_{wa}^{\,4} - T_s^{\,4}}{T_{wa} - T_s} \right)}$$

Example with Units

$$0.407 = \frac{1.5\,\text{W/m}^2\text{*K}}{5.7\text{E-}8 \cdot \left(\frac{300\,\text{K}^{\,4} - 200\,\text{K}^{\,4}}{300\,\text{K} - 200\,\text{K}} \right)}$$

4) Enthalpy of evaporation given critical heat flux Formula

Evaluate Formula

Formula

$$\Delta H = \frac{Q_c}{0.18 \cdot \rho_v \cdot \left(\frac{Y \cdot [g] \cdot \left(\rho_l - \rho_v \right)}{\rho_v^{\,2}} \right)^{0.25}}$$

Example with Units

$$500\,\text{J/mol} = \frac{332.842530370989\,\text{W/m}^2}{0.18 \cdot 0.5\,\text{kg/m}^3 \cdot \left(\frac{21.8\,\text{N/m} \cdot 9.8066\,\text{m/s}^2 \cdot \left(4\,\text{kg/m}^3 - 0.5\,\text{kg/m}^3 \right)}{0.5\,\text{kg/m}^3{}^2} \right)^{0.25}}$$

5) Enthalpy of evaporation to nucleate pool boiling Formula

Evaluate Formula

Formula

$$\Delta H = \left(\left(\frac{1}{Q} \right) \cdot \mu_f \cdot \left(\frac{[g] \cdot \left(\rho_l - \rho_v \right)}{Y} \right)^{0.5} \cdot \left(\frac{C_l \cdot \Delta T}{C_s \cdot \left(Pr \right)^{1.7}} \right)^3 \right)^{0.5}$$

Example with Units

$$500\,\text{J/mol} = \left(\left(\frac{1}{69.4281385117412\,\text{W/m²}} \right) \cdot 8\,\text{Pa*s} \cdot \left(\frac{9.8066\,\text{m/s²} \cdot \left(4\,\text{kg/m³} - 0.5\,\text{kg/m³} \right)}{21.8\,\text{N/m}} \right)^{0.5} \cdot \left(\frac{3\,\text{J/(kg*K)} \cdot 12\,\text{K}}{0.55 \cdot \left(0.7 \right)^{1.7}} \right)^3 \right)^{0.5}$$

6) Heat flux to nucleate pool boiling Formula

Evaluate Formula

Formula

$$Q = \mu_f \cdot \Delta H \cdot \left(\frac{[g] \cdot \left(\rho_l - \rho_v \right)}{Y} \right)^{0.5} \cdot \left(\frac{C_l \cdot \Delta T}{C_s \cdot \Delta H \cdot \left(Pr \right)^{1.7}} \right)^{3.0}$$

Example with Units

$$69.4281\,\text{W/m²} = 8\,\text{Pa*s} \cdot 500\,\text{J/mol} \cdot \left(\frac{9.8066\,\text{m/s²} \cdot \left(4\,\text{kg/m³} - 0.5\,\text{kg/m³} \right)}{21.8\,\text{N/m}} \right)^{0.5} \cdot \left(\frac{3\,\text{J/(kg*K)} \cdot 12\,\text{K}}{0.55 \cdot 500\,\text{J/mol} \cdot \left(0.7 \right)^{1.7}} \right)^{3.0}$$

7) Heat transfer coefficient by convection for stable film boiling Formula

Evaluate Formula

Formula

$$h_c = 0.62 \cdot \left(\frac{k_v^{\,3} \cdot \rho_v \cdot [g] \cdot \left(\rho_l - \rho_v \right) \cdot \left(\Delta H + \left(0.68 \cdot C_v \right) \cdot \Delta T \right)}{\mu_v \cdot D \cdot \Delta T} \right)^{0.25}$$

Example with Units

$$1.15\,\text{W/m²*K} = 0.62 \cdot \left(\frac{11.524\,\text{W/(m*K)}^{\,3} \cdot 0.5\,\text{kg/m³} \cdot 9.8066\,\text{m/s²} \cdot \left(4\,\text{kg/m³} - 0.5\,\text{kg/m³} \right) \cdot \left(500\,\text{J/mol} + \left(0.68 \cdot 5\,\text{J/(kg*K)} \right) \cdot 12\,\text{K} \right)}{1000\,\text{Pa*s} \cdot 100\,\text{m} \cdot 12\,\text{K}} \right)^{0.25}$$

8) Heat transfer coefficient by radiation Formula

Evaluate Formula

Formula

$$h_r = \frac{h - h_c}{0.75}$$

Example with Units

$$1.5\,\text{W/m²*K} = \frac{2.275\,\text{W/m²*K} - 1.15\,\text{W/m²*K}}{0.75}$$

9) Heat transfer coefficient due to radiation for horizontal tubes Formula

Evaluate Formula

Formula

$$h_r = [\text{Stefan-BoltZ}] \cdot \varepsilon \cdot \left(\frac{T_{wa}^{\,4} - T_s^{\,4}}{T_{wa} - T_s} \right)$$

Example with Units

$$1.5\,\text{W/m²*K} = 5.7\text{E-}8 \cdot 0.406974 \cdot \left(\frac{300\,\text{K}^{\,4} - 200\,\text{K}^{\,4}}{300\,\text{K} - 200\,\text{K}} \right)$$

10) Heat transfer coefficient for convection Formula

Evaluate Formula

Formula

$$h_c = h - 0.75 \cdot h_r$$

Example with Units

$$1.15\,\text{W/m}^2\text{*K} = 2.275\,\text{W/m}^2\text{*K} - 0.75 \cdot 1.5\,\text{W/m}^2\text{*K}$$

11) Heat transfer coefficient in film boiling Formula

Evaluate Formula

Formula

$$h = h_c + 0.75 \cdot h_r$$

Example with Units

$$2.275\,\text{W/m}^2\text{*K} = 1.15\,\text{W/m}^2\text{*K} + 0.75 \cdot 1.5\,\text{W/m}^2\text{*K}$$

12) Maximum heat flux to nucleate pool boiling Formula

Evaluate Formula

Formula

$$Q_m = \left(1.464 \cdot 10^{-9}\right) \cdot \left(\frac{C_l \cdot {k_l}^2 \cdot {\rho_l}^{0.5} \cdot \left(\rho_l - \rho_v\right)}{\rho_v \cdot \Delta H \cdot {\mu_f}^{0.5}}\right)^{0.5} \cdot \left(\frac{\Delta H \cdot \rho_v \cdot \Delta T}{Y \cdot T_f}\right)^{2.3}$$

Example with Units

$$0.0029\,\text{W/m}^2 = \left(1.464 \cdot 10^{-9}\right) \cdot \left(\frac{3\,\text{J/(kg*K)} \cdot 380\,\text{W/(m*K)}^2 \cdot 4\,\text{kg/m}^3{}^{0.5} \cdot \left(4\,\text{kg/m}^3 - 0.5\,\text{kg/m}^3\right)}{0.5\,\text{kg/m}^3 \cdot 500\,\text{J/mol} \cdot 8\,\text{Pa*s}^{0.5}}\right)^{0.5} \cdot \left(\frac{500\,\text{J/mol} \cdot 0.5\,\text{kg/m}^3 \cdot 12\,\text{K}}{21.8\,\text{N/m} \cdot 1.55\,\text{K}}\right)^{2.3}$$

13) Thermal Resistance in Convection Heat Transfer Formula

Evaluate Formula

Formula

$$R_{th} = \frac{1}{A_e \cdot h_{co}}$$

Example with Units

$$0.0045\,\text{K/W} = \frac{1}{11.1\,\text{m}^2 \cdot 20\,\text{W/m}^2\text{*K}}$$

Variables used in list of Boiling Formulas above

- ΔH Change in Enthalpy of Vaporization *(Joule Per Mole)*
- A_e Exposed Surface Area *(Square Meter)*
- C_l Specific Heat of Liquid *(Joule per Kilogram per K)*
- C_s Constant in Nucleate Boiling
- C_v Specific Heat of Vapour *(Joule per Kilogram per K)*
- **D** Diameter *(Meter)*
- **h** Heat Transfer Coefficient by Boiling *(Watt per Square Meter per Kelvin)*
- h_c Heat Transfer Coefficient by Convection *(Watt per Square Meter per Kelvin)*
- h_{co} Coefficient of Convective Heat Transfer *(Watt per Square Meter per Kelvin)*
- h_r Heat Transfer Coefficient by Radiation *(Watt per Square Meter per Kelvin)*
- h_t Heat Transfer Coefficient *(Watt per Square Meter per Kelvin)*
- k_l Thermal Conductivity of Liquid *(Watt per Meter per K)*
- k_v Thermal Conductivity of Vapor *(Watt per Meter per K)*
- **Pr** Prandtl Number
- **Q** Heat Flux *(Watt per Square Meter)*
- Q_c Critical Heat Flux *(Watt per Square Meter)*
- Q_m Maximum Heat Flux *(Watt per Square Meter)*
- R_{th} Thermal Resistance *(Kelvin per Watt)*
- T_{aw} Recovery Temperature *(Kelvin)*
- T_f Temperature of Fluid *(Kelvin)*
- T_s Saturation Temperature *(Kelvin)*
- T_w Surface Temperature *(Kelvin)*
- T_{wa} Wall Temperature *(Kelvin)*
- **Y** Surface Tension *(Newton per Meter)*
- ΔT Excess Temperature *(Kelvin)*
- ε Emissivity
- μ_f Dynamic Viscosity of Fluid *(Pascal Second)*
- μ_v Dynamic Viscosity of Vapour *(Pascal Second)*
- ρ_l Density of Liquid *(Kilogram per Cubic Meter)*
- ρ_v Density of Vapour *(Kilogram per Cubic Meter)*

Constants, Functions, Measurements used in list of Boiling Formulas above

- constant(s): **[g]**, 9.80665
  Gravitational acceleration on Earth
- constant(s): **[Stefan-BoltZ]**, 5.670367E-8
  Stefan-Boltzmann Constant
- Measurement: **Length** in Meter (m)
  Length Unit Conversion
- Measurement: **Temperature** in Kelvin (K)
  Temperature Unit Conversion
- Measurement: **Area** in Square Meter (m²)
  Area Unit Conversion
- Measurement: **Temperature Difference** in Kelvin (K)
  Temperature Difference Unit Conversion
- Measurement: **Thermal Resistance** in Kelvin per Watt (K/W)
  Thermal Resistance Unit Conversion
- Measurement: **Thermal Conductivity** in Watt per Meter per K (W/(m*K))
  Thermal Conductivity Unit Conversion
- Measurement: **Specific Heat Capacity** in Joule per Kilogram per K (J/(kg*K))
  Specific Heat Capacity Unit Conversion
- Measurement: **Heat Flux Density** in Watt per Square Meter (W/m²)
  Heat Flux Density Unit Conversion
- Measurement: **Heat Transfer Coefficient** in Watt per Square Meter per Kelvin (W/m²*K)
  Heat Transfer Coefficient Unit Conversion
- Measurement: **Surface Tension** in Newton per Meter (N/m)
  Surface Tension Unit Conversion
- Measurement: **Dynamic Viscosity** in Pascal Second (Pa*s)
  Dynamic Viscosity Unit Conversion
- Measurement: **Density** in Kilogram per Cubic Meter (kg/m³)
  Density Unit Conversion
- Measurement: **Energy Per Mole** in Joule Per Mole (J/mol)
  Energy Per Mole Unit Conversion

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