Important Devices to Measure Flow Rate Formulas PDF

Formulas
Examples
with Units

List of 25
Important Devices to Measure Flow Rate Formulas

1) Orifice Meter Formulas

1.1) Actual Velocity at Section 2 given Coefficient of Contraction Formula

Evaluate Formula

Formula

$$v = C_v \cdot \sqrt{2 \cdot [g] \cdot h_{venturi} + \left(V_{p2} \cdot C_c \cdot \frac{a_o}{A_i}\right)^2}$$

Example with Units

$$11.8609\,\mathrm{m/s} = 0.92 \cdot \sqrt{2 \cdot 9.8066\,\mathrm{m/s^2} \cdot 24\,\mathrm{mm} + \left(34\,\mathrm{m/s} \cdot 0.611 \cdot \frac{4.4\,\mathrm{m^2}}{7.1\,\mathrm{m^2}}\right)^2}$$

1.2) Actual Velocity given Theoretical Velocity at Section 2 Formula

Evaluate Formula

Formula

$$v = C_v \cdot V_{p2}$$

Example with Units

$$31.28\,\mathrm{m/s} = 0.92 \cdot 34\,\mathrm{m/s}$$

1.3) Area at Section 2 or at Vena Contracta Formula

Evaluate Formula

Formula

$$A_f = C_c \cdot a_o$$

Example with Units

$$2.6884\,\mathrm{m^2} = 0.611 \cdot 4.4\,\mathrm{m^2}$$

1.4) Area of Orifice given Area at Section 2 or at Vena Contracta Formula

Evaluate Formula

Formula

$$a_o = \frac{A_f}{C_c}$$

Example with Units

$$2.946\,\mathrm{m^2} = \frac{1.8\,\mathrm{m^2}}{0.611}$$

1.5) Coefficient of Contraction Formula

Evaluate Formula

Formula

$$C_c = \frac{C_d}{C_v}$$

Example

$$0.7174 = \frac{0.66}{0.92}$$

1.6) Coefficient of Contraction given Coefficient of Discharge Formula

Evaluate Formula

Formula

$$C_c = \frac{C_d}{C_v}$$

Example

$$0.7174 = \frac{0.66}{0.92}$$

1.7) Coefficient of Discharge given Coefficient of Contraction Formula

Evaluate Formula

Formula

$$C_d = C_v \cdot C_c$$

Example

$$0.5621 = 0.92 \cdot 0.611$$

1.8) Coefficient of Velocity given Coefficient of Discharge Formula

Evaluate Formula

Formula

$$C_v = \frac{C_d}{C_c}$$

Example

$$1.0802 = \frac{0.66}{0.611}$$

1.9) Discharge through Pipe given Coefficient of Discharge Formula

Evaluate Formula

Formula

$$Q_O = C_d \cdot W \cdot \left(H_{Bottom} - H_{Top} \right) \cdot \left(\sqrt{2 \cdot 9.81 \cdot H} \right)$$

Example with Units

$$0.0405\,\mathrm{m^3/s} = 0.66 \cdot 3.1\,\mathrm{m} \cdot \left(20\,\mathrm{m} - 19.9\,\mathrm{m} \right) \cdot \left(\sqrt{2 \cdot 9.81 \cdot 0.002\,\mathrm{m}} \right)$$

1.10) Theoretical Velocity at Section 1 in Orifice Meter Formula

Evaluate Formula

Formula

$$V_1 = \sqrt{\left(V_{p2}^{\ 2} \right) - \left(2 \cdot [g] \cdot h_{venturi} \right)}$$

Example with Units

$$33.9931\,\mathrm{m/s} = \sqrt{\left(34\,\mathrm{m/s}^{\ 2} \right) - \left(2 \cdot 9.8066\,\mathrm{m/s^2} \cdot 24\,\mathrm{mm} \right)}$$

1.11) Theoretical Velocity at Section 2 in Orifice Meter Formula

Evaluate Formula

Formula

$$V_{p2} = \sqrt{2 \cdot [g] \cdot h_{venturi} + V_1^{\ 2}}$$

Example with Units

$$58.0341\,\mathrm{m/s} = \sqrt{2 \cdot 9.8066\,\mathrm{m/s^2} \cdot 24\,\mathrm{mm} + 58.03\,\mathrm{m/s}^{\ 2}}$$

2) Pitot Tube Formulas

2.1) Actual Velocity of Flowing Stream Formula

Evaluate Formula

Formula

$$v = C_v \cdot \sqrt{2 \cdot [g] \cdot H_f}$$

Example with Units

$$14.1728\,\text{m/s} = 0.92 \cdot \sqrt{2 \cdot 9.8066\,\text{m/s}^2 \cdot 12.10}$$

2.2) Height of Fluid raised in Tube given Actual Velocity of Flowing Stream Formula

Evaluate Formula

Formula

$$H_f = \frac{\left(\frac{V_{theoritical}}{C_v}\right)^2}{2 \cdot [g]}$$

Example with Units

$$13.0346 = \frac{\left(\frac{1.5\,\text{m/s}}{0.92}\right)^2}{2 \cdot 9.8066\,\text{m/s}^2}$$

2.3) Height of Fluid raised in Tube given Theoretical Velocity of Flowing Stream Formula

Evaluate Formula

Formula

$$H_f = \frac{V_{theoritical}^2}{2 \cdot [g]}$$

Example with Units

$$11.0325 = \frac{1.5\,\text{m/s}^2}{2 \cdot 9.8066\,\text{m/s}^2}$$

2.4) Theoretical Velocity of Flowing Stream Formula

Evaluate Formula

Formula

$$V_{theoritical} = \sqrt{2 \cdot [g] \cdot H_f}$$

Example with Units

$$15.4052\,\text{m/s} = \sqrt{2 \cdot 9.8066\,\text{m/s}^2 \cdot 12.10}$$

3) Venturi Meter Formulas

3.1) Actual Discharge given Coefficient of Discharge Formula

Evaluate Formula

Formula

$$Q_{actual} = V_{theoritical} \cdot C_d$$

Example with Units

$$0.99\,\text{m}^3\text{/s} = 1.5\,\text{m/s} \cdot 0.66$$

3.2) Coefficient of Discharge given Discharges Formula

Evaluate Formula

Formula

$$C_d = \frac{Q_{actual}}{V_{theoritical}}$$

Example with Units

$$0.3913 = \frac{0.587\,\text{m}^3\text{/s}}{1.5\,\text{m/s}}$$

3.3) Density of Liquid in Pipe given Venturi Head Formula

Evaluate Formula

Formula

$$\gamma_f = \frac{w}{\frac{h_{venturi}}{L} + 1}$$

Example with Units

$$9.8104\,\text{kN/m}^3 = \frac{9888.84\,\text{N/m}^3}{\frac{24\,\text{mm}}{3\,\text{m}} + 1}$$

3.4) Density of Manometric Liquid given Venturi Head Formula

Evaluate Formula

Formula

$$w = \gamma_f \cdot \left(\frac{h_{venturi}}{L} + 1 \right)$$

Example with Units

$$9888.48\,\mathrm{N/m^3} = 9.81\,\mathrm{kN/m^3} \cdot \left(\frac{24\,\mathrm{mm}}{3\,\mathrm{m}} + 1 \right)$$

3.5) Inlet Area given Theoretical Discharge Formula

Evaluate Formula

Formula

$$A_i = \sqrt{\frac{\left(Q_{th} \cdot A_f\right)^2}{\left(Q_{th}\right)^2 - \left(A_f^{\,2} \cdot 2 \cdot [g] \cdot h_{venturi}\right)}}$$

Example with Units

$$7.0735\,\mathrm{m^2} = \sqrt{\frac{\left(1.277\,\mathrm{m^3/s} \cdot 1.8\,\mathrm{m^2}\right)^2}{\left(1.277\,\mathrm{m^3/s}\right)^2 - \left(1.8\,\mathrm{m^2}^{\,2} \cdot 2 \cdot 9.8066\,\mathrm{m/s^2} \cdot 24\,\mathrm{mm}\right)}}$$

3.6) Theoretical Discharge given Coefficient of Discharge Formula

Evaluate Formula

Formula

$$Q_{th} = \frac{Q_{actual}}{C_d}$$

Example with Units

$$0.8894\,\mathrm{m^3/s} = \frac{0.587\,\mathrm{m^3/s}}{0.66}$$

3.7) Theoretical Discharge through Pipe Formula

Evaluate Formula

Formula

$$Q_{th} = \frac{A_i \cdot A_f \cdot \left(\sqrt{2 \cdot [g] \cdot h_{venturi}}\right)}{\sqrt{\left(A_i\right)^2 - \left(A_f\right)^2}}$$

Example with Units

$$1.2767\,\mathrm{m^3/s} = \frac{7.1\,\mathrm{m^2} \cdot 1.8\,\mathrm{m^2} \cdot \left(\sqrt{2 \cdot 9.8066\,\mathrm{m/s^2} \cdot 24\,\mathrm{mm}}\right)}{\sqrt{\left(7.1\,\mathrm{m^2}\right)^2 - \left(1.8\,\mathrm{m^2}\right)^2}}$$

3.8) Throat Area given Theoretical Discharge Formula

Evaluate Formula

Formula

$$A_f = \sqrt{\frac{(A_i \cdot Q_{th})^2}{\left(A_i^2 \cdot 2 \cdot [g] \cdot h_{venturi}\right) + Q_{th}^2}}$$

Example with Units

$$1.8004\,\mathrm{m^2} = \sqrt{\frac{(7.1\,\mathrm{m^2} \cdot 1.277\,\mathrm{m^3/s})^2}{\left(7.1\,\mathrm{m^2}^2 \cdot 2 \cdot 9.8066\,\mathrm{m/s^2} \cdot 24\,\mathrm{mm}\right) + 1.277\,\mathrm{m^3/s}^2}}$$

3.9) Venturi Head given Difference in Levels of Manometric Liquid in Two Limbs Formula

Evaluate Formula

Formula

$$h_{venturi} = L \cdot \left(\frac{w}{\gamma_f} - 1\right)$$

Example with Units

$$24.1101\,\mathrm{mm} = 3\,\mathrm{m} \cdot \left(\frac{9888.84\,\mathrm{N/m^3}}{9.81\,\mathrm{kN/m^3}} - 1\right)$$

3.10) Venturi Head given Theoretical Discharge through Pipe Formula

Evaluate Formula

Formula

$$h_{venturi} = \left(\left(\frac{Q_{th}}{A_i \cdot A_f}\right) \cdot \left(\sqrt{\frac{(A_i)^2 - (A_f)^2}{2 \cdot [g]}}\right)\right)^2$$

Example with Units

$$24.0124\,\mathrm{mm} = \left(\left(\frac{1.277\,\mathrm{m^3/s}}{7.1\,\mathrm{m^2} \cdot 1.8\,\mathrm{m^2}}\right) \cdot \left(\sqrt{\frac{(7.1\,\mathrm{m^2})^2 - (1.8\,\mathrm{m^2})^2}{2 \cdot 9.8066\,\mathrm{m/s^2}}}\right)\right)^2$$

Variables used in list of Devices to Measure Flow Rate Formulas above

- A_f Cross Section Area 2 *(Square Meter)*
- A_i Cross Section Area 1 *(Square Meter)*
- a_o Area of Orifice *(Square Meter)*
- C_c Coefficient of Contraction
- C_d Coefficient of Discharge
- C_v Coefficient of Velocity
- **H** Difference in Liquid Level *(Meter)*
- H_{Bottom} Height of Liquid Bottom Edge *(Meter)*
- H_f Height of Fluid
- H_{Top} Height of Liquid Top Edge *(Meter)*
- $h_{venturi}$ Venturi Head *(Millimeter)*
- **L** Length of Venturi meter *(Meter)*
- Q_{actual} Actual Discharge *(Cubic Meter per Second)*
- Q_O Discharge through Orifice *(Cubic Meter per Second)*
- Q_{th} Theoretical Discharge *(Cubic Meter per Second)*
- **v** Actual Velocity *(Meter per Second)*
- V_1 Velocity at Point 1 *(Meter per Second)*
- V_{p2} Velocity at Point 2 *(Meter per Second)*
- $V_{theoritical}$ Theoretical Velocity *(Meter per Second)*
- **W** Width of Pipe *(Meter)*
- γ_f Specific Weight of Liquid *(Kilonewton per Cubic Meter)*
- w Weight per unit Volume of Manometer Fluid *(Newton per Cubic Meter)*

Constants, Functions, Measurements used in list of Devices to Measure Flow Rate Formulas above

- constant(s): **[g]**, 9.80665
  Gravitational acceleration on Earth
- 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), Meter (m)
  Length Unit Conversion
- Measurement: **Area** in Square Meter (m^2)
  Area Unit Conversion
- Measurement: **Speed** in Meter per Second (m/s)
  Speed Unit Conversion
- Measurement: **Volumetric Flow Rate** in Cubic Meter per Second (m^3/s)
  Volumetric Flow Rate Unit Conversion
- Measurement: **Specific Weight** in Kilonewton per Cubic Meter (kN/m^3), Newton per Cubic Meter (N/m^3)
  Specific Weight Unit Conversion

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