Formulas

Designation	Formula	Comments
Product		
Viscosity	$\nu = \frac{\mu}{\rho}$	where: ν = Kinematic viscosity (mm^2/s) μ = Absolute viscosity (mPa.s) ρ = fluid density (kg/m^3)
	or	
	$\nu = \frac{\mu}{SG}$	where: ν = Kinematic viscosity (cSt) μ = Absolute viscosity (cP) SG = specific gravity
	or	
	$\mu = \nu \times SG$	1 Poise = 100 cP 1 Stoke = 100 cSt
Flow		
Velocity	$V = \frac{Q}{A}$	where: V = fluid velocity (m/s) Q = capacity (m^3/s) A = tube area (m^2)
	or	
	$V = \frac{Q \times 353.6}{D^2}$	where: V = fluid velocity (m/s) Q = capacity (m^3/h) D = tube diameter (mm)
	or	
	$V = \frac{Q \times 0.409}{D^2}$	*where:* *V = fluid velocity (ft/s)* *Q = capacity (US gall/min)* *D = tube diameter (in)*
	or	
	$V = \frac{Q \times 0.489}{D^2}$	*where:* *V = fluid velocity (ft/s)* *Q = capacity (UK gall/min)* *D = tube diameter (in)*
Reynolds number (ratio of inertia forces to viscous forces)	$Re = \frac{D \times V \times \rho}{\mu}$	where: D = tube diameter (m) V = fluid velocity (m/s) ρ = density (kg/m^3) μ = absolute viscosity (Pa.s)
	or	
	$Re = \frac{D \times V \times \rho}{\mu}$	where: D = tube diameter (mm) V = fluid velocity (m/s) ρ = density (kg/m^3) μ = absolute viscosity (cP)
	or	
	$Re = \frac{21230 \times Q}{D \times \mu}$	where: D = tube diameter (mm) Q = capacity (l/min) μ = absolute viscosity (cP)

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Reynolds number (ratio of inertia forces to viscous forces)	or $Re = \frac{3162 \times Q}{D \times \nu}$ or $Re = \frac{3800 \times Q}{D \times \nu}$	*where:* D = *tube diameter (in)* Q = *capacity (US gall/min)* ν = *kinematic viscosity (cSt)* *where:* D = *tube diameter (in)* Q = *capacity (UK gall/min)* ν = *kinematic viscosity (cSt)*
Pressure/Head		
Pressure (total force per unit area exerted by a fluid)	$P = \frac{F}{A}$	where: F = Force A = Area
Static Pressure/Head (relationship between pressure and elevation)	$P = \rho \times g \times h$ or $P = \frac{h \times SG}{10}$ or $P = \frac{h \times SG}{2.31}$	where: P = pressure/head (Pa) ρ = fluid density (kg/m^3) g = acceleration due to gravity (m/s^2) h = height of fluid (m) where: P = pressure/head (bar) h = height of fluid (m) *where:* P = *pressure/head (psi)* h = *height of fluid (ft)*
Total head	$H = H_t - (\pm H_s)$	where: H_t = total discharge head H_s = total suction head
Total discharge head	$H_t = h_t + h_{ft} + p_t$	where: h_t = static discharge head h_{ft} = pressure drop in discharge line $p_t > 0$ for pressure $p_t < 0$ for vacuum $p_t = 0$ for open tank
Total suction head	$H_s = h_s - h_{fs} + (\pm p_s)$	where: h_s = static suction head > 0 for flooded suction < 0 for suction lift h_{fs} = pressure drop in suction line $p_s > 0$ for pressure $p_s < 0$ for vacuum $p_s = 0$ for open tank
Friction loss (Miller equation)	$Pf = \frac{f_D \times L \times \rho \times V^2}{D \times 2}$	where: Pf = friction loss (Pa) f_D = friction factor (Darcy) L = tube length (m) V = fluid velocity (m/s) ρ = fluid density (kg/m^3) D = tube diameter (m)

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Friction loss (Miller equation)	or $Pf = \dfrac{5 \times SG \times f_D \times L \times V^2}{D}$ or $Pf = \dfrac{0.0823 \times SG \times f_D \times L \times V^2}{D}$	where: Pf = friction loss (bar) f_D = friction factor (Darcy) L = tube length (m) V = fluid velocity (m/s) SG = specific gravity D = tube diameter (mm) *where:* *Pf = friction loss (psi)* *f_D = friction factor (Darcy)* *L = tube length (ft)* *V = fluid velocity (ft/s)* *SG = specific gravity* *D = tube diameter (in)*
Darcy friction factor	$f_D = \dfrac{64}{Re}$	where: f_D = friction factor Re = Reynolds number
NPSHa (Net Positive Suction Head available)	$NPSHa = Pa \pm h_s - h_{fs} - Pvp$ (+h_s for flooded suction) (– h_s for suction lift)	where: Pa = pressure absolute above fluid level (bar) h_s = static suction head (m) h_{fs} = pressure drop in suction line (m) Pvp = vapour pressure (bar a) or *where:* *Pa = pressure absolute above fluid level (psi)* *h_s = static suction head (ft)* *h_{fs} = pressure drop in suction line (ft)* *Pvp = vapour pressure (psia)*
Power		
Hydraulic power (theoretical energy required)	Power (W) = $Q \times H \times \rho \times g$ or Power (kW) = $\dfrac{Q \times H}{k}$ or *Power (hp)* = $\dfrac{Q \times H}{k}$ or *Power (hp)* = $\dfrac{Q \times H}{k}$	where: Q = capacity (m^3/s) H = total head (m) ρ = fluid density (kg/m^3) g = acceleration due to gravity (m/s^2) where: Q = capacity (l/min) H = total head (bar) k = 600 *where:* *Q = capacity (US gall/min)* *H = total head (psi)* *k = 1715* *where:* *Q = capacity (UK gall/min)* *H = total head (psi)* *k = 1428*

Designation	**Formula**	**Comments**
Required power (power needed at the pump shaft)	$\frac{\text{Hydraulic power}}{\text{Efficiency (100\% = 1.0)}}$	
Torque		
Torque	Torque (Nm) = $\frac{\text{Required power (kW) x 9550}}{\text{Pump speed (rev/min)}}$ or Torque (Kgfm) = $\frac{\text{Required power (kW) x 974}}{\text{Pump speed (rev/min)}}$ or *Torque (ftlb) =* $\frac{\textit{Required power (hp) x 5250}}{\textit{Pump speed (rev/min)}}$	
Efficiency		
Hydraulic efficiency (η_h)	$\frac{\text{Pump head loss (m)}}{\text{Total head (m)3}} \times 100\%$	
Mechanical efficiency (η_m)	$1 - \frac{\text{Pump mech. losses}}{\text{Required power}} \times 100\%$	
Volumetric efficiency (Centrifugal and Liquid Ring pumps)	$\eta_v = \frac{Q}{Q + Q_L} \times 100\%$	where: η_v = volumetric efficiency Q = pump capacity Q_L = fluid losses due to leakage through the impeller casing clearances
Volumetric efficiency (Rotary Lobe pumps)	$\eta_v = \frac{Q}{q} \times 100\%$	where: η_v = volumetric efficiency Q = pump capacity q = pump displacement
Pump efficiency (η_p)	$\frac{\text{Water horse power}}{\text{Required power}} \times 100\%$ or $\eta_p = \frac{Q \times H \times \rho \times g}{\omega \times T}$	where: η_p = pump efficiency Q = capacity (m^3/s) H = total head/pressure (m) ρ = fluid density (kg/m^3) g = acceleration due to gravity (m/s^2) ω = shaft angular velocity (rad/s) T = shaft torque (Nm)
Overall efficiency (η_{oa})	$\frac{\text{Water horse power}}{\text{Drive power}} \times 100\%$	

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Pump speed - Rotary Lobe Pump		
Pump speed	$n = \frac{Q \times 100}{q \times \eta_v \times 60}$ or $n = \frac{Q \times 100}{q \times \eta_v}$ or $n = \frac{Q \times 100}{q \times \eta_v}$	where: n = pump speed (rev/min) Q = capacity (m^3/h) q = pump displacement ($m^3/100$ rev) η_v = vol. efficiency (100% = 1.0) *where:* *n = pump speed (rev/min)* *Q = capacity (US gall/min)* *q = pump displacement (US gall/100 rev)* *η_v = vol. efficiency (100% = 1.0)* *where:* *n = pump speed (rev/min)* *Q = capacity (UK gall/min)* *q = pump displacement (UK gall/100 rev)* *η_v = vol. efficiency (100% = 1.0)*
Flow Control - Centrifugal Pump		
Connection between impeller diameter and capacity	$D_2 = D_1 \times \sqrt[3]{\frac{Q_2}{Q_1}}$	where: D = impeller diameter (mm) Q = capacity (m^3/h)
Connection between impeller diameter and head	$D_2 = D_1 \times \sqrt{\frac{H_2}{H_1}}$	where: D = impeller diameter (mm) H = head (m)
Connection between impeller diameter and power	$D_2 = D_1 \times \sqrt[5]{\frac{P_2}{P_1}}$	where: D = impeller diameter (mm) P = power (kW)
Reduction of multi-stage impeller diameter	$D_2 = D_1 \times \sqrt{\frac{c-b}{a-b}}$	where: D_1 = standard diameter (mm) a = max. working point (m) b = min. working point (m) c = required working point (m)
Connection between impeller speed and capacity	$n_2 = n_1 \times \frac{Q_2}{Q_1}$	where: n = impeller speed (rev/min) Q = capacity (m^3/h)
Connection between impeller speed and head	$n_2 = n_1 \times \sqrt{\frac{H_2}{H_1}}$	where: n = impeller speed (rev/min) H = head (m)
Connection between impeller speed and power	$n_2 = n_1 \times \sqrt[3]{\frac{P_2}{P_1}}$	where: n = impeller speed (rev/min) P = power (kW)