Applied Fluid Power

Fluid Power Formulas

Basic Formulas

Fluid Pressure $$\text{Pressure} = \frac{\text{Force (pounds)}}{\text{Unit Area (square inches)}}$$	Fluid Power $$\text{Horsepower} = \frac{\text{Pressure(psi)x Flow (GPM)}}{1714}$$
Fluid Flow Rate $$\text{Flow Rate} = \frac{\text{Volume (Gallons)}}{\text{Unit Time(Minute)}}$$	

Fluid Formulas

Velocity Through Piping $$\text{Velocity} = \frac{.3208 \text{ x GPM}}{\text{Internal Area (Square Inches)}}$$	Compressibility of Oil $$\text{Additional Volume} = \frac{\text{PSI x Vol of Oil under Pressure}}{\text{250,000 (approx.)}}$$
Compressibility of a Fluid $$\text{Compressibility} = \frac{1}{\text{Bulk Modulus of the Fluid}}$$	Specific Gravity of a Fluid $$\text{Specific Gravity} = \frac{\text{Weight of 1 Cubic Ft of Fluid}}{62.4283}$$
Valve Flow Factor $$\text{Valve Factor} = \frac{(\text{GPM} \sqrt{\text{Specific Gravity}})}{\sqrt{\text{Pressure Drop}} \;\; (\Delta\text{PSI})}$$	
Viscosity in Centistokes For Viscosities of 32 -100 Saybolt Universal Seconds: $$\text{Centistokes} = .2253\text{x SUS} - \left(\frac{194.4}{\text{SUS}}\right)$$	
For Viscosities of 100-240 Saybolt Universal Seconds: $$\text{Centistokes} = .2193 \text{ x SUS} - \left(\frac{134.6}{SUS}\right)$$	
For Viscosities greater than 240 Saybolt Universal Seconds: $$\text{Centistokes} = \frac{SUS}{4.635}$$	

Pump Formulas

Pump Outlet Flow

$$\text{Flow}= \frac{\text{RPM x Pump Displacement (Cu.In/Ref.)}}{231}$$

Pump Input Power

$$\text{Horsepower} = \frac{\text{Flow Rate Output (GPM)x Pressure(PSI)}}{\text{1714 Efficiency (Overall)}}$$

Pump Efficiency (Overall in Percent)

$$\text{Overall Efficiency} = \frac{\text{HPout}}{HP_{In}}\ x\ 100$$

Overall Efficiency = Volumetric Eff. x Mechanical Eff.

Pump Efficiency (Volumetric in Percent)

$$\text{Volumetric Eff.} = \frac{\text{Actual Flow Rate (GPM)}}{\text{Theoretical Flow Rate (GPM)}} \text{ x } 100$$

Pump Efficiency (Mechanical in Percent)

$$\text{Mechanical Eff.} = \frac{\text{Theoretical Torque}}{\text{Actual Torque}} \text{ x } 100$$

Pump Life B_{10} Bearing Life

$$B_{10}= \text{Rated Hrs x } \left(\frac{RPM_r}{RPM_n}\right)\ x\ \left(\frac{PSI^r}{PSI_n}\right)^3$$

Actuator Formulas

Cylinder Area

$$\text{Area}= \pi \text{ x Radius}^2$$
$$\text{Area}= .7854 \text{ x Diameter}^2$$

Cylinder Force

$$F = P \text{ x } A$$

Cylinder Velocity

$$\text{Velocity} = \frac{\text{231 x Flow Rate (GPM)}}{\text{12 x 60 x Net Area (sq.in.)}}$$

Cylinder Flow Rate

$$\text{Flow Rate} = \frac{\text{12 x 60 x Velocity x Net Area}}{231}$$

Cylinder Volume Capacity

$$\text{Volume}= \frac{\pi \text{ x Radius }^2\text{(in.)x Stroke (in.)}}{231}$$

Cylinder Volume Capacity

$$\text{Volume}= \frac{\text{Area (in.}^2\text{)x Stroke (in.)}}{231}$$

Fluid Motor Torque

$$\text{Torque}= \frac{\text{Pressure x F.M. Displacement (Cu .In./Rev)}}{2\pi}$$

$$\text{Torque}= \frac{\text{Horsepower x 63025}}{\text{RPM}}$$

	$$\text{Torque} = \frac{\text{Flow Rate x Pressure x 36.77}}{\text{RPM}}$$
Fluid Motor Torque/100 psi	$$\frac{\text{Torque}}{100} = \frac{\text{F.M. Displacement (Cu .In./Rev)}}{.0628}$$
Fluid Motor Speed (Revolutions per Minute) $$\text{RPM} = \frac{231 * \text{GPM}}{\text{Displacement (Cu .In./Rev)}}$$	Fluid Motor Power (Horsepower Output) $$\text{Horsepower} = \frac{\text{Torque Output x RPM}}{63025}$$

Thermal Formulas

Reservoir Cooling Capacity Heat(BTU/HR) = 2.0 x Temp. Difference between Reservoir Walls and Air (F^0) x Area of Reservoir (Sq. Ft.)	
Heat in Hydraulic Oil Heat(BTU/HR) = Flow Rate (GPM) x 210 x Temp. Diff. (F^0)	
Heat in Fresh Water Heat(BTU/HR) = Flow Rate (GPM) x 500 x Temp. Diff. (F^0)	

Accumulator Formulas

Pressure or Volume - Constant Temperature $P_1V_1 = P_2V_2$ Isothermic	
Pressure or Temperature – Constant Volume $P_1T_2 = P_2T_1$ Isochoric	

Volume or Temperature – Constant Pressure $V_1T_2 = V_2T_1$ Isobaric
Pressure or Volume - Temperature Change due to Heat of Compression $P_1V_1^n = P_2V_2^N$ $\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{n-1} = \left(\frac{P_2}{P_1}\right)^{(n-1)/n}$

Volume and Capacity Formulas

					Water at Max. Density	
	Cubic Inches	Cubic Centimeters	Liters	U.S. Gallons	Pounds of Water	Kilograms of Water
Cubic Inches	1	16. 384	0.016384	0.004329	0.361275	0.0163872
Cubic Centimeters	0.0610	1	0.001	.000264	0.0002205	0.0001
Liters	61.0234	0.001308	1	0.264170	2.20462	1
U.S. Gallons	231	0.004951	3.78543	1	8.34545	3.78543
Pounds of Water	27.6798	0.0005929	0.453592	0.119825	0.0998281	0.453593