Fluid Power Formulas

Basic Formulas

FORMULA FOR:	WORD FORMULA:	LETTER FORMULA:
FLUID PRESSURE In Pounds/Square Inch	$\text{Pressure} = \frac{\text{Force (Pounds)}}{\text{Unit Area (Square Inches)}}$	P = F/A or psi = F/A
FLUID FLOW RATE In Gallons/Minute	$\text{Flow Rate} = \frac{\text{Volume (Gallons)}}{\text{Unit Time (Minute)}}$	Q = V/T
FLUID POWER In Horsepower	$\text{Horsepower} = \frac{\text{Pressure (psi) x Flow (GPM)}}{1714}$	HP = PQ/1714

Fluid Formulas

FORMULA FOR:	WORD FORMULA:	LETTER FORMULA:
VELOCITY THROUGH PIPING In Feet/Second Velocity	$\text{Velocity} = \frac{\text{.3208 x Flow Rate through I.D. (GPM)}}{\text{Internal Area (Square Inches)}}$	V = .3208Q/A
COMPRESSIBILITY OF OIL In Additional Required Oil to Reach Pressure	$\text{Additional Volume} = \frac{\text{Pressure (psi) x Volume of Oil under Pressure}}{\text{250,000 (approx.)}}$	V_A = PV/250,000 (approx.)
COMPRESSIBILITY OF A FLUID	$\text{Compressibility} = \frac{1}{\text{Bulk Modulus of the Fluid}}$	C(ß) = 1/BM
SPECIFIC GRAVITY OF A FLUID	$\text{Specific Gravity} = \frac{\text{Weight of One Cubic Foot of Fluid}}{\text{Weight of One Cubic Foot of Water}}$	SG = W/62.4283
VALVE (Cv) FLOW FACTOR	$\text{Valve Factor} = \frac{\text{Flow Rate (GPM)}\sqrt{\text{Specific Gravity}}}{\sqrt{\text{Pressure Drop (psi)}}}$	$Cv = (Q\sqrt{SG})/(\sqrt{\Delta p})$
VISCOSITY IN CENTISTOKES	For Viscosities of 32 to 100 Saybolt Universal Seconds: $\text{Centistokes} = .2253 \times \text{SUS} - \left(\frac{194.4}{\text{SUS}}\right)$	CS = .2253 SUS - (194.4/SUS)
	For Viscosities of 100 to 240 Saybolt Universal Seconds: $\text{Centistokes} = .2193 \times \text{SUS} - \left(\frac{134.6}{\text{SUS}}\right)$	CS = .2193 SUS - (134.6/SUS)
	For Viscosities greater than 240 Saybolt Universal Seconds: $\text{Centistokes} = \left(\frac{\text{SUS}}{4.635}\right)$	CS = SUS/4.635

Note: Saybolt Universal Seconds can also be abbreviated as SSU.

Pump Formulas

FORMULA FOR:	WORD FORMULA:	LETTER FORMULA:
PUMP OUTLET FLOW In Gallons/Minute	Flow = $\frac{\text{RPM x Pump Displacement (Cu. In./Ref.)}}{231}$	Q = nd/231
PUMP INPUT POWER In Horsepower Required	Horsepower Input = $\frac{\text{Flow Rate Output (GPM) x Pressure (psi)}}{\text{1714 Efficiency (Overall)}}$	Hp_{in} = QP/1714Eff. or (GPM x psi)/1714Eff.
PUMP EFFICIENCY Overall in Percent	Overall Efficiency = $\left(\frac{\text{Output Horsepower}}{\text{Input Horsepower}}\right)$ x 100	$Eff_{OV} = (HP_{out} / HP_{in}) \times 100$
	Overall Efficiency = Volumetric Eff. x Mechanical Eff.	$Eff_{ov} = Eff_{vol} \times Eff_{mech}$
PUMP EFFICIENCY Volumetric in Percent	Volumetric Efficiency = $\frac{\text{Actual Flow Rate Output (GPM)}}{\text{Theoretical Flow Rate Output (GPM)}}$ x 100	$Eff_{vol} = (Q_{act}/Q_{theo}) \times 100$
PUMP EFFICIENCY Mechanical in Percent	Mechanical Efficiency = $\frac{\text{Theoretical Torque to Drive}}{\text{Actual Torque to Drive}}$ x 100	$Eff_{mech} = (T_{theo}/T_{act}) \times 100$
PUMP LIFE B_{10} Bearing Life	B_{10} Hrs. Bearing Life = Rated Life Hrs. x $\frac{\text{Rated Speed (RPM)}}{\text{New Speed (RPM)}}$ x $\frac{\text{Rated Pressure (psi)}}{\text{New Pressure (psi)}}$	B_{10} = Rated Hrs x $(RPM_r/RPM_n) \times (P^r/P_n)^3$

Actuator Formulas

FORMULA FOR:	WORD FORMULA:	LETTER FORMULA:
CYLINDER AREA In Square Inches	Area = π x Radius^2 (Inches)	$A = \pi r^2$
	Area = (P/4) x Diameter^2 (Inches)	$A = (\pi D^2)/4$ or $A = .785D^2$
CYLINDER FORCE In Pounds, Push or Pull	Area = Pressure (psi) x Net Area (sq in.)	F = psi x A or F = PA
CYLINDER VELOCITY or SPEED In Feet/Second	Velocity = $\frac{\text{231 x Flow Rate (GPM)}}{\text{12 x 60 x Net Area (sq in.)}}$	v = 231Q/720A or v = .3208Q/A
CYLINDER VOLUME CAPACITY In Gallons of Fluid	Volume = $\frac{\pi \text{ x Radius}^2 \text{ (in.) x Stroke (in.)}}{231}$	$V = (\pi r^2 L)/231$
	Volume = $\frac{\text{Net Area (sq. in.) x Stroke (in.)}}{231}$	V= (A L)/231
CYLINDER FLOW RATE In Gallons/Minute	Flow Rate = $\frac{\text{12 x 60 x Velocity (Ft/Sec) x Net Area (sq. in.)}}{231}$	Q = (720vA)231 or Q = 3.117vA
FLUID MOTOR TORQUE In Inch Pounds	Torque = $\frac{\text{Pressure (psi) x F.M. Displacement (Cu. In./Rev.)}}{2\pi}$	$T = psi\ d/2\pi$ or $T = Pd/2\pi$
	Torque = $\frac{\text{Horsepower x 63025}}{\text{RPM}}$	T = 63025 HP/n
	Torque = $\frac{\text{Flow Rate (GPM) x Pressure (psi) x 36.77}}{\text{RPM}}$	T = 36.77QP/n or T = 36.77Qpsi/n
FLUID MOTOR TORQUE/100 psi In Inch Pounds	$\frac{\text{Torque}}{100} = \frac{\text{F.M. Displacement (Cu. In./Rev.)}}{.0628}$	T_{100psi} = d/.0628
FLUID MOTOR SPEED In Revolutions/Minute	Speed = $\frac{\text{231 Flow Rate (GPM)}}{\text{F.M. Displacement (Cu. In./Rev.)}}$	n = 231 Q/d
FLUID MOTOR POWER In Horsepower Output	Horsepower = $\frac{\text{Torque Output (Inch Pounds) x RPM}}{63025}$	HP = Tn/63025

Thermal Formulas

FORMULA FOR:	WORD FORMULA:	LETTER FORMULA:
RESERVOIR COOLING CAPACITY Based on Adequate Air Circulation	Heat (BTU/Hr) = 2 x Temperature Difference Between Reservoir Walls and Air (F°) x Area of Reservoir (Sq. Ft.)	BTU/Hr = 2.0 x DT x A
HEAT IN HYDRAULIC OIL Due to System Inefficiency (SG=.89-.92)	Heat (BTU/Hr) = Flow Rate (GPM) x 210 x Temp. Difference (F°)	BTU/Hr = Q x 210 x DT
HEAT IN FRESH WATER	Heat (BTU/Hr) = Flow Rate (GPM) x 500 x Temp. Difference (F°)	BTU/Hr = Q x 500 x DT

Note: One British Thermal Unit (BTU) is the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit. One Horsepower = 2545 BTU/Hr.

Accumulator Formulas

FORMULA FOR:	WORD FORMULA:	LETTER FORMULA:
PRESSURE OR VOLUME With Constant T (Temperature)	Original Pressure x Original Volume = Final Pressure x Final Volume	$P_1V_1 = P_2V_2$ Isothermic
PRESSURE OR TEMPERATURE With Constant V (Volume)	Original Pressure x Final Temp. = Final Pressure x Original Temp.	$P_1T_2 = P_2T_1$ Isochoric
VOLUME OR TEMPERATURE With Constant P (Pressure)	Original Volume x Final Temp. = Final Volume x Original Temp.	$V_1T_2 = V_2T_1$ Isobaric
PRESSURE OR VOLUME With Temp. Change Due to Heat of Compression	Original Press. x Original Volume^n = Final Press. x Final Volume^n	$P_1V_1^n=P_2V_2^n$
	Final Temp./Orig. Temp. = (Orig. Vol./Final Vol.)$^{n-1}$ = (Final Press./Orig. Press.)$^{(n-1)/n}$	$T_2/T_1=(V_1/V_2)^{n-1} = (P_2/P_1)^{(n-1)/n}$

Volume and Capacity Formulas

	Cubic Inches	Cubic Feet	Cubic Centimeters	Liters	U.S. Gallons	Imperial Gallons	Water at Max Density	
							Pounds of Water	Kilograms of Water
Cubic Inches	1	0.0005787	16.384	0.016384	0.004329	0.0036065	0.361275	0.0163872
Cubic Feet	1728	1	0.037037	28.317	7.48052	6.23210	62.4283	28.3170
Cubic Centimeters	0.0610	0.0000353	1	0.001	0.000264	0.000220	0.002205	0.0001
Liters	61.0234	0.0353145	0.001308	1	0.264170	0.220083	2.20462	1
U.S. Gallons	231	0.133681	0.004951	3.78543	1	0.833111	8.34545	3.78543
Imperial Gallons	277.274	0.160459	0.0059429	4.54374	1.20032	1	10.0172	4.54373
Pounds of Water	27.6798	0.0160184	0.0005929	0.453592	0.119825	0.0998281	1	0.453593