Fluid Power Formulas

Torque and horsepower Relations:

T=HP×5252÷RPM
HP=T×RPM÷5252
RPM=HP×5252÷T
Torque values are in foot pounds.

Hydraulic (fluid power) horsepower:

HP = PSI × GPM ÷ 1714
PSI is gauge pressure in pounds per square inch; GPM is oil flow in gallons per minute.

Velocity of oil flow in pipe:

V = GPM × 0.3208 ÷ A
V is oil velocity in feet per second;
GPM is flow in gallons per minute;
A is inside area of pipe in square inches.

Charles' Law for behavior of gases:

T1V2 = **T2V1**, or **T1P2** = **T2P1**
T1, **P1**, and **V1** are initial temperature, pressure, and volume, and **T2**, **P2**, and **V2** are final conditions.

Boyle's Law for behavior of gases:

$P_1V_1 = P_2V_2$
P1 and **V1** are initial pressure and volume;
P2 and **V2** are final conditions.

Circle formulas:

Area = πr^2, or $\pi D^2 \div 4$
Circumference = $2\pi r$, or πD
r is radius; **D** is diameter, inches.

Heat equivalent of fluid power:

BTU per hour = PSI × GPM × 1Z\x

Hydraulic cyl. piston travel speed:

S=CIM÷A
S is piston travel speed, inches per minute;
CIM is oil flow into cylinder, cubic inches per minute;
A is piston area in square inches.

Force or thrust of any cylinder:

F=A×PSI
F is thrust or force, in pounds;
A is piston net area in square inches; **PSI** is gauge pressure.

Force for piercing or shearing sheet metal:

F=P×T×PSI
F is force required, in pounds;
P is perimeter around area to be sheared, in inches;
T is sheet thickness in inches;
PSI is the shear strength rating of the material in pounds per square inch.

Side load on pump or motor shaft:

F = (HP × 63024) ÷ (RPM × R)
F is the side load, in pounds, against shaft; **R** is the pitch radius, in inches, of sheave on pump shaft;
HP is driving power applied to shaft.

Effective force of a cylinder working at an angle to direction of the load travel:

F = T × sin A
T is the total cylinder force, in pounds; **F** is the part of the force which is effective, in pounds;
A is the least angle, in degrees, between cylinder axis and load direction.

Heat radiating capacity of a steel reservoir:

HP=0.001×A×TD
HP is the power radiating capacity expressed in horsepower;
A is surface area, in square feet;
TD is temperature difference in degrees **F** between oil and surrounding air.

Burst pressure of pipe or tubing:

P = 2t × S ÷ O
P is burst pressure in PSI;
t is wall thickness, in inches;
S is tensile strength of material in PSI; **O** is outside diameter, in inches.

Relationship between displacement and torque of a hydraulic motor:

T=D×PSI÷24π
T is torque in foot-lbs.;
D is displacement in cubic inches per revolution;
PSI is pressure difference across motor;
π = 3.14.

Rules-of-Thumb

Horsepower for driving a pump:

For every 1 HP of drive, the equivalent of 1 GPM @ 1500 PSI can be produced.

Horsepower for idling a pump:

To idle a pump when it is unloaded will require about 5% of its full rated horsepower.

Compressibility of hydraulic oil:

Volume reduction is approximately 1/2% for every 1000 PSI of fluid pressure.

Compressibility of water:

Volume reduction is about 1/3% for every 1000 PSI pressure.

Wattage for heating hydraulic oil:

Each watt will raise the temperature of 1 gallon of oil by 1ºF per hour.

Flow velocity in hydraulic lines: Pump suction lines 2 to 4 feet per second; pressure lines up to 500 PSI, 10 to 15 feet per sec; pressure lines 500 to 3000 PSI, 15 to 20 feet per sec.; pressure lines over 3000 PSI, 25 feet per sec.; all oil lines in air-over-oil system, 4 feet per sec.