Basic Hydraulic Formulas

Pressure, Force and Horsepower Relationships:

Pressure (psi) = force (lbs) / area (in^2)

Force (lbs) = area (in^2) x pressure (psi)

Area (in^2) = force (lbs) / pressure (psi)

Fluid Power Horsepower:

Fluid Power Horsepower (hp) = pressure (psi) x pump flow (gpm) / 1,714

Torque and Horsepower Relationships:

Torque (ft lbs) = horsepower (hp) x 5,252 / speed (rpm)

Horsepower (hp) = torque (ft lbs) x speed (rpm) / 5,252

Speed (rpm) = horsepower (hp) x 5,252 / torque (ft lbs)

Basic Cylinder Calculations:

Piston Cylinder Area (in^2) = diameter squared x .7854

(Can also use 3.1416 x radius squared (ins))

Piston Rod End (annulus end) Area (in^2) = piston cylinder area (in^2) - rod area (in^2)

Cylinder Force (lbs) = pressure (psi) x area (in^2)

Cylinder Speed (ft/min) = 19.25 x flow rate (gpm) / area (in^2)

(Divide by 60 to convert speed to ft/sec)

Cylinder Speed (in/min) = flow rate (cu ins/min) / area (in^2)

(Note that 1 US gallon = 231 cu ins)

Cylinder Time (secs) = area (in^2) x cylinder stroke (ins) x .26 / flow rate (gpm)

Cylinder Flow Rate (gpm) = 12 x 60 x cylinder speed (ft/sec) x area (in^2) / 231

Cylinder Volume Capacity (gals) = cylinder area (in^2) x cylinder stroke (ins) / 231

Basic Hydraulic Motor Calculations:

Motor Torque (in lbs) = pressure (psi) x motor displacement (cu ins/rev) / 6.28

(Can also use horsepower (hp) x 63,025 / speed (rpm)

Motor Speed (rpm) = 231 x flow rate (gpm) / motor displacement (cu ins/rev)

Motor Horsepower (hp) = torque (in lbs) x motor speed (rpm) / 63,025

Motor Flow Rate (gpm) = motor speed (rpm) x motor displacement (cu ins/rev) / 231

Motor Displacement (cu ins/rev) = torque (in lbs) x 6.28 / pressure (psi)

Basic Pump Calculations:

Pump Outlet Flow (gpm) = pump speed (rpm) x pump displacement (cu ins/rev) / 231

Pump Speed (rpm) = 231 x pump flow rate (gpm) / pump displacement (cu ins/rev)

Pump Horsepower (hp) = flow rate (gpm) x pressure (psi) / 1,714 x pump efficiency factor

(Can also use horsepower (hp) = torque (in lbs) x pump speed (rpm) / 63,025)

Pump Torque (in lbs) = pressure (psi) x pump displacement (cu ins/rev) / 6.28

(Can also use horsepower (hp) x 63,025 / pump displacement (cu ins/rev)

Heat Generation Formulas: Converting heat into other units

1 hp = 2,545 BTU/hr = 42.4 BTU/min = 33,000 ft. lbs./min = 746 watts

Horsepower (hp) = pressure (psi) x flow (gpm) / 1714 -or- BTU/hr = 1½ x psi x gpm

1 BTU/hr = .0167 BTU/min = .00039 hp

Example: 10 gpm flow across a pressure reducing valve with a 300-psi drop = 1.75 hp of heat generated

1.75 hp of heat = 4,453 BTU/hr = 105 BTU/min = 57,750 ft. lbs./min = 1,305 watts

- Most of this heat will be carried back to the reservoir.
- Note that heat is generated anytime no mechanical output work is produced

General cooling capacity of a steel reservoir: HP (heat) = .001 x TD x A

TD = temperature difference of the oil in the reservoir and the surrounding ambient air

A = entire surface area of the reservoir in square feet (including the bottom if elevated)

General Information and "Rules of Thumb":

Estimating pump drive horsepower: 1 hp of input drive for each 1 gpm at 1,500 psi pump output

Horsepower when idling a pump: an idle and unloaded pump will require about 5% of its full rate hp

Reservoir capacity (GALS) = length (INS) x width (INS) x height (INS) / 231

Oil compressibility: 1/2 % approximate volume reduction for every 1,000 psi of pressure

Water compressibility: 1/3 % approximate volume reduction for every 1,000 psi of pressure

Wattage to heat hydraulic oil: each 1 watt will raise the temperature of 1 gallon of oil by 1°F per hour

Guidelines for flow velocity in hydraulic lines:

- 2 to 4 ft/sec = suction lines
- 10 to 15 ft/sec = pressure lines up to 500 psi
- 15 to 20 ft/sec = pressure lines 500 – 3,000 psi
- 25 ft/sec = pressure lines over 3,000 psi
- 4 ft/sec = any oil lines in air-over-oil systems

Velocity of oil flow in a pipe: velocity (ft/sec) = flow (gpm) x .3208 / inside area of the pipe (sq ins)

Circle area formulas:

- Area (sq ins) = π x r^2 where π (pi) = 3.1416 and r = radius in inches squared

- Area (sq ins) = π x d^2 / 4 where π (pi) = 3.1416 and d = diameter in inches
- Circumference (ins) = 2 x π x r where π (pi) = 3.1416 and r is radius in inches
- Circumference (ins) = π x d where π (pi) = 3.1416 and d = diameter in inches

Commonly Used Fluid Power Equivalents:

One US gallon equals:

- 231 cubic inches
- 3.785 liters (1 liter = .2642 US gals)
- 4 quarts or 8 pints
- 128 ounces liquid / 133.37 ounces weight
- 8.3356 pounds weight

One horsepower equals:

- 33,000 ft lbs per minute
- 550 ft lbs per sec
- 42.4 BTU per min
- 2,545 BTU per hour
- 746 watts
- 0.746 kw

On psi equals:

- .0689 bar (1 bar = 14.504 psi)
- 6.895 kilopascal
- 2.0416 hg (inches of mercury)
- 27.71” water

One atmosphere equal:

- 14.696 psi
- 1.013 bar
- 29.921 hg (inches of mercury)

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