Hydraulic Calculations

Target Hydraulics make a list here for you learn and check when you design your hydraulic system/hydraulic power pack unit or hydraulic components.

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1. Hydraulic Pump Calculations
Horsepower Required to Drive Pump:
GPM x PSI x .0007 (this is a 'rule-of-thumb' calculation)
Example: How many horsepower are needed to drive a 5 gpm pump at 1500 psi?
GPM = 5  PSI = 1500
GPM x PSI x .0007 = 5 x 1500 x .0007 = 5.25 horsepower

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Hydraulic Pump.jpg

Pump Displacement Needed for GPM of Output Flow:
231 x GPM ÷ RPM
Example: What displacement is needed to produce 5 gpm at 1500 rpm?
GPM = 5
RPM = 1500
231 x GPM ÷ RPM = 231 x 5 ÷ 1500 = 0.77 cubic inches per revolution

Pump Output Flow (in Gallons Per Minute):
RPM x Pump Displacement ÷ 231
Example: How much oil will be produced by a 2.5 cubic inch pump operating at 1200 rpm?
RPM = 1200
Pump Displacement = 2.5 cubic inches
RPM x Pump Displacement ÷ 231 = 1200 x 2.5 ÷ 231 = 12.99 gpm
2. Hydraulic Cylinder Calculations

Cylinder Rod End Area (in square inches):

Blind End Area - Rod Area

Example: What is the rod end area of a 6" diameter cylinder which has a 3" diameter rod?

Cylinder Blind End Area = 28.26 square inches

Rod Diameter = 3"

Radius is 1/2 of rod diameter = 1.5"

Radius² = 1.5" x 1.5" = 2.25"

π x Radius² = 3.14 x 2.25 = 7.07 square inches

Blind End Area - Rod Area = 28.26 - 7.07 = 21.19 square inches
Cylinder Blind End Area (in square inches):

\[
\pi \times (\text{Cylinder Radius})^2
\]

Example: What is the area of a 6" diameter cylinder?

Diameter = 6"

Radius is 1/2 of diameter = 3"

Radius^2 = 3" \times 3" = 9"

\[
\pi \times (\text{Cylinder Radius})^2 = 3.14 \times (3)^2 = 3.14 \times 9 = 28.26 \text{ square inches}
\]

Cylinder Blind End Output (GPM):

\[
\text{Blind End Area} \div \text{Rod End Area} \times \text{GPM In}
\]

Example: How many GPM come out the blind end of a 6" diameter cylinder with a 3" diameter rod when there is 15 gallons per minute put in the rod end?

Cylinder Blind End Area = 28.26 square inches

Cylinder Rod End Area = 21.19 square inches

GPM Input = 15 gpm

\[
\text{Blind End Area} \div \text{Rod End Area} \times \text{GPM In} = 28.26 \div 21.19 \times 15 = 20 \text{ gpm}
\]

Cylinder Output Force (in pounds):

\[
\text{Pressure (in PSI)} \times \text{Cylinder Area}
\]

Example: What is the push force of a 6" diameter cylinder operating at 2,500 PSI?

Cylinder Blind End Area = 28.26 square inches

Pressure = 2,500 psi

Pressure \times \text{Cylinder Area} = 2,500 \times 28.26 = 70,650 \text{ pounds}

What is the pull force of a 6" diameter cylinder with a 3" diameter rod operating at 2,500 PSI?

Cylinder Rod End Area = 21.19 square inches

Pressure = 2,500 psi

Pressure \times \text{Cylinder Area} = 2,500 \times 21.19 = 52,975 \text{ pounds}
Cylinder Speed (in inches per second):

\[(231 \times \text{GPM}) \div (60 \times \text{Net Cylinder Area})\]

Example: How fast will a 6" diameter cylinder with a 3" diameter rod extend with 15 gpm input?

GPM = 6
Net Cylinder Area = 28.26 square inches

\[(231 \times \text{GPM}) \div (60 \times \text{Net Cylinder Area}) = (231 \times 15) \div (60 \times 28.26) = 2.04 \text{ inches per second}\]

How fast will it retract?
Net Cylinder Area = 21.19 square inches

\[(231 \times \text{GPM}) \div (60 \times \text{Net Cylinder Area}) = (231 \times 15) \div (60 \times 21.19) = 2.73 \text{ inches per second}\]

GPM of Flow Needed for Cylinder Speed:

Cylinder Area x Stroke Length in Inches \div 231 x 60 \div Time in seconds for one stroke

Example: How many GPM are needed to extend a 6" diameter cylinder 8 inches in 10 seconds?
Cylinder Area = 28.26 square inches
Stroke Length = 8 inches
Time for 1 stroke = 10 seconds

Area x Length \div 231 x 60 \div Time = 28.26 \times 8 \div 231 \times 60 \div 10 = 5.88 \text{ gpm}\n
If the cylinder has a 3" diameter rod, how many gpm is needed to retract 8 inches in 10 seconds?
Cylinder Area = 21.19 square inches
Stroke Length = 8 inches
Time for 1 stroke = 10 seconds
Area x Length ÷ 231 x 60 ÷ Time = 21.19 x 8 ÷ 231 x 60 ÷ 10 = 4.40 gpm

**Fluid Pressure in PSI Required to Lift Load (in PSI):**

Pounds of Force Needed ÷ Cylinder Area

Example: What pressure is needed to develop 50,000 pounds of push force from a 6" diameter cylinder?

Pounds of Force = 50,000 pounds

Cylinder Blind End Area = 28.26 square inches

Pounds of Force Needed ÷ Cylinder Area = 50,000 ÷ 28.26 = 1,769.29 PSI

What pressure is needed to develop 50,000 pounds of pull force from a 6" diameter cylinder which has a 3" diameter rod?

Pounds of Force = 50,000 pounds

Cylinder Rod End Area = 21.19 square inches

Pounds of Force Needed ÷ Cylinder Area = 50,000 ÷ 21.19 = 2,359.60 PSI

3. **Hydraulic Motor Calculations**
GPM of Flow Needed for Fluid Motor Speed:

Motor Displacement \times Motor RPM \div 231

Example: How many GPM are needed to drive a 3.75 cubic inch motor at 1500 rpm?

Motor Displacement = 3.75 cubic inches per revolution
Motor RPM = 1500
Motor Displacement \times Motor RPM \div 231 = 3.75 \times 1500 \div 231 = 24.35 \text{ gpm}

Fluid Motor Speed from GPM Input:

231 \times \text{GPM} \div \text{Fluid Motor Displacement}

Example: How fast will a 0.75 cubic inch motor turn with 6 gpm input?

GPM = 6
Motor Displacement = 0.75 cubic inches per revolution
231 \times \text{GPM} \div \text{Fluid Motor Displacement} = 231 \times 6 \div 0.75 = 1,848 \text{ rpm}

Fluid Motor Torque from Pressure and Displacement:

\text{PSI} \times \text{Motor Displacement} \div (2 \times n)

Example: How much torque does a 2.5 cubic inch motor develop at 2,000 psi?
Pressure = 2,000 psi
Motor Displacement = 2.5 cubic inches per revolution
PSI x Motor Displacement ÷ (2 x n) = 2,000 x 2.5 ÷ 6.28 = 796.19 inch pounds

Fluid Motor Torque from GPM, PSI and RPM:

GPM x PSI x 36.77 ÷ RPM

Example: How much torque does a motor develop at 1,200 psi, 1500 rpm, with 10 gpm input?

GPM = 10
PSI = 1,500
RPM = 1200
GPM x PSI x 36.7 ÷ RPM = 10 x 1,500 x 36.7 ÷ 1200 = 458.75 inch pounds second

Fluid Motor Torque from Horsepower and RPM:

Horsepower x 63025 ÷ RPM

Example: How much torque is developed by a motor at 12 horsepower and 1750 rpm?

Horsepower = 12
RPM = 1750
Horsepower x 63025 ÷ RPM = 12 x 63025 ÷ 1750 = 432.17 inch pound
4. Fluid and Piping Calculations

Velocity of Fluid through Piping

\[ 0.3208 \times \text{GPM} \div \text{Internal Area} \]

What is the velocity of 10 gpm going through a 1/2” diameter schedule 40 pipe?

GPM = 10

Internal Area = .304 (see note below)

\[ 0.3208 \times \text{GPM} \div \text{Internal Area} = 0.3208 \times 10 \div 0.304 = 10.55 \text{ feet per second} \]

Note: The outside diameter of pipe remains the same regardless of the thickness of the pipe. A heavy duty pipe has a thicker wall than a standard duty pipe, so the internal diameter of the heavy duty pipe is smaller than the internal diameter of a standard duty pipe. The wall thickness and internal diameter of pipes can be found on readily available charts.

Hydraulic steel tubing also maintains the same outside diameter regardless of wall thickness.

Hose sizes indicate the inside diameter of the plumbing. A 1/2” diameter hose has an internal diameter of 0.50 inches, regardless of the hose pressure rating.
Suggested Piping Sizes:

- Pump suction lines should be sized so the fluid velocity is between 2 and 4 feet per second.
- Oil return lines should be sized so the fluid velocity is between 10 and 15 feet per second.
- Medium pressure supply lines should be sized so the fluid velocity is between 15 and 20 feet per second.
- High pressure supply lines should be sized so the fluid velocity is below 30 feet per second.
4. General Conversions

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