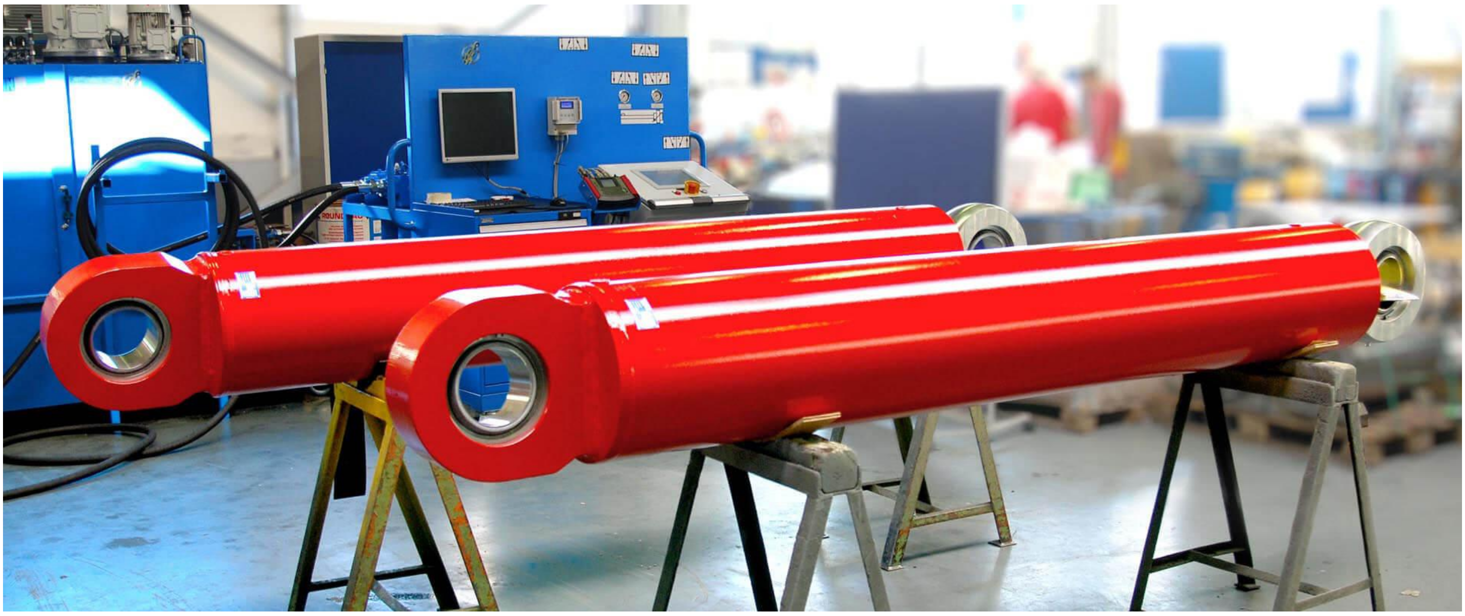
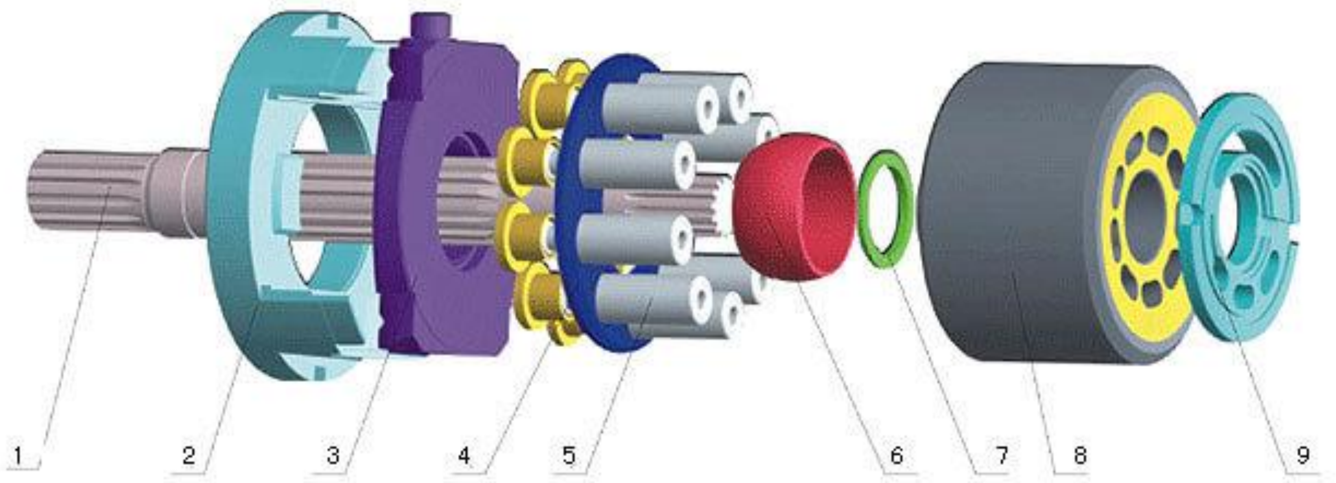
Hydraulic Calculations

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



--Hydraulic Test Bench.jpg

1. Hydraulic Pump Calculations



--Hydraulic Piston Pump.jpg

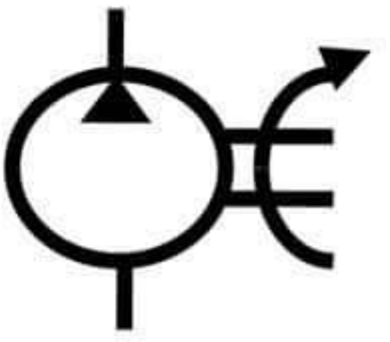
Horsepower Required to Drive Pump:

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



--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

--Double Acting Hydraulic Cylinder.jpg

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 x (Cylinder Radius)2

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

Diameter = 6"

Radius is 1/2 of diameter = 3"

Radius2 = 3" x 3" = 9"

π x (Cylinder Radius)2 = 3.14 x (3)2 = 3.14 x 9 = 28.26 square inches

Cylinder Blind End Output (GPM):

Blind End Area ÷ Rod End Area x 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

Blind End Area ÷ Rod End Area x GPM In = 28.26 ÷ 21.19 x 15 = 20 gpm

Cylinder Output Force (in pounds):

Pressure (in PSI) x 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 x Cylinder Area = 2,500 X 28.26 = 70,650 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 x Cylinder Area = 2,500 x 21.19 = 52,975 pounds

--Hydraulic Cylinder.jpg

Cylinder Speed (in inches per second):

(231 x GPM) ÷ (60 x 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 x GPM) ÷ (60 x Net Cylinder Area) = (231 x 15) ÷ (60 x 28.26) = 2.04 inches per second

How fast will it retract?

Net Cylinder Area = 21.19 square inches

(231 x GPM) ÷ (60 x Net Cylinder Area) = (231 x 15) ÷ (60 x 21.19) = 2.73 inches per second

GPM of Flow Needed for Cylinder Speed:

Cylinder Area x Stroke Length in Inches ÷ 231 x 60 ÷ 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 ÷ 231 x 60 ÷ Time = 28.26 x 8 ÷ 231 x 60 ÷ 10 = 5.88 gpm

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

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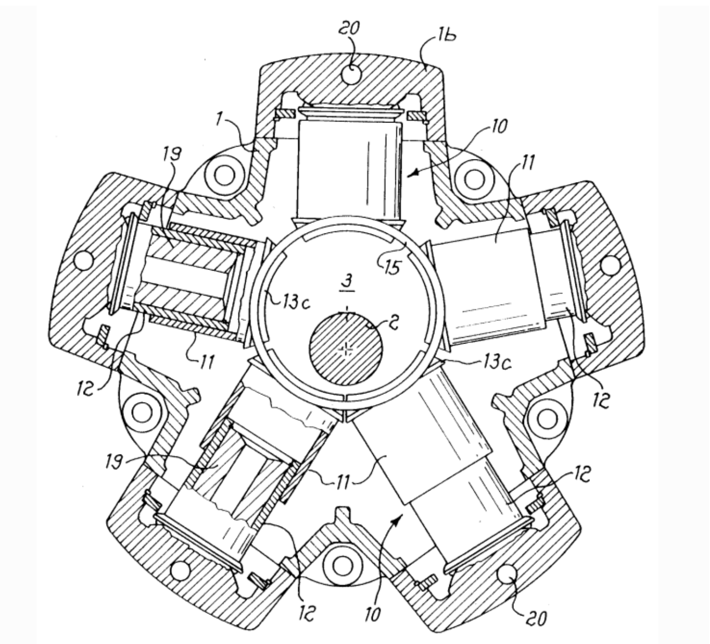
3. Hydraulic Motor Calculations



--Hydraulic motor.jpg

GPM of Flow Needed for Fluid Motor Speed:

Motor Displacement x Motor RPM ÷ 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 x Motor RPM ÷ 231 = 3.75 x 1500 ÷ 231 = 24.35 gpm

Fluid Motor Speed from GPM Input:

231 x GPM ÷ 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 x GPM ÷ Fluid Motor Displacement = 231 x 6 ÷ 0.75 = 1,848 rpm

Fluid Motor Torque from Pressure and Displacement:

PSI x Motor Displacement ÷ (2 x п)

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 п) = 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:

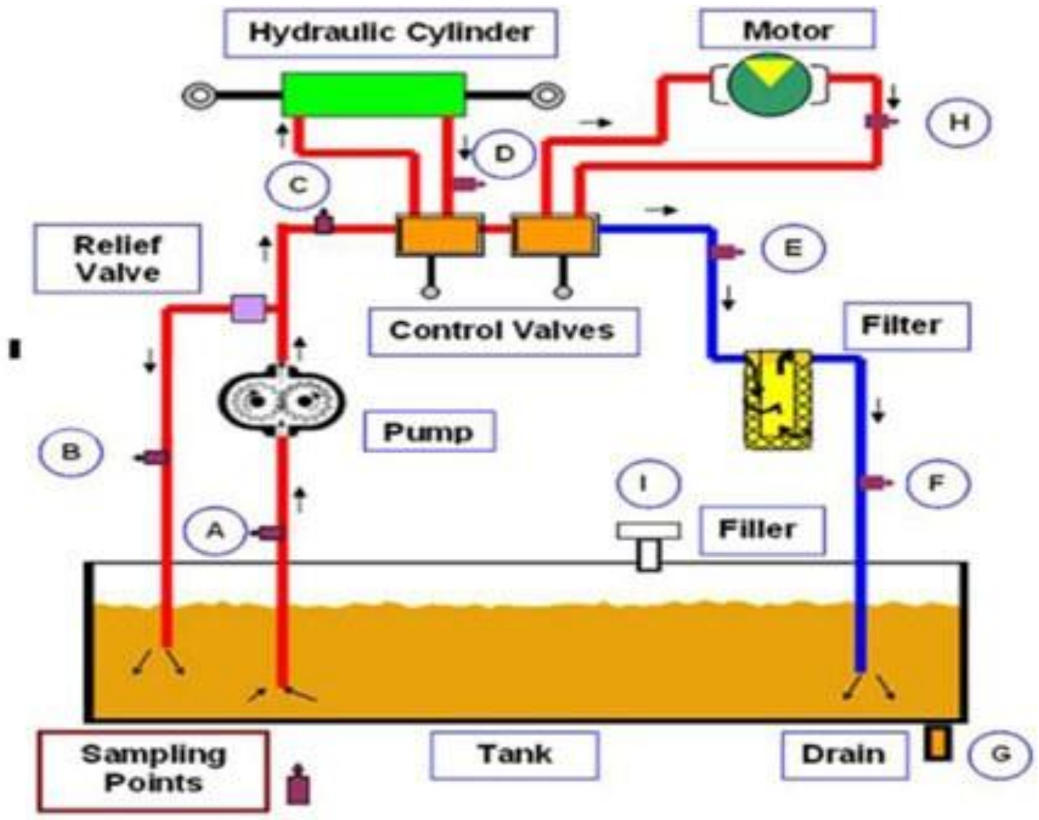
Horsepower x 63025 ÷ RPM

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



--hydraulic-system.jpg

4.Fluid and Piping Calculations

Velocity of Fluid through Piping

0.3208 x GPM ÷ 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 x GPM ÷ Internal Area = .3208 x 10 ÷ .304 = 10.55 feet per second

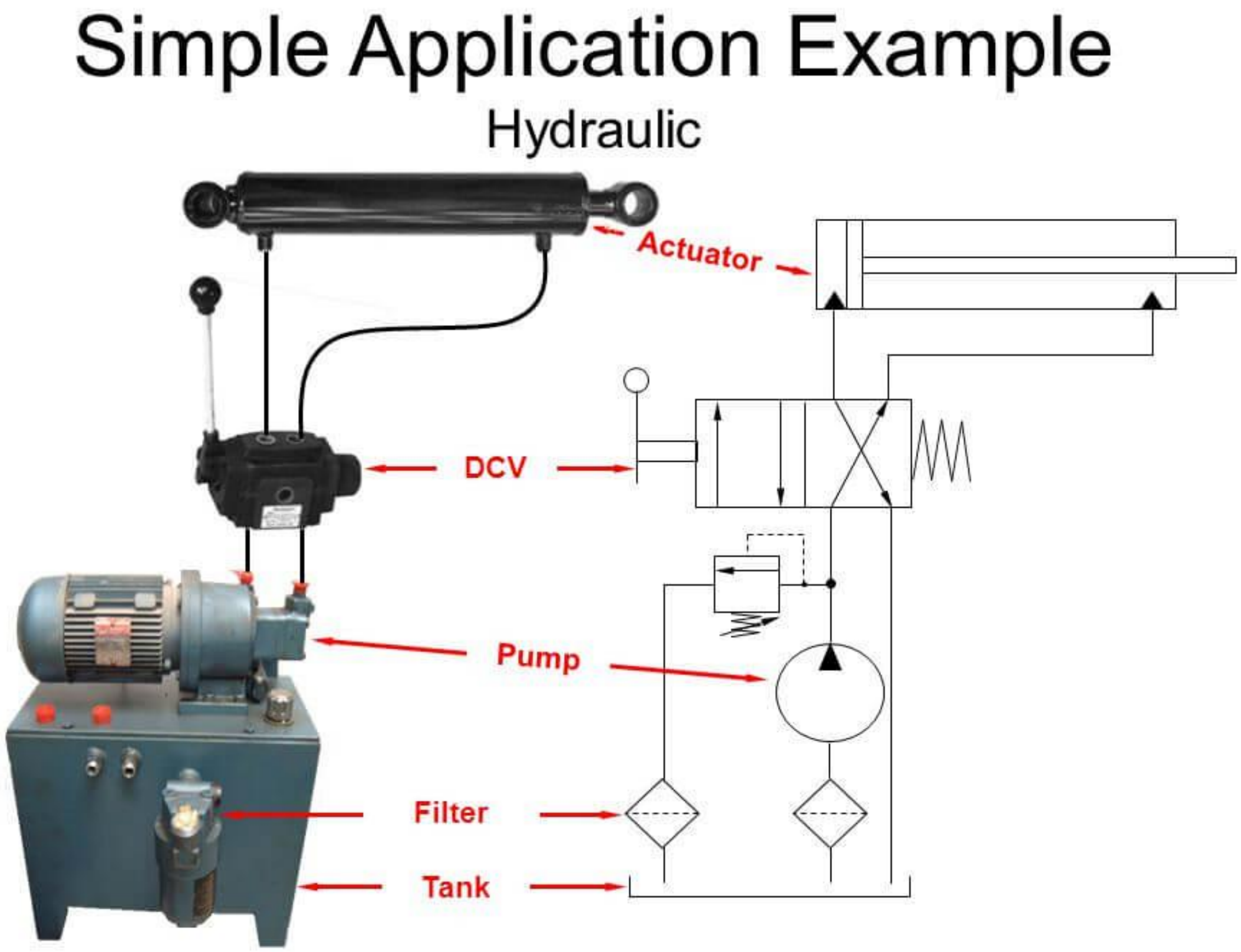
Note: The outside diameter of pipe remains the same regardless of the thickness of the pipe. A heavy duty pipe has a thicker wall than a standard duty pipe, so the internal diameter of the heavy duty pipe is smaller than the internal diameter of a standard duty pipe. The wall thickness and internal diameter 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.



--simple-hydraulic-system.jpg

4.General Conversions

To Convert	*Into*	*Multiply By*
Bar	PSI	14.5
cc	Cu. In.	0.06102
°C	°F	(°C x 1.8) + 32
Kg	lbs.	2.205
KW	HP	1.341
Liters	Gallons	0.2642
mm	Inches	0.03937
Nm	lb.-ft	0.7375
Cu. In.	cc	16.39
°F	°C	(°F - 32) ÷ 1.8
Gallons	Liters	3.785
HP	KW	0.7457
Inch	mm	25.4
lbs.	Kg	0.4535
lb.-ft.	Nm	1.356
PSI	Bar	0.06896
In. of HG	PSI	0.4912
In. of H_2O	PSI	0.03613

Target hydraulics assumes no liability for errors in data nor in safe and/or satisfactory operation of equipment designed from this information.