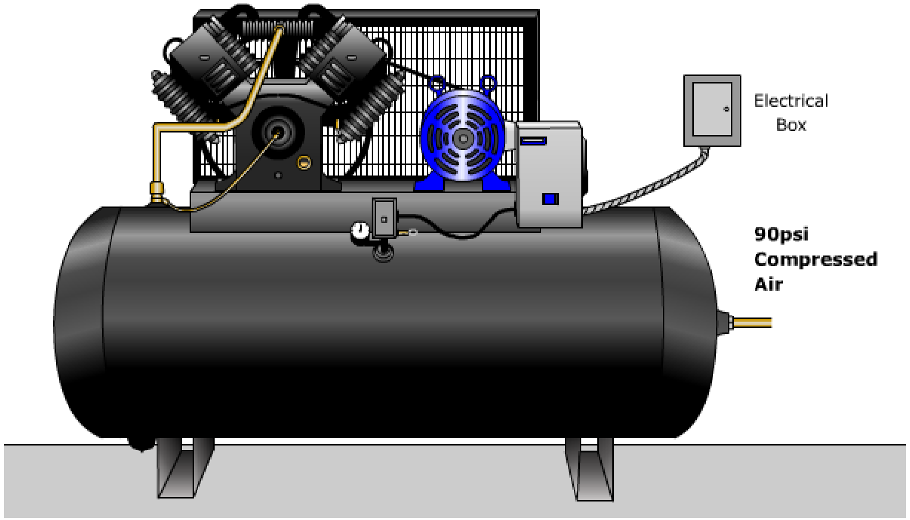
Hydraulic and Pneumatic Power Systems

Power Unit

- Provides Energy for operation of the system
- Moves the fluid through the system
- Provides a safe maximum limit on system pressure.
- Assists to maintain proper system operating temperature and fluid cleanliness.
- Consist of Prime mover, Coupler, Pump, Storage, Pressure control valve, Filters and Strainers

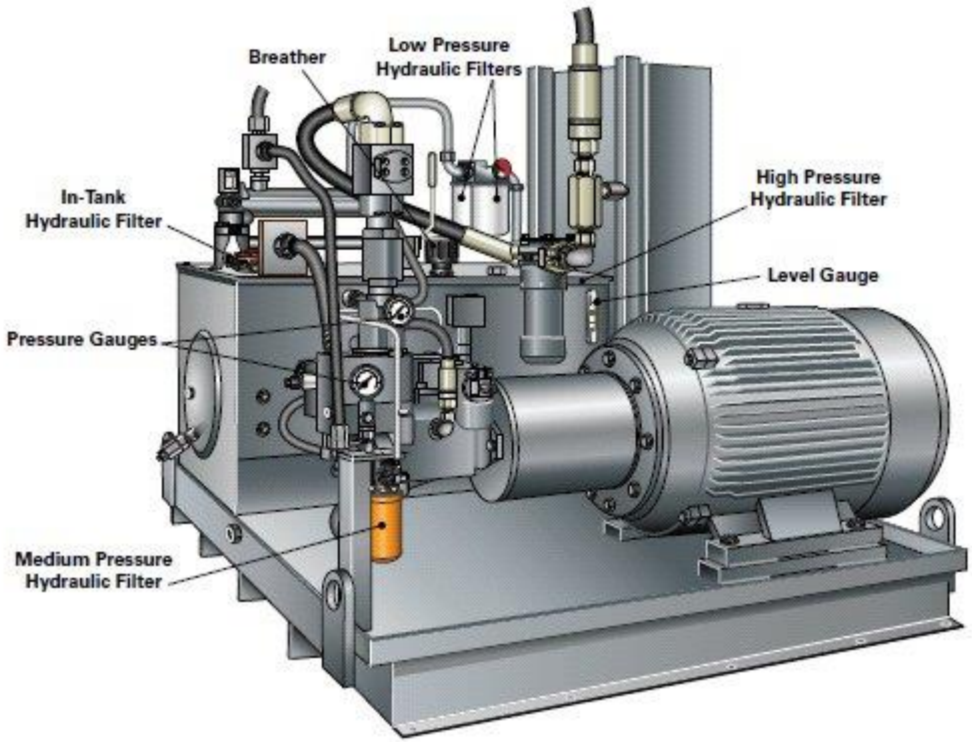
Power Unit



Hydraulic Power Unit

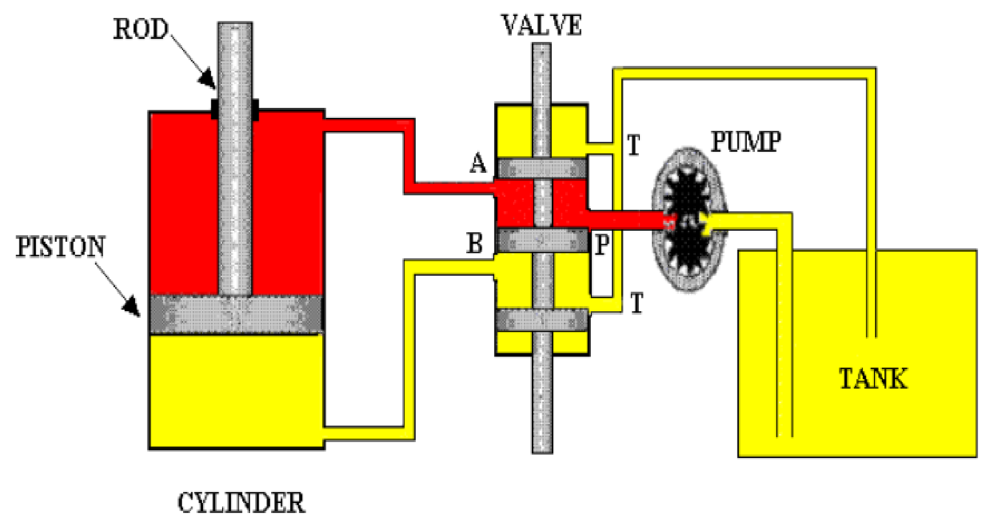
Components

- Prime Mover
- Pump
- Coupler
- Reservoir
- Pressure control valve
- Filters and strainers



Hydraulic Pump

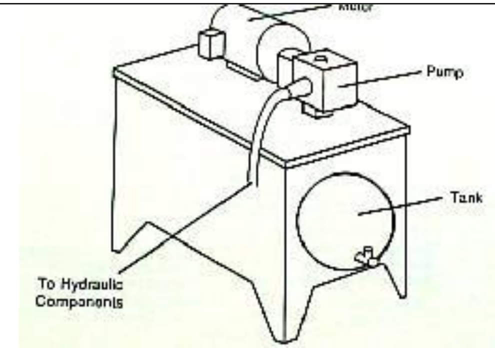
- The device that causes the fluid to move through the system carrying the energy to the point where it is needed.
- Selection of the pump depends on the
  - System flow rate
  - System operating pressure
  - Other requirements



Classification

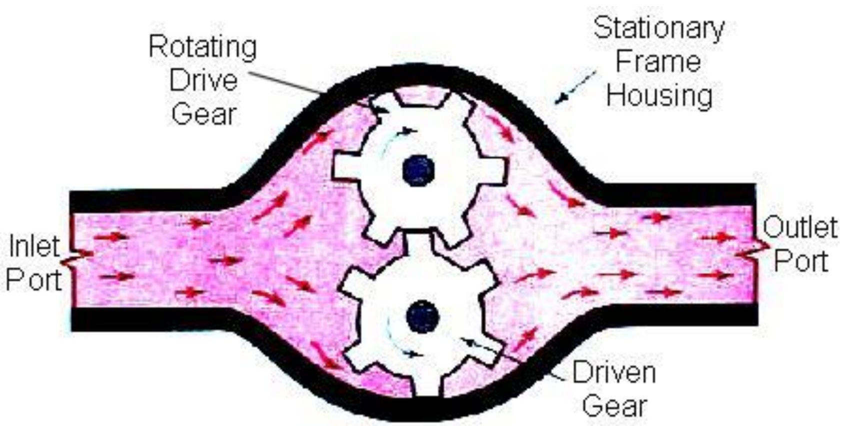
- Displacement – Positive or Non-positive
- Pumping motion – Rotary or Reciprocating
- Fluid delivery characteristics – Fixed-delivery or Variable delivery

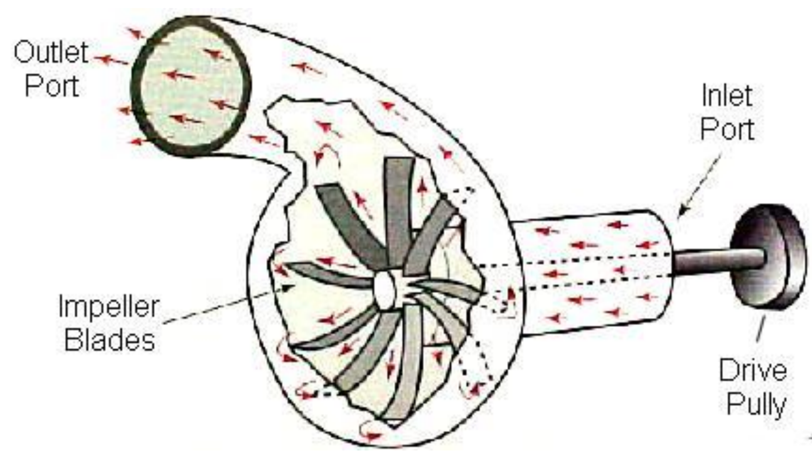
Positive or Non-positive Displacement



- Positive displacement pump (Gear Pump): a specific amount of fluid passes through the pump for each rotation

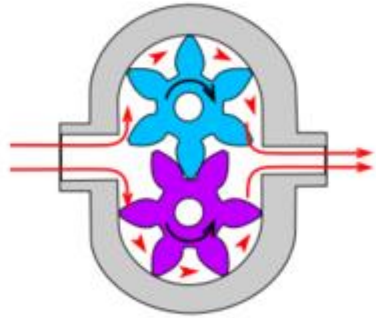
- Centrifugal pump: no specific amount of fluid flow per rotation; flow depends on speed of blades

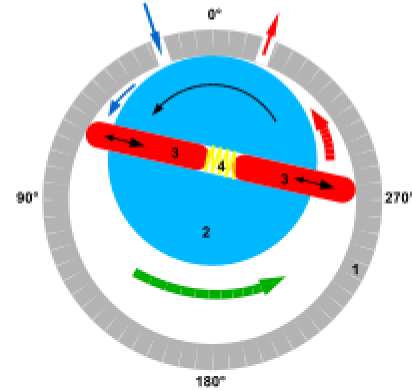


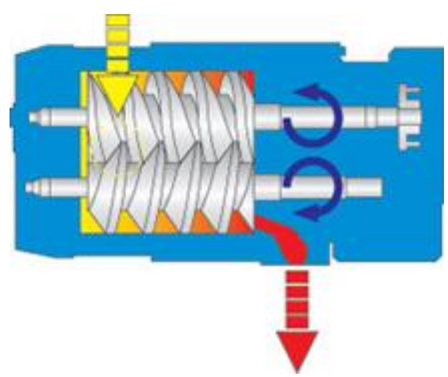


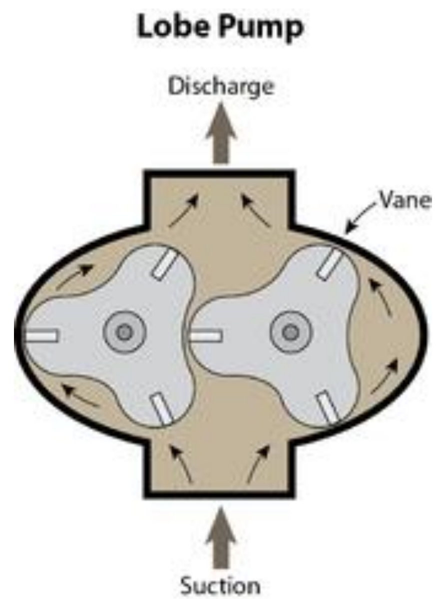
Types

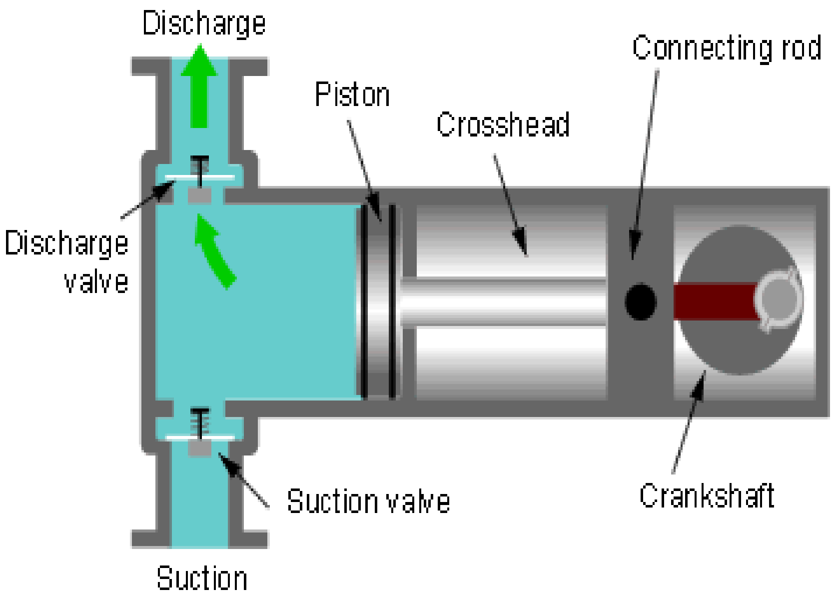
- Gear Pump
- Vane Pump
- Piston Pump
- Screw Pump
- Lobe Pump
- Centrifugal Pump
- Propeller Pump
- Jet Pump

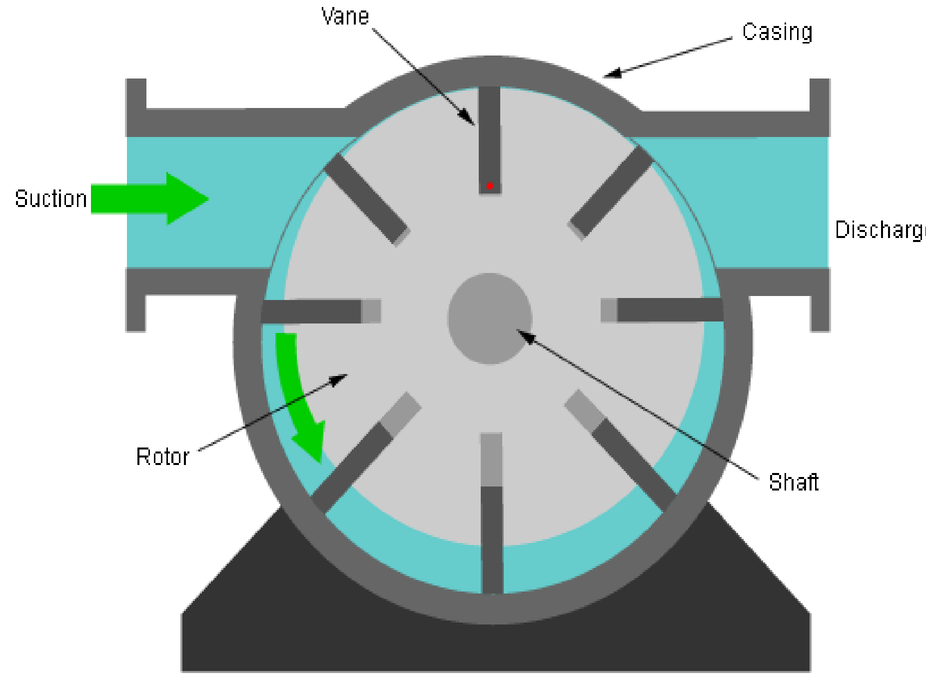


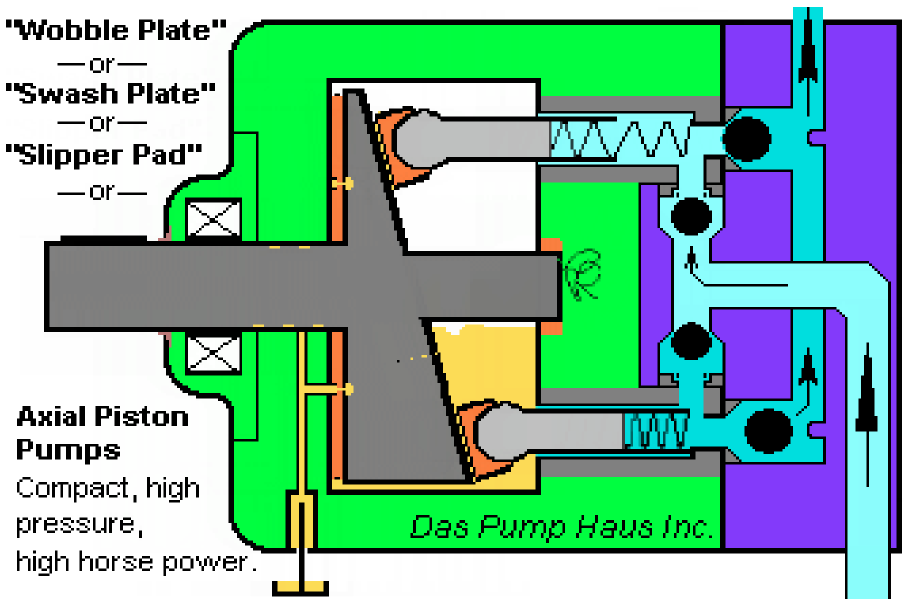


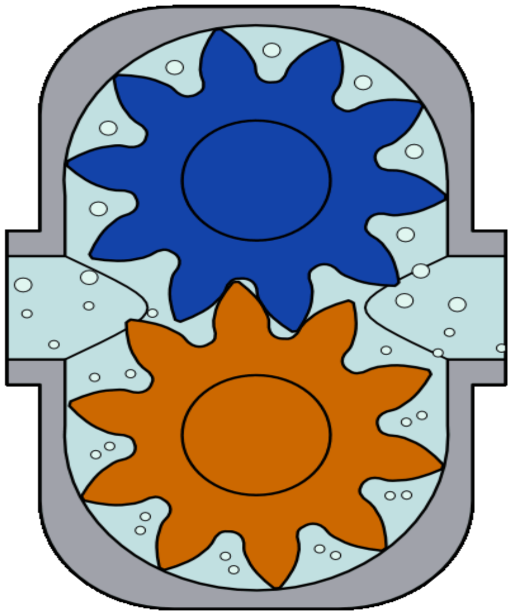





Discharge
Piston
Crosshead
Connecting rod
Discharge valve
Suction valve
Crankshaft
Suction


Vane
Casing
Suction
Discharge
Rotor
Shaft


"Wobble Plate"
—or—
"Swash Plate"
—or—
"Slipper Pad"
—or—
Axial Piston Pumps
Compact, high pressure,
high horse power.
Das Pump Haus Inc.



Pump and Power Unit Design

- Design of the Power unit involve selection of adequately sized pump, prime mover and plumbing to assure that the expected task can be performed.
- Three concepts are needed
  - Reading pump specification
  - Calculating system power requirement
  - Designing pump inlet line to eliminate cavitation

SHAFT POWER

- The shaft power of a pump is the mechanical power transmitted to it by the motor/prime mover.
- It is the product of peed and torque:

$$S.P. = T\omega$$

  - ω is the angular speed of the shaft in radians/s and
  - T is the torque transmitted in Nm.
  - Since speed is more usually measured in rev/min , N

$$S.P. = (2\pi N/60)T$$

FLUID POWER

- Fluid power is the energy per second carried in the fluid in the form of pressure and quantity.
- It is defined mathematically as

$$F.P. = Q\,\Delta p$$

  - Q is the flow rate in m^3/s and
  - Δp the change in pressure over the pump in N/m^2 .
-

OVERALL EFFICIENCY

- The overall efficiency is the ratio of output power (Fluid Power) to input power (Shaft Power).
- Because of friction and internal leakage, the power input to a pump is larger than the fluid power (added to the fluid). The overall efficiency of the pump is hence:

$$\eta = F.P./S.P.$$

Pump Selection Factors

- Cost
- Pressure ripple and noise
- Suction Performance
- Contaminant sensitivity
- Speed
- Weight
- Fixed or Variable displacement
- Maximum Pressure and flow or Power
- Fluid type

Flow rate

- For the ideal Machine with no leakage, the displacement of the machine and its speed of rotation determine the flow rate Q

$$Q = D\omega$$

where D is volumetric displacement [m^3 rad^{-1}]
ω is the rotational speed [rad sec^{-1}]

Torque and Pressure Relation

- For the ideal machine, the mechanical Power is entirely converted to fluid power

$$Power = T\omega = \Delta PQ$$

$$T = \frac{\Delta PQ}{\omega}$$

$$T = \Delta PD$$

$$T \alpha \Delta P$$

Where T is the torque [Nm]
P is the differential pressure [N m^{-2}]

Volumetric Efficiency

- The internal flow leakage in pumps affects the relationship between flow and speed

$$Q = \eta_v D \omega$$

- The volumetric efficiency varies with **fluid viscosity, pressure and rotating speed**

Mechanical Efficiency

- The presence of friction between moving parts creates mechanical losses that are represented by the mechanical efficiency
- Input torque:

$$T = \frac{\Delta P D}{\eta_m}$$

- The mechanical efficiency varies with fluid viscosity, pressure and rotating speed

Power Input

- The power input to a pump is

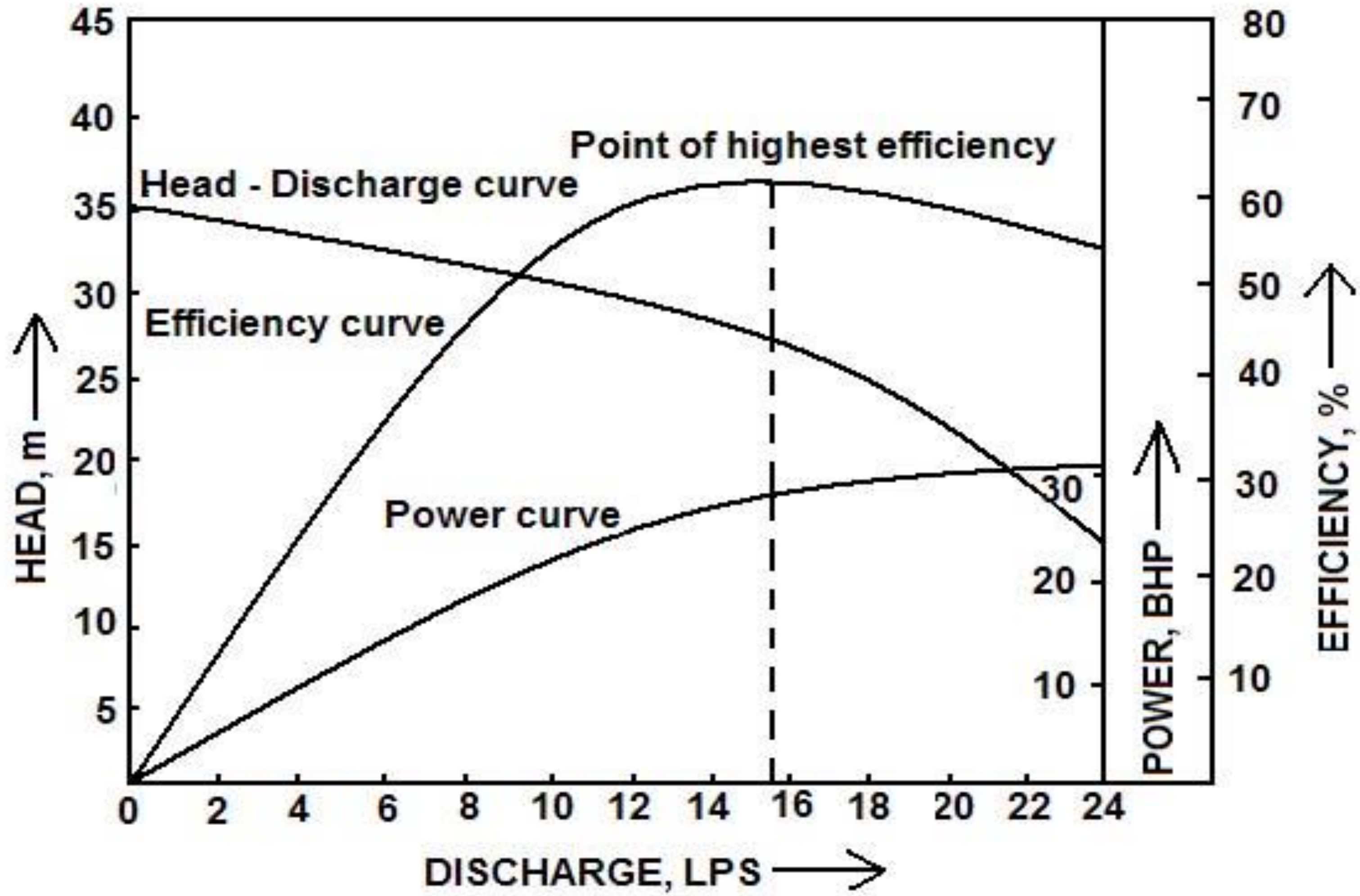
$$H = \frac{\Delta PQ}{\eta_v \eta_m}$$

- With total machine efficiency

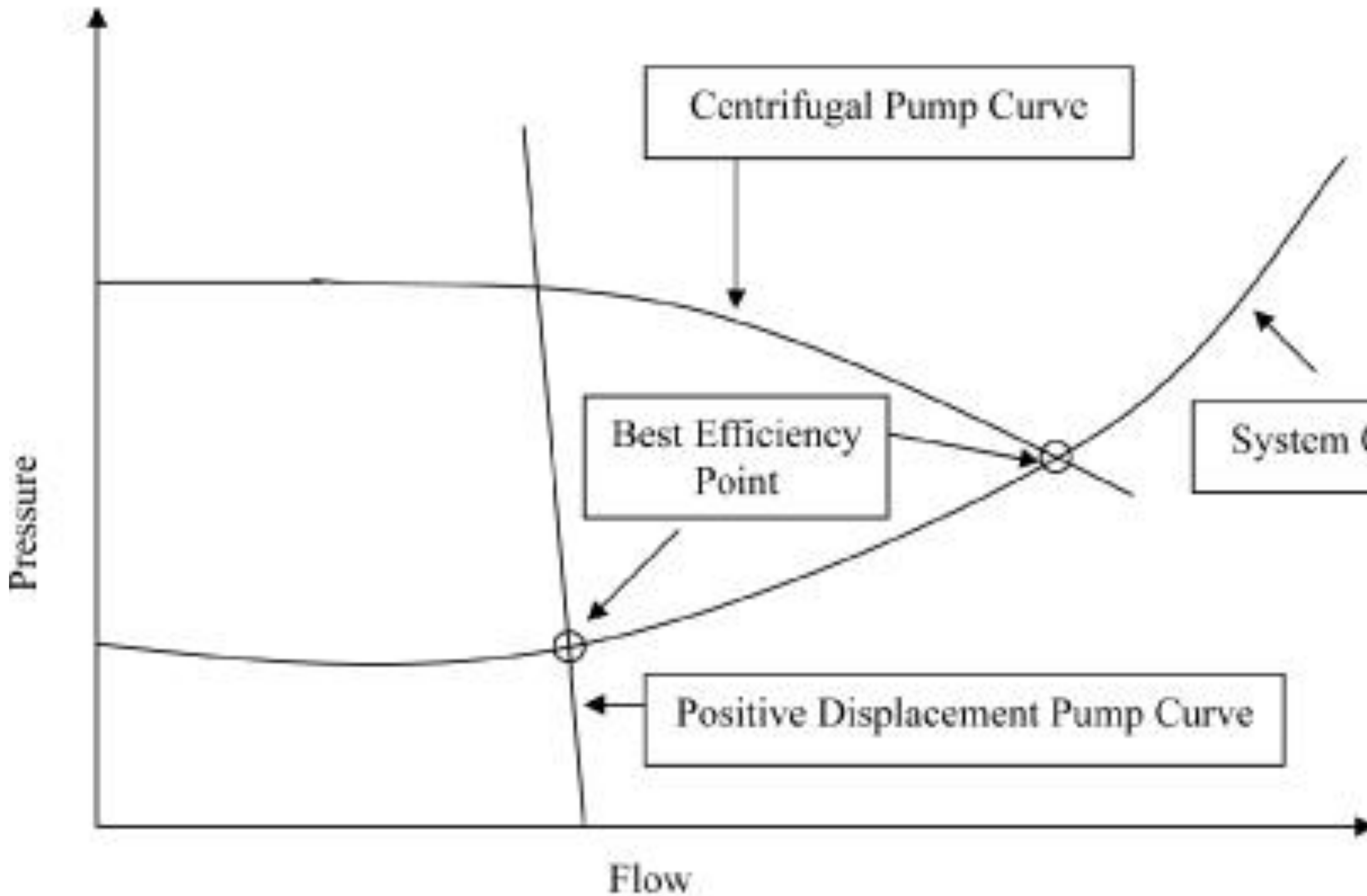
$$\eta_T = \eta_v \eta_m$$

$$H = \frac{\Delta PQ}{\eta_T}$$

Pump characteristics



Pump characteristics

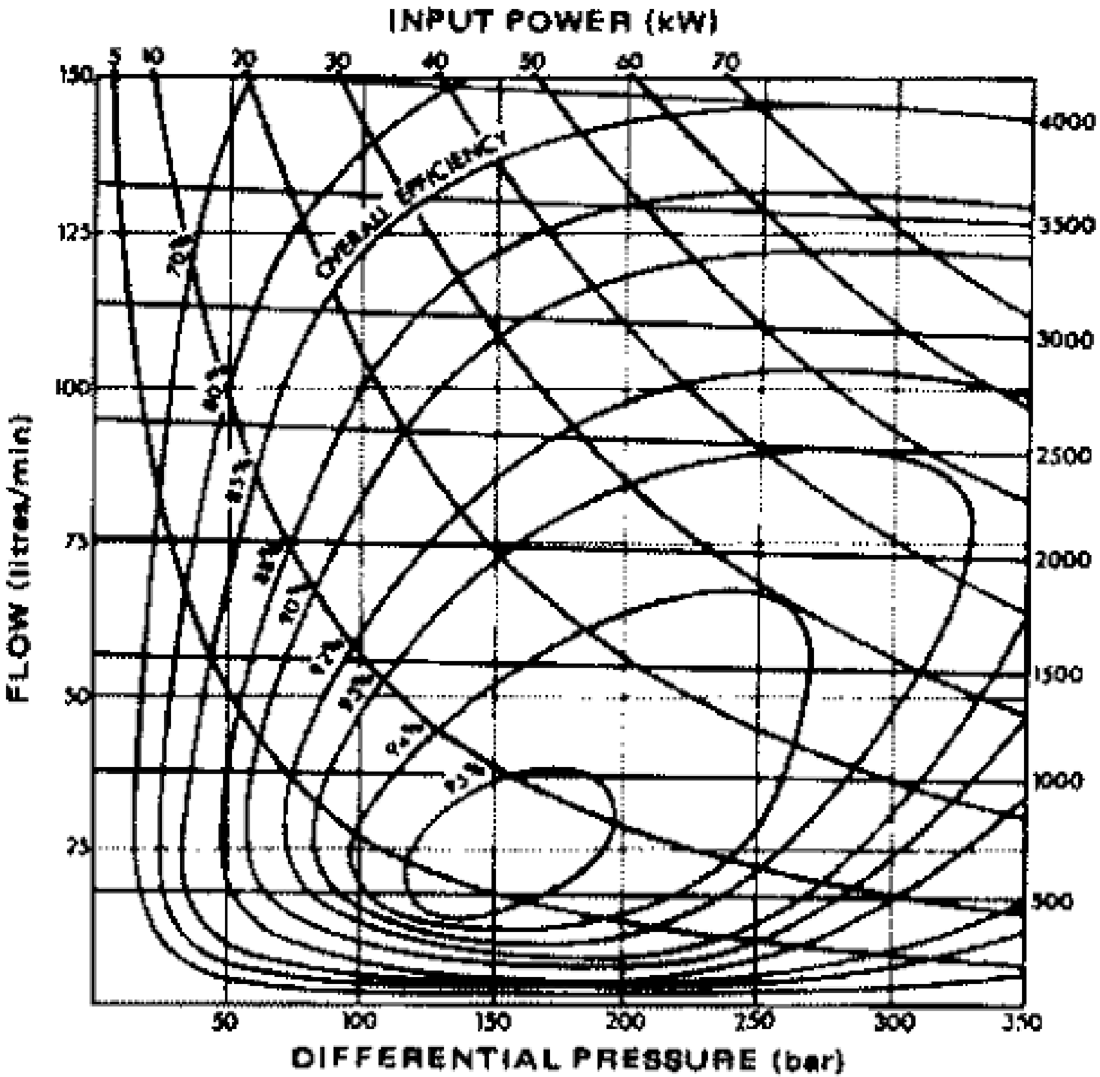


Power Unit efficiency

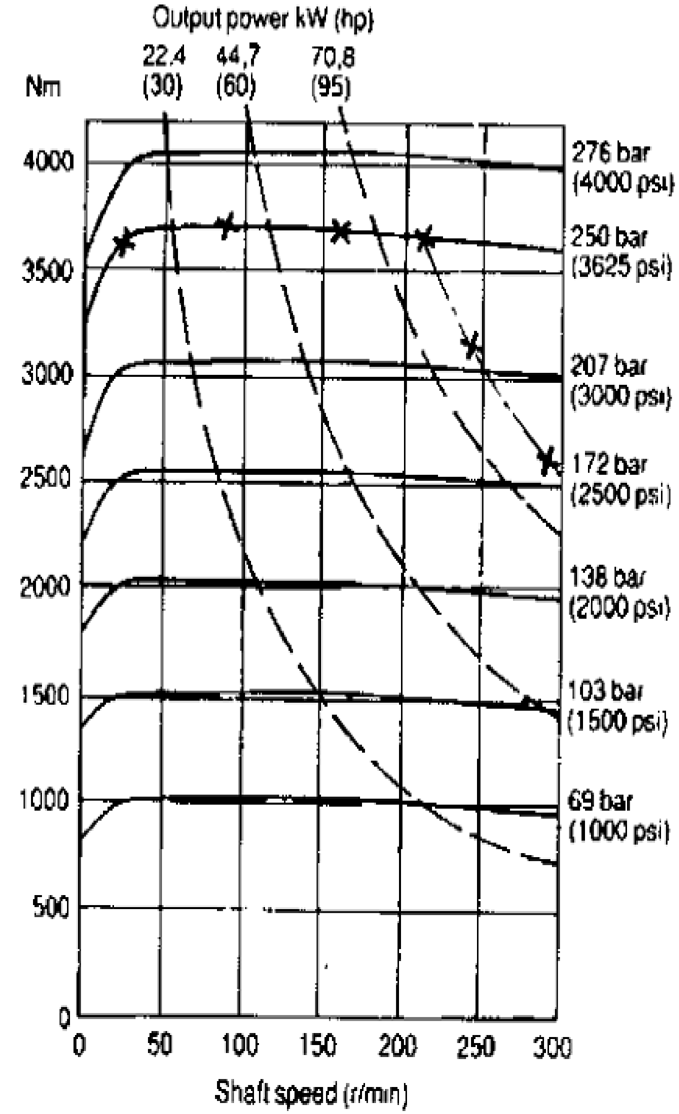
$$Volumetric\ Efficiency\ (Ve) = \frac{actual\ pump\ flow\ rate}{theoritical\ pump\ flow\ rate} \times 100$$

$$Mechanical\ Efficiency\ (Me) = \frac{theoretical\ HP\ needed\ to\ operate\ pump}{actual\ HP\ required\ to\ operat\ pump} \times 100$$

$$Overall\ Efficiency\ (Oe) = \frac{Ve\ \times Me}{100}$$



INPUT POWER (kW)
5
10
20
30
40
50
60
70
OVERALL EFFICIENCY
FLOW (litres/min)
150
125
100
75
50
25
SPEED (rev/min)
4000
3500
3000
2500
2000
1500
1000
500
50
100
150
200
250
300
350
DIFFERENTIAL PRESSURE (bar)



Output power kW (hp)
22,4 (30)
44,7 (60)
70,8 (95)
Nm
4000
3500
3000
2500
2000
1500
1000
500
0
276 bar (4000 psi)
250 bar (3625 psi)
207 bar (3000 psi)
172 bar (2500 psi)
138 bar (2000 psi)
103 bar (1500 psi)
69 bar (1000 psi)
0
50
100
150
200
250
300
Shaft speed (r/min)

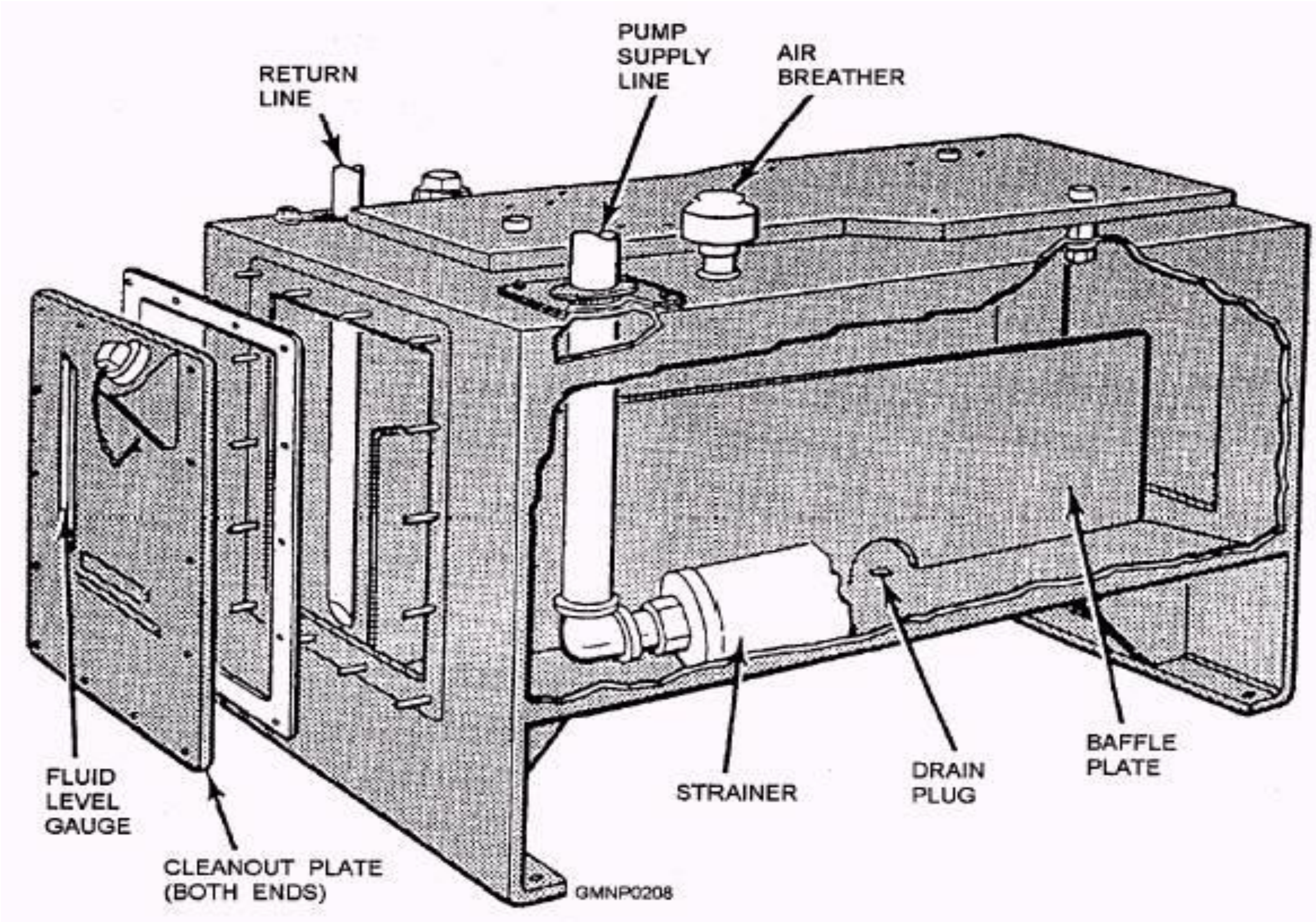
Data from Manufacturer

- General Specification
  - Displacement per revolution
  - Flow at rated speed and pressure
  - Maximum rated speed
  - Continue rated operating pressure
  - Allowable inlet line vacuum
- Performance Data
  - Overall pump efficiency
  - Volumetric efficiency
- Installation Drawing
  - Information about shape and size of pump
- Application Information
  - General information about pump installation and operation

Reservoir

- The reservoir has four basic purposes:
  - holds a reserve supply of oil for the hydraulic system,
  - dissipates heat from the hydraulic system,
  - settles larger contaminates from the system oil and
  - helps dissipate air from the system oil.

Reservoir



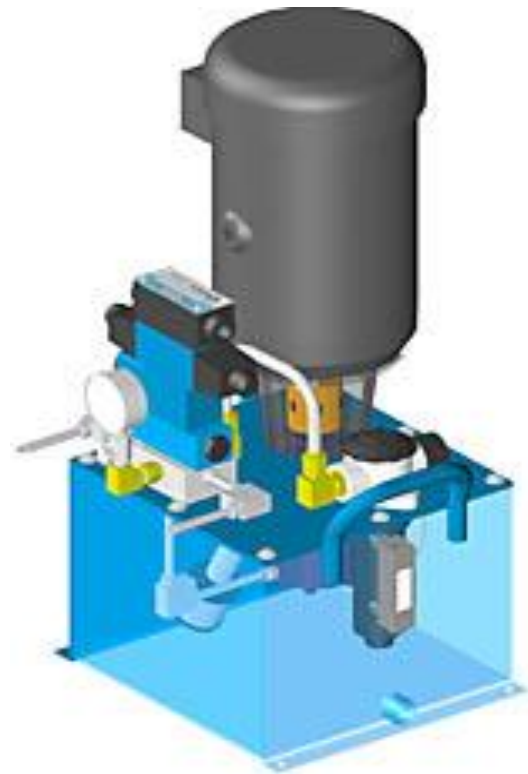
RETURN LINE
PUMP SUPPLY LINE
AIR BREATHER
FLUID LEVEL GAUGE
CLEANOUT PLATE (BOTH ENDS)
STRAINER
DRAIN PLUG
BAFFLE PLATE
GMNP0208

Reservoir

- The reservoir must be large enough to handle the fluctuation of oil volume used in the system when extending and retracting cylinders.
- Single action cylinders require the most oil because there is normally no return oil from the cylinder as it is being extended. The larger the cylinder, the more oil volume required.
- Maintaining the proper oil level in the reservoir is of utmost importance for satisfactory operation of a Power Unit.
- Too high an oil level may cause messy overflow, blow the seal between the reservoir and adaptor, clog the breather and foam. causing cavitation of the pump
- Foaming will lead to poor pump performance and eventual damage to the pump and other components in the hydraulic system.

Reservoir shape

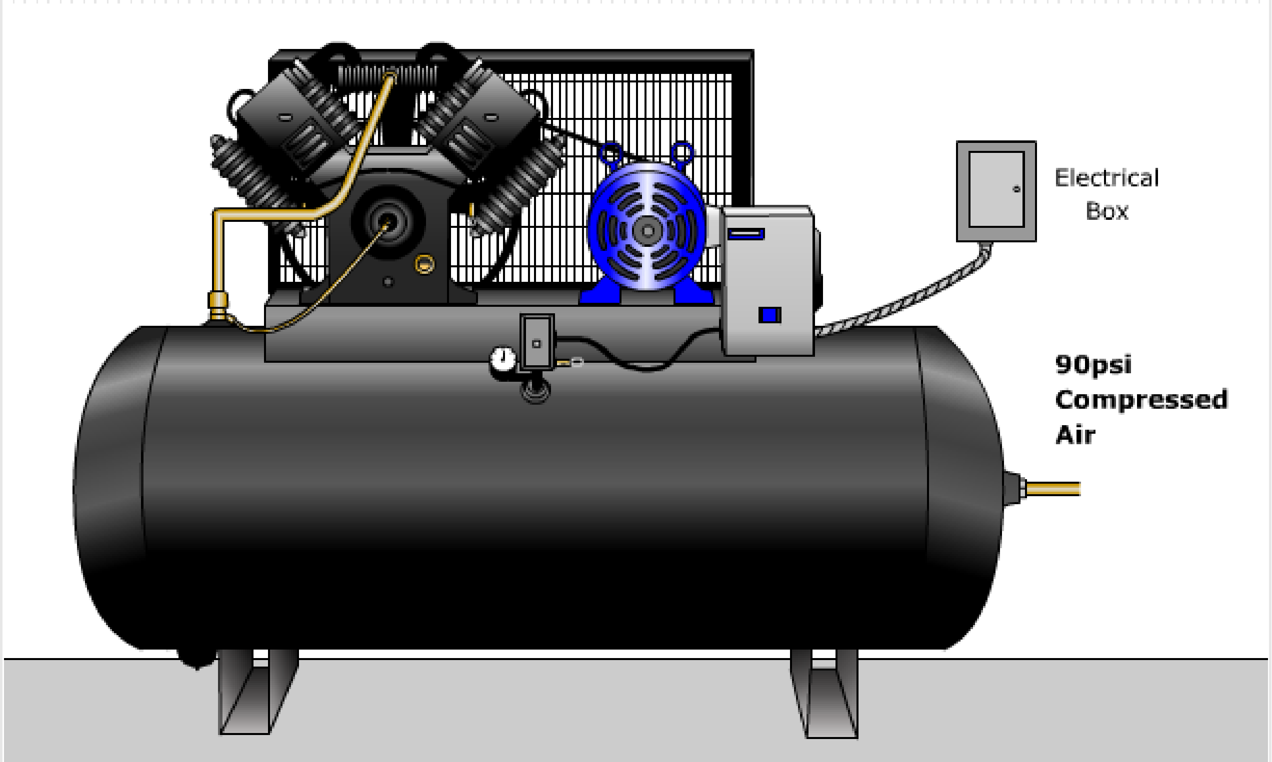
- High reservoir is good for heat dissipation
- Wide reservoir is good for air separation
- Intake and return lines should be as far as possible and beneath lowest oil level
- Baffle & Separation plate between intake and return areas.
- Base plate should slope down to drain screw.
- Ventilation & exhaust to balance the pressure in case of fluctuating oil level. Not necessary in case of closed reservoirs



Problems Associated with Reservoirs

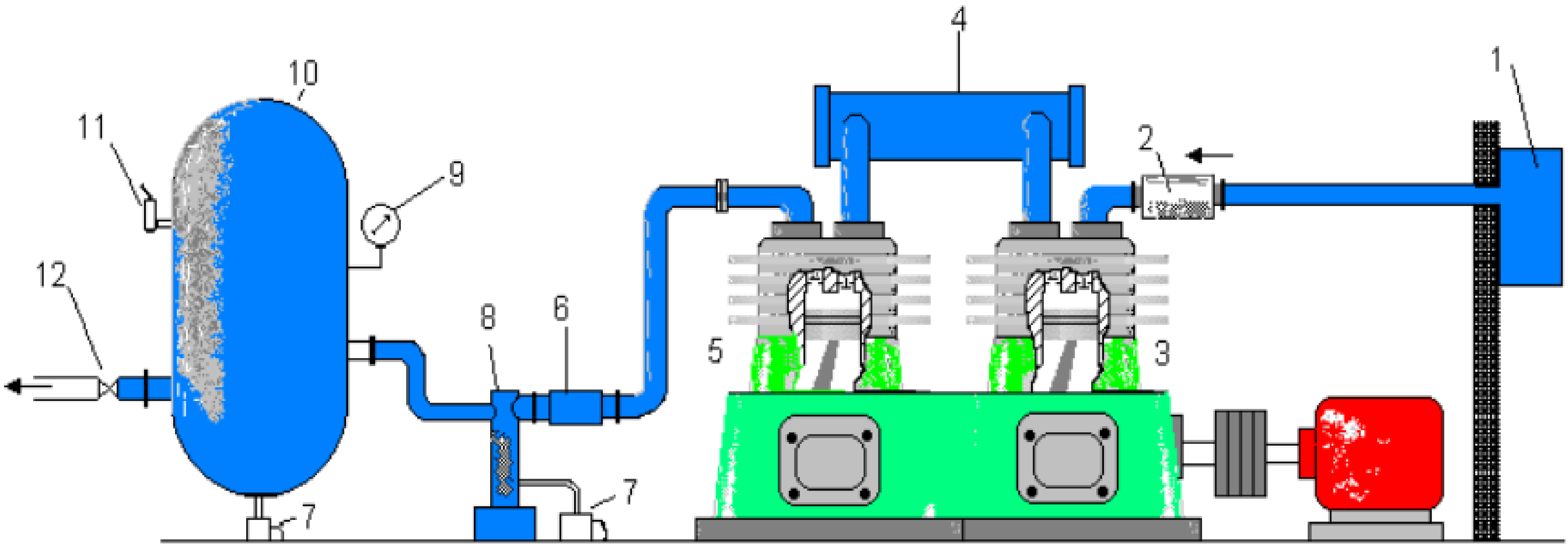
- **MOTOR AND PUMP RUNS BUT HYDRAULIC SYSTEM DOES NOT FUNCTION**.
  - Check oil level in reservoir, fill reservoir to proper fluid level with recommended hydraulic fluid.
- **SLOW OPERATION OF HYDRAULIC SYSTEM**.
  - Check oil level in reservoir, low oil supply could cause erratic operation of system. Fill to proper level.
  - Caution! Overfilling may cause foaming and poor performance.
- **HYDRAULIC SYSTEM OIL TOO HOT**
  - Check fluid level in reservoir, low oil supply can prevent heat dissipation. Fill to proper level.

Pneumatic Power Unit



Compressed air Unit

- Provide the prime mover energy needed to compress air
- Control air temperature, retained water vapour and entrapped dirt.
- Provides means of controlling maximum air pressure in the system
- Store and condition air until needed at the workstation.

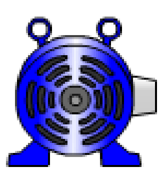


2 STAGE RECIPROCATING COMPRESSOR

Components

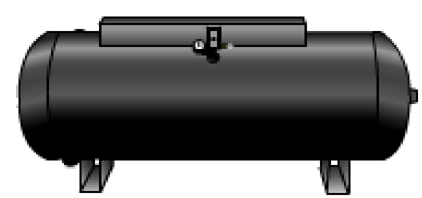
- Prime mover
- Compressor
- Receiver
- Capacity limiting system
- Safety valve
- Air filter
- Cooler and dryer

Prime Mover



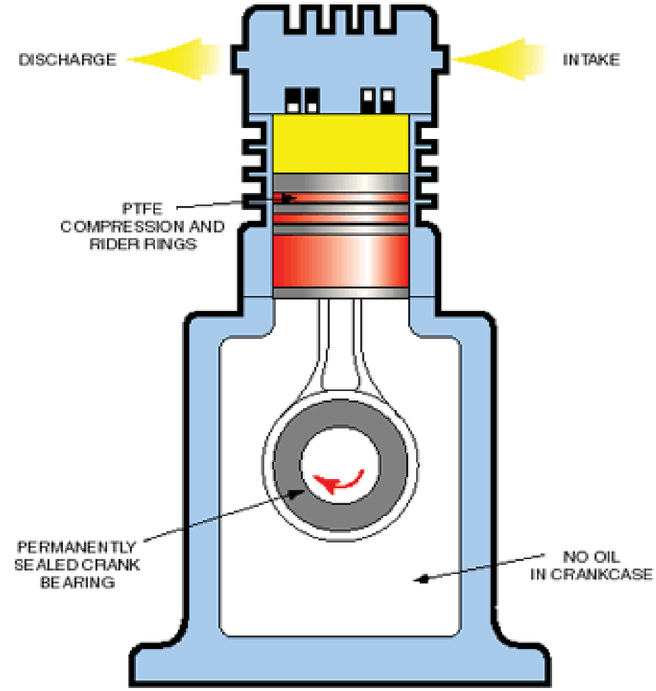
Compressor

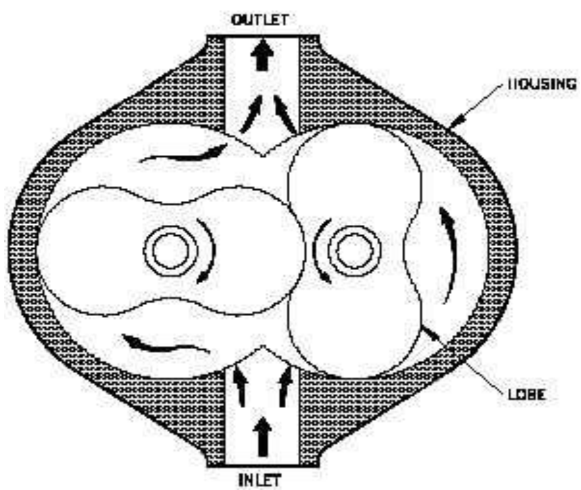
Receiver Tank

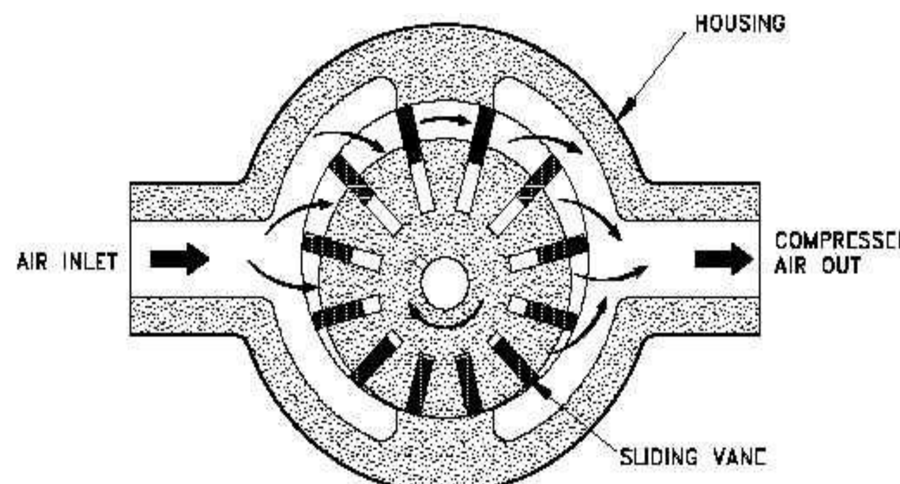


Compressor types

- Reciprocating-piston compressors
  - Single-Acting
  - Double-Acting
- Rotary, sliding vane compressors
- Rotary screw compressors
- Dynamic compressors
- Lobe-type compressors

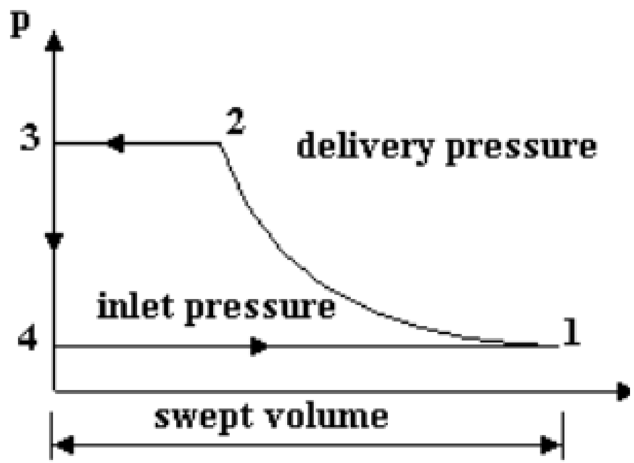




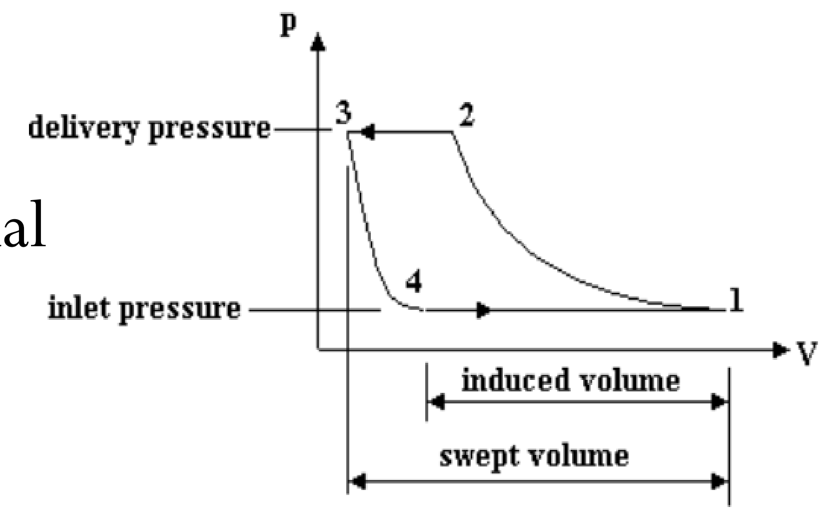


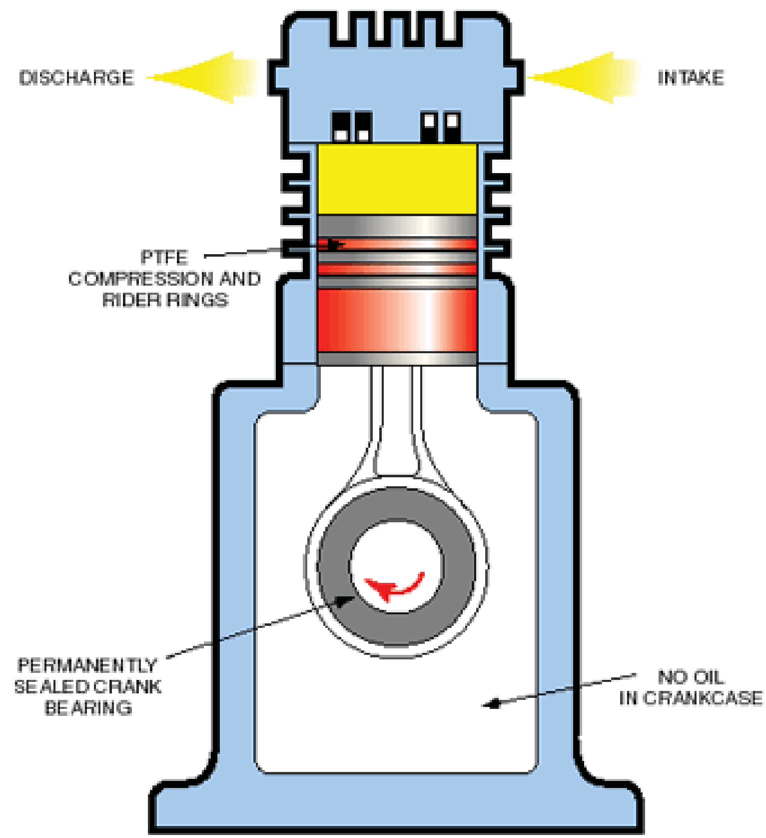
Reciprocating-piston compressors

Ideal



Actual





Selecting a Compressor Package

- Establish needed capacity for the pneumatic system – requires listing of all tools and equipment to be operated.
- Estimate increases in system demand
- Select a compressor type
- Select a system prime mover
- Determine the regulation method to control volume of air delivery.
- Select auxiliary components