Solo Technopark

Pump Operation, Maintenance and Troubleshooting (for Mechanical Rotating)

Introduction

- This module covers:
  - Pump
  - Specification and selection for centrifugal pump.
  - Mechanical selection
  - Maintenance and repair part for centrifugal Pump
  - Troubleshooting centrifugal pump and positive displacement pump

Aims

In this module, you will be understanding of the various types of reciprocating, rotary, and centrifugal pumps. The characteristics, selection criteria, sizing calculations, sealing arrangements, common problems, repair techniques, as well as the preventive and predictive maintenance of these pumps are covered in detail

Objectives

- Maximize the efficiency, reliability, and longevity of all types of pumps.
- Size and select out of the various types of dynamic and positive displacement pumps using the performance characteristics and the selection criteria that you learn in this program.
- Carry out diagnostic testing and inspection of critical components with the knowledge of common failure modes of pumps by applying advanced fault detection techniques.

Objectives

- Select bearings and lubrication, pump sealing arrangements, meet commissioning requirements, troubleshoot, provide predictive and preventive maintenance, enhance reliability, and reduce cost.
- Determine the maintenance required to minimize pump downtime and operating cost and maximize its efficiency, reliability, and useful life.
- Gain a thorough understanding of pump characteristics.

Objectives

- Understand all the causes of failures in pumps.
- Determine all the design features that improve the efficiency and reliability of all pumps.

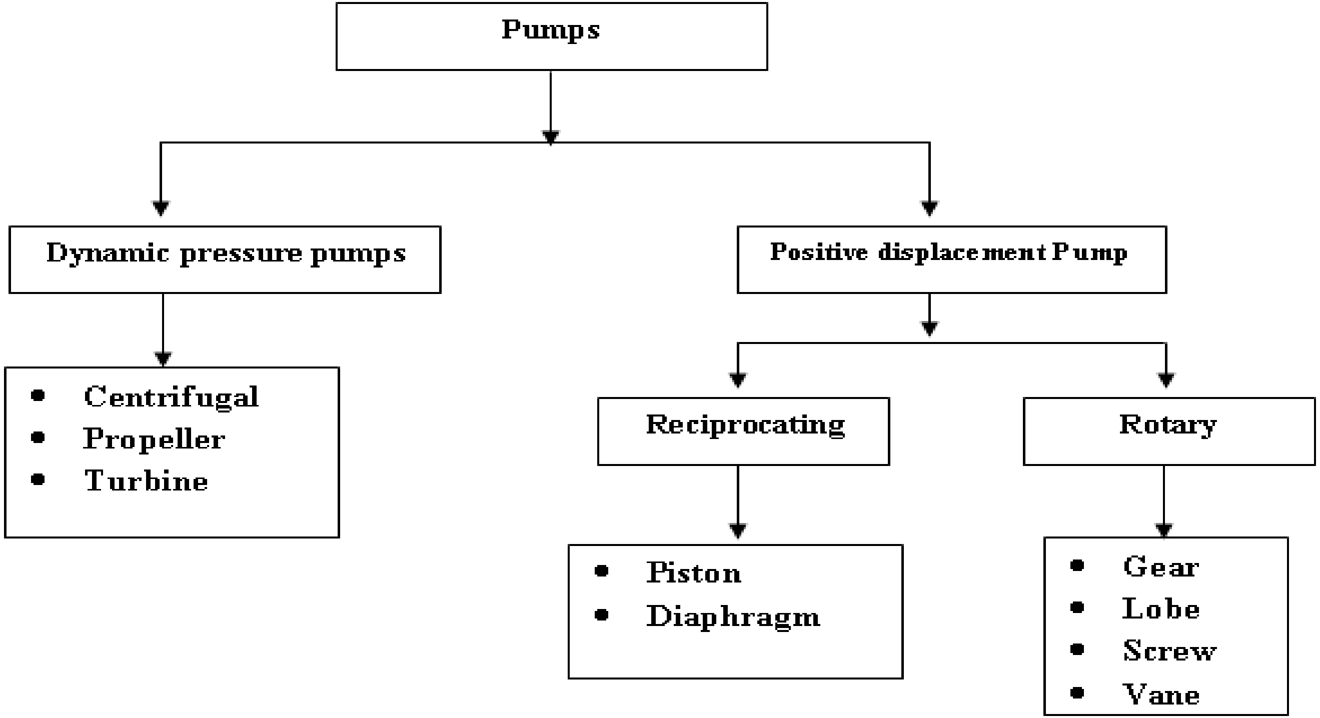
Pump General Overview

- A pump is a mechanical device that works to move the fluid where in the process there is a change in pressure.
- In the concept of thermodynamics, the pump is a system in which the fluid flowing in it experiences a state of increasing pressure, flow rate and temperature.
- Pumps have two main purposes:
  - Transfer of liquid from one place to another place (e.g., water from an underground into a water storage tank).
  - Circulate liquid around a system (e.g., cooling water or lubricants through machines and equipment).

Type of Pumps

- Pumps classification done on the basis of its mechanical configuration and their working principle.
- Pumps can be broadly classified into two categories as mentioned below.
  - Positive Displacement Pumps
  - Dynamic Pressure Pumps

Type of Pumps



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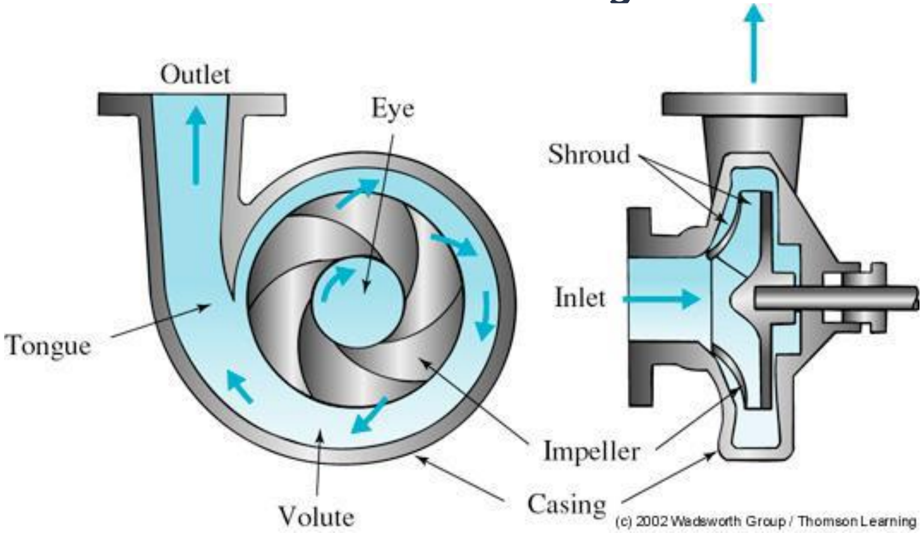
  - Dynamic Pressure Pumps

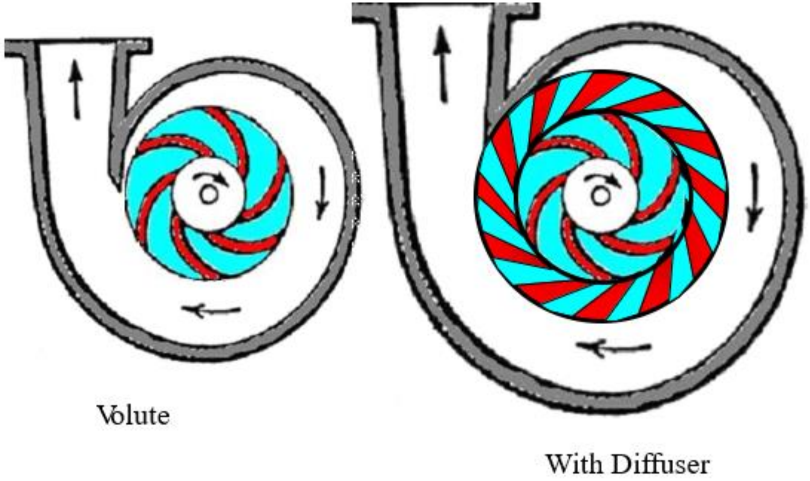
Dynamic Pressure Pumps

- Known as kinetic pump.
- Impart velocity and pressure to the fluid as it moves past or through the pump impeller and, subsequently, convert some of that velocity into additional pressure.
- Classification of Dynamic Pumps:
  - Centrifugal Pumps (Radial Flow)
  - Propeller pump (Axial Flow)
  - Turbine pump (Mixed Flow)

Dynamic Pressure Pumps - Centrifugal Pumps (Radial Flow)

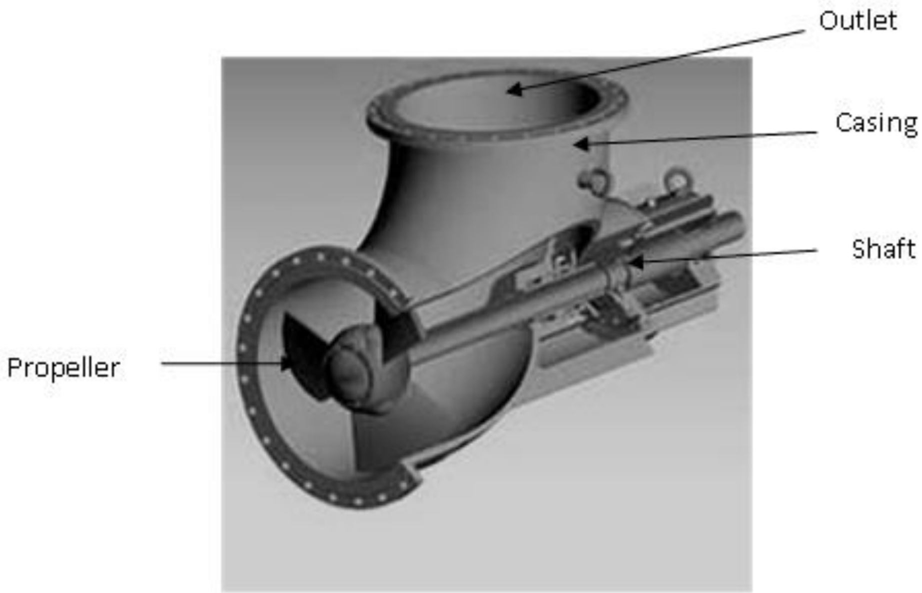
- A centrifugal pump is a rotating machine in which flow and pressure are generated dynamically.
- The energy changes occur by virtue of two main parts of the pump, the impeller and the volute or casing.
- Used where the higher head and low discharge is required



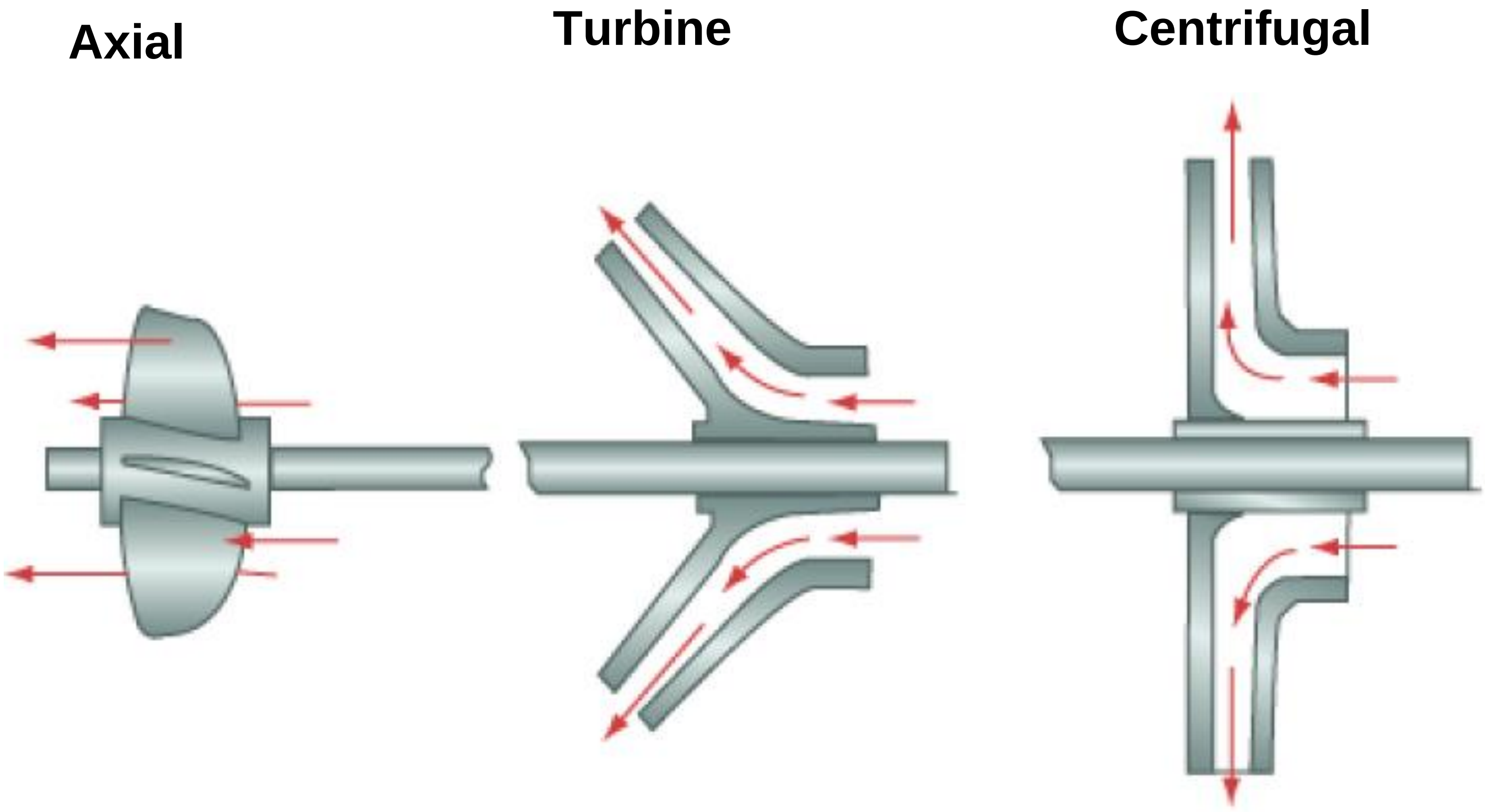


Dynamic Pressure Pumps - Propeller pump (Axial Flow)

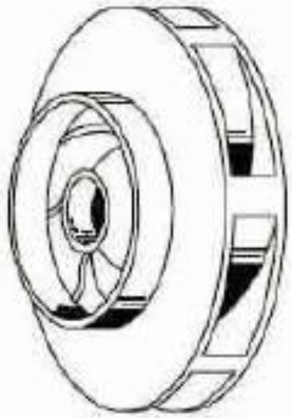
- Produces flow parallel to the shaft axis with a lower head and very high discharge rate.
- Used where the lower head and high discharge is required.



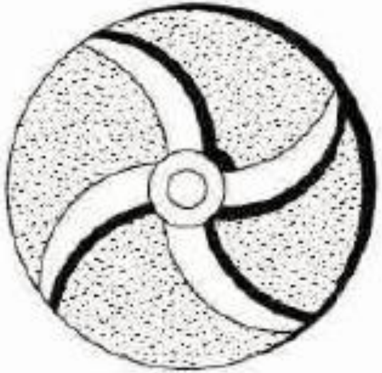
Dynamic Pressure Pumps – Dynamic Pump



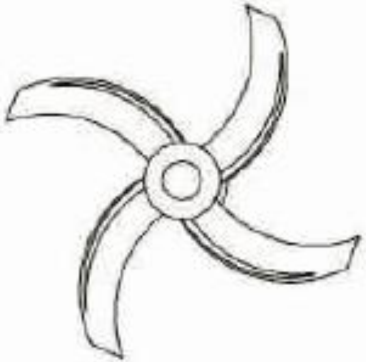
Dynamic Pressure Pumps - Types Of Impellers Based On Mechanical Construction - Used Depending On The Nature Of The Liquid Pumped



closed

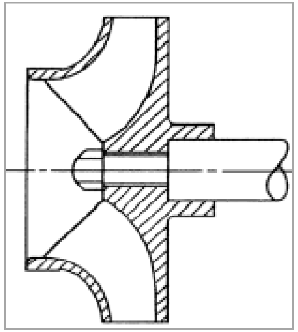


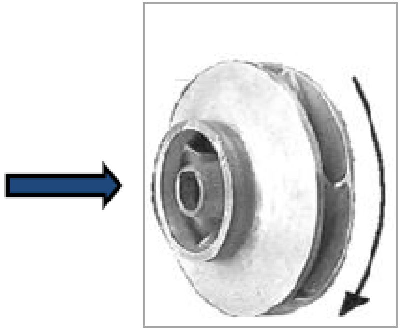
semi-open



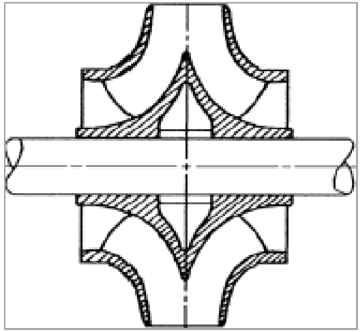
open

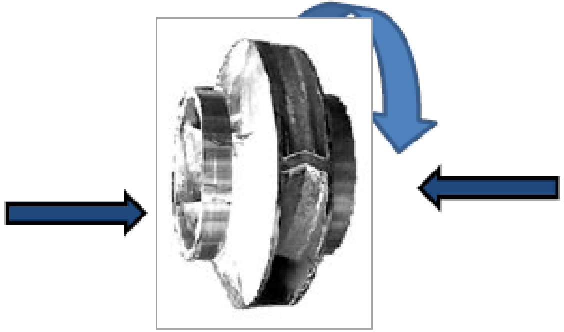
Dynamic Pressure Pumps - Types Of Impellers Based On Number Of Suction Eyes





SINGLE SUCTION IMPELLER



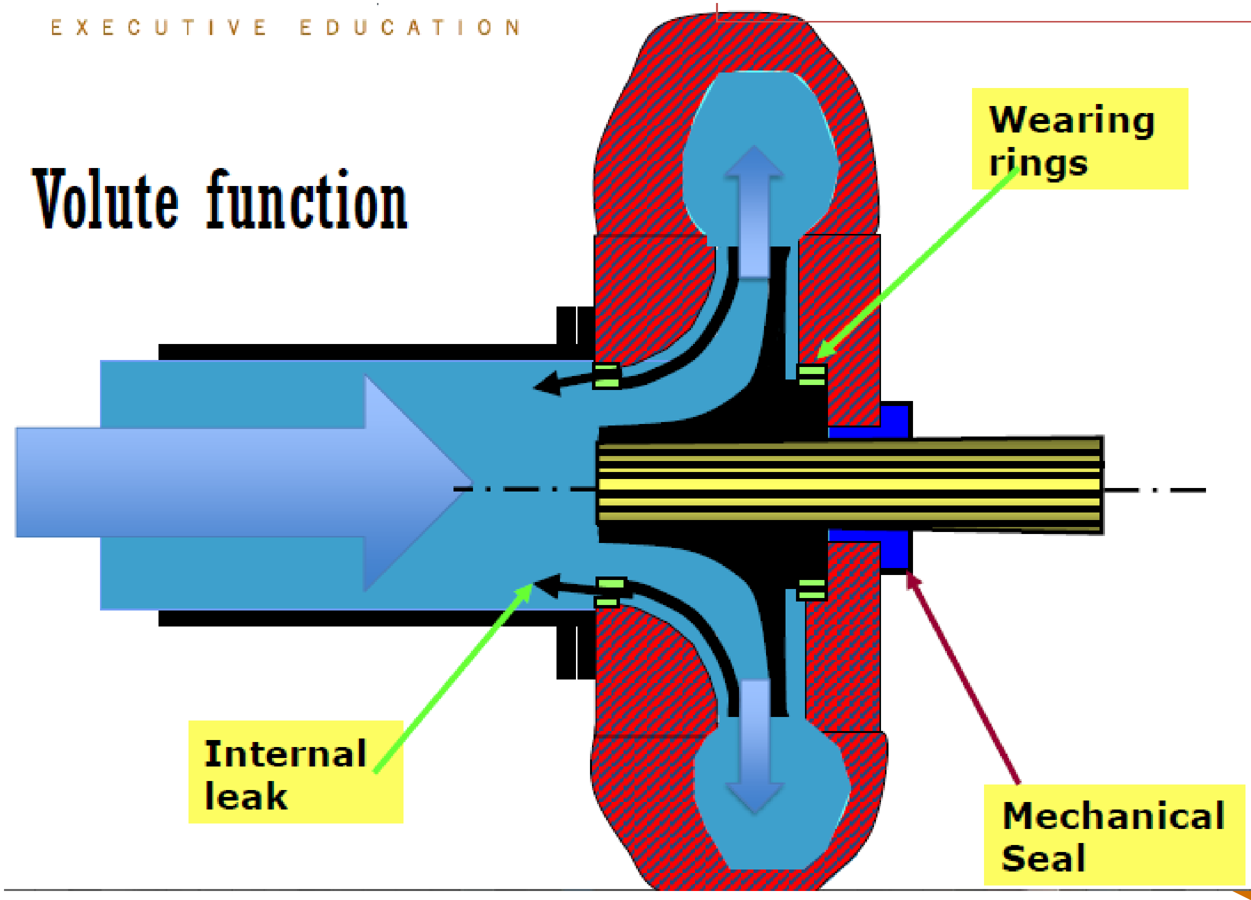


DOUBLE SUCTION IMPELLER

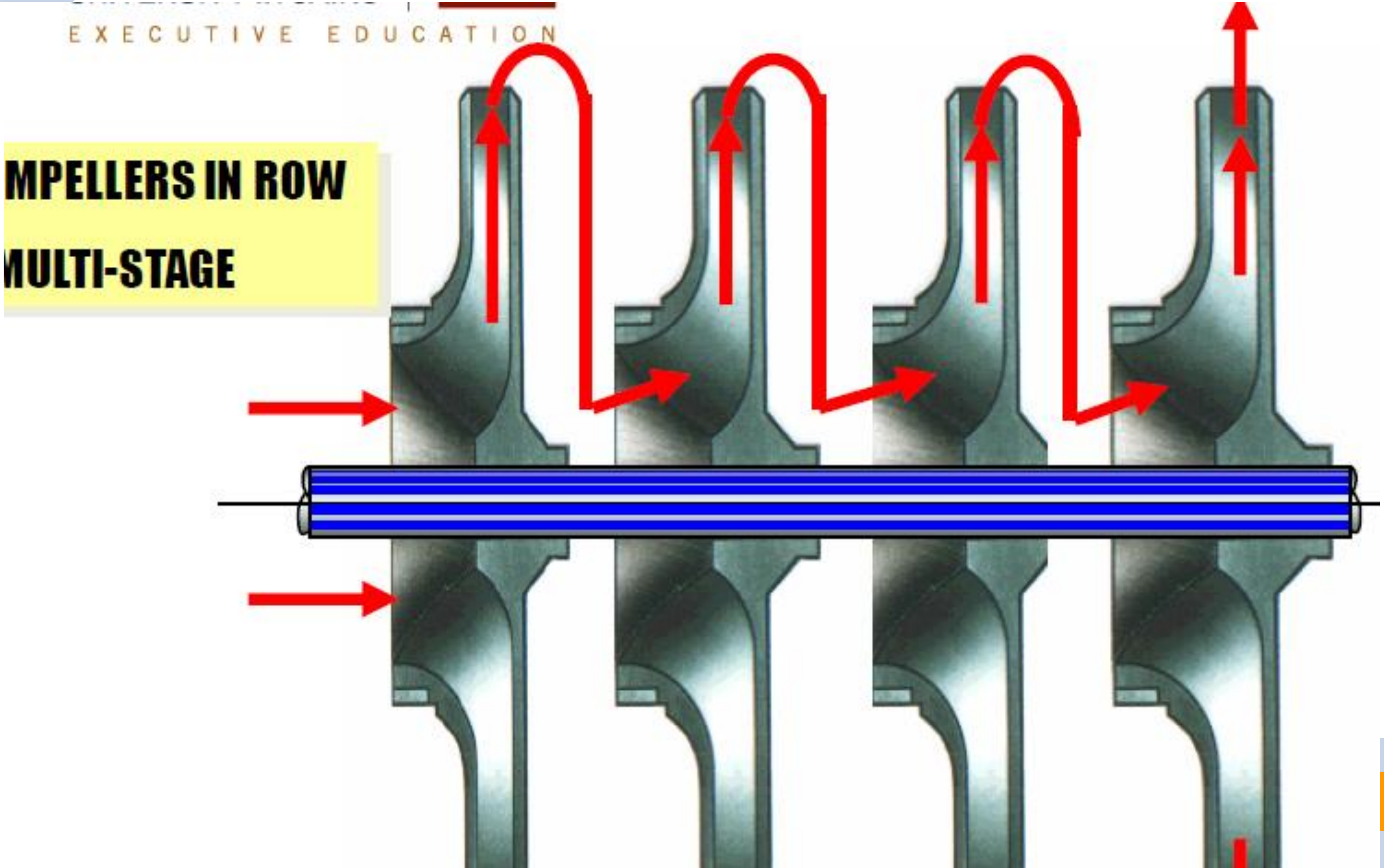
Dynamic Pressure Pumps – Parts Of Centifugal Pumps

EXECUTIVE EDUCATION

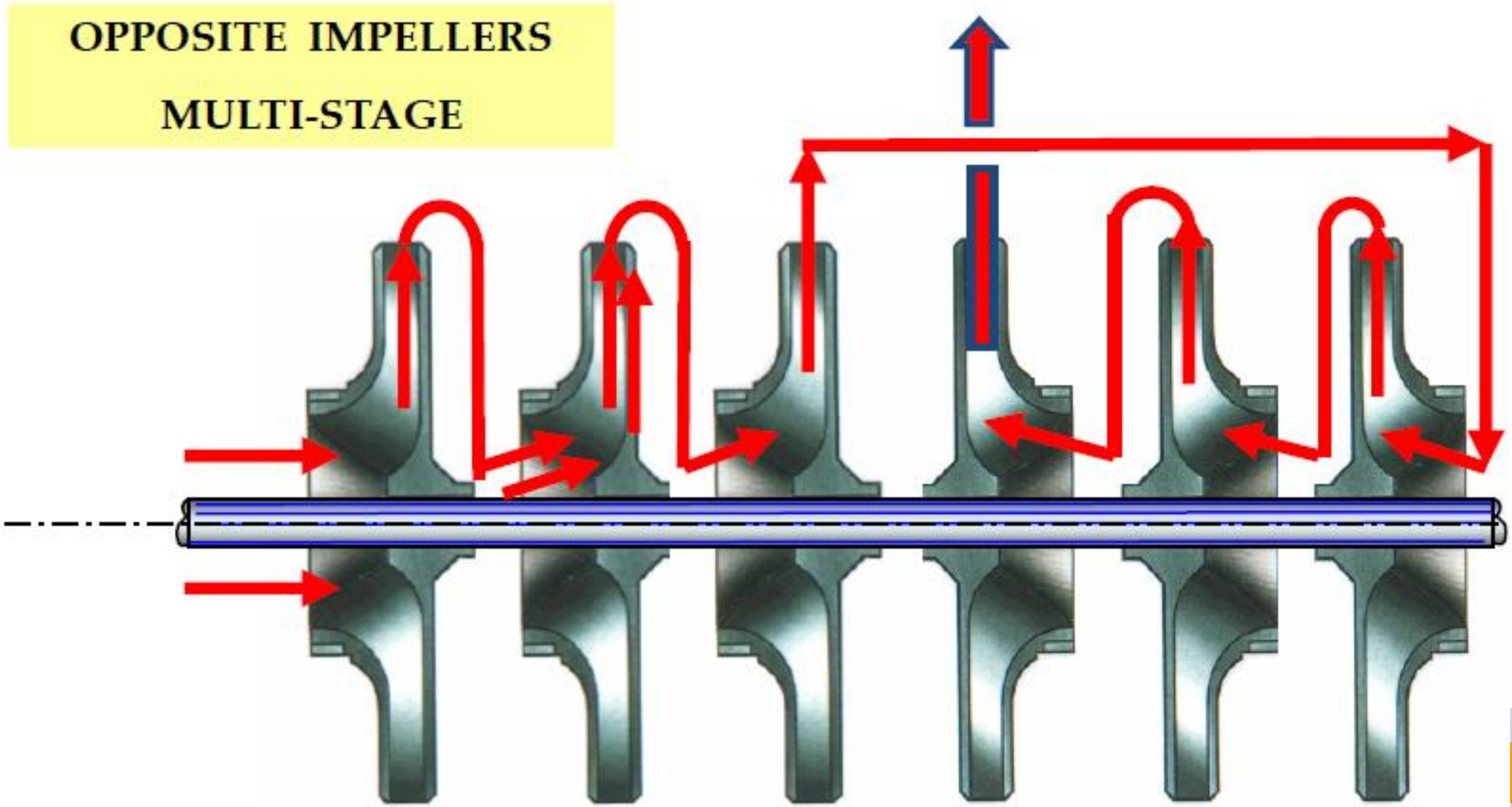
Volute function



Dynamic Pressure Pumps – Multistage



Dynamic Pressure Pumps – Opposite Impeller Multistage



Positive Displacement Pumps

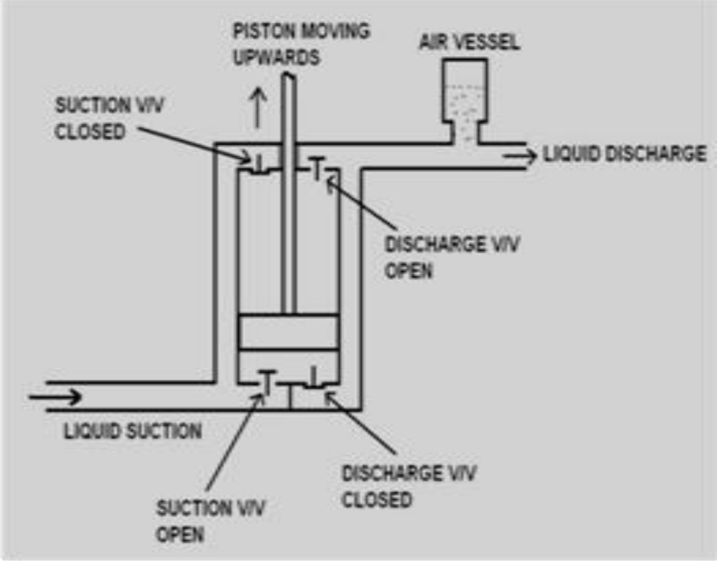
- The moving element (piston, plunger, rotor, lobe, or gear) displaces the liquid from the pump casing (or cylinder) and, at the same time, raises the pressure of the liquid.
- Designed to displace a more or less fixed volume of fluid during each cycle of operation. The flow capacity is fixed by the design, size, and operating speed of the pump
- Most often found on industrial applications or high-pressure services.
- Classification of Positive Displacement Pumps:
  - Reciprocating Pumps
  - Rotary Type Pumps

Positive Displacement Pumps – Reciprocating Pumps

- In a reciprocating pump, a piston or plunger moves up and down. During the suction stroke, the pump cylinder fills with fresh liquid, and the discharge stroke displaces it through a check valve into the discharge line.
- Reciprocating pumps can develop very high pressures.
- Plunger, piston, and diaphragm pumps are under these types of pumps.

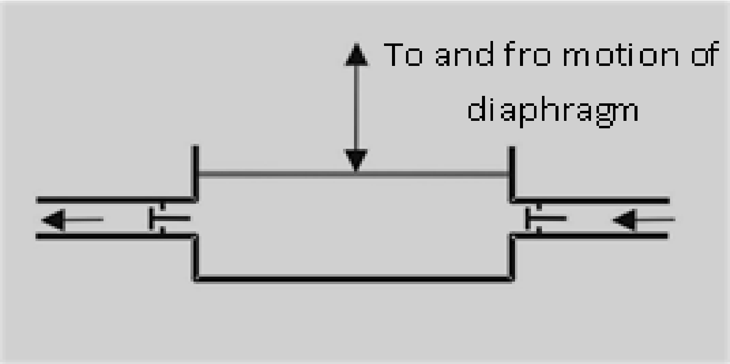
Piston Pump

- A piston pump is a type of positive displacement pump where the high-pressure seal reciprocates with the piston.



Diaphragm Pump

- Uses a combination of the reciprocating action of a rubber, thermoplastic or Teflon diaphragm and suitable non-return check valves to pump a fluid.
- Also called a membrane pump.

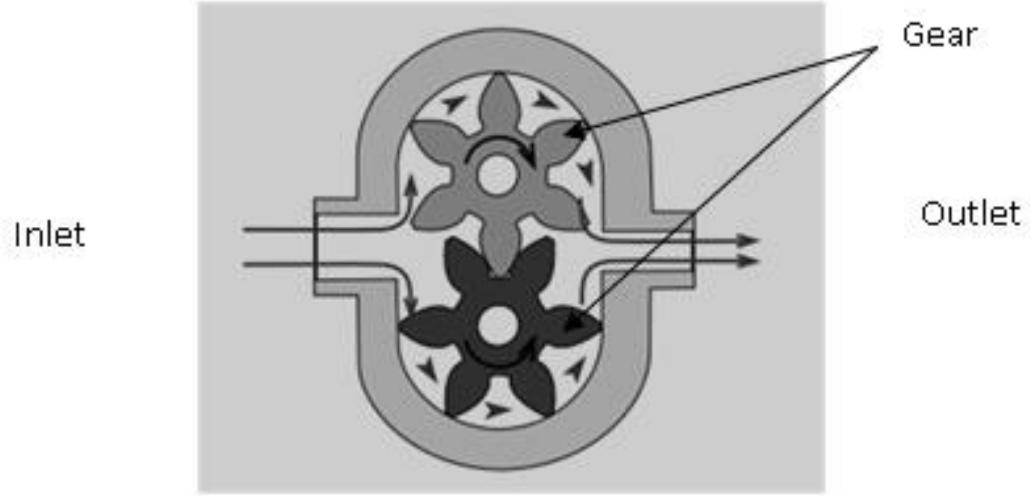


Positive Displacement Pumps – Rotary Pumps

- The pump rotor of rotary pumps displaces the liquid either by rotating or by a rotating and orbiting motion.
- In rotary pumps, relative movement between rotating elements and the stationary element of the pump cause the pumping action.
- Are designed so that a continuous seal is maintained between inlet and outlet ports by the action and position of the pumping elements and close running clearances of the pump.
- Rotary pumps such as: screw, lobe, and gear pumps.

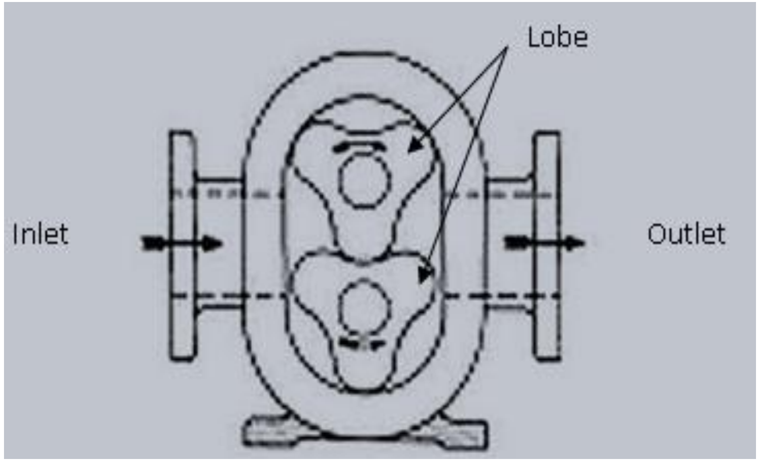
Gear Pump

- Uses the meshing of gears to pump fluid by displacement. They are one of the most common types of pumps for hydraulic fluid power applications. The rigid design of the gears and houses allow for very high pressures and the ability to pump highly viscous fluids.



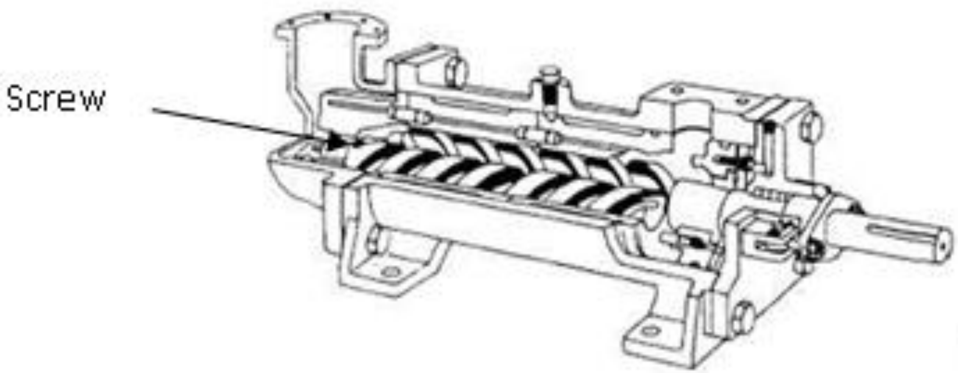
Lobe Pump

- Lobe pumps are similar to external gear pumps in operation in that fluid flows around the interior of the casing.
- As the lobes come out of mesh, they create expanding volume on the inlet side of the pump.



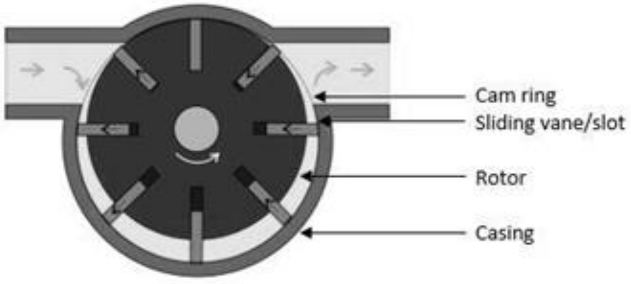
Screw Pump

- These pumps are rotary, positive displacement pumps that can have one or more screws to transfer high or low viscosity fluids along an axis.
- Screw pumps provide a specific volume with each cycle and can be dependable in metering application.

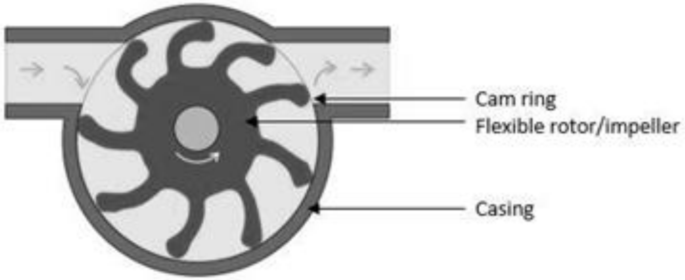


Vane Pump

- A rotary vane pump is a positive-displacement pump that consists of vanes mounted to a rotor that rotates inside of a cavity.
- In some cases, these vanes can be variable length and/or tensioned to maintain contact with the walls as the pump rotates.



Sliding Vane Pump



Flexible Vane Pump

Centrifugal Vs Positive Displacement Pumps

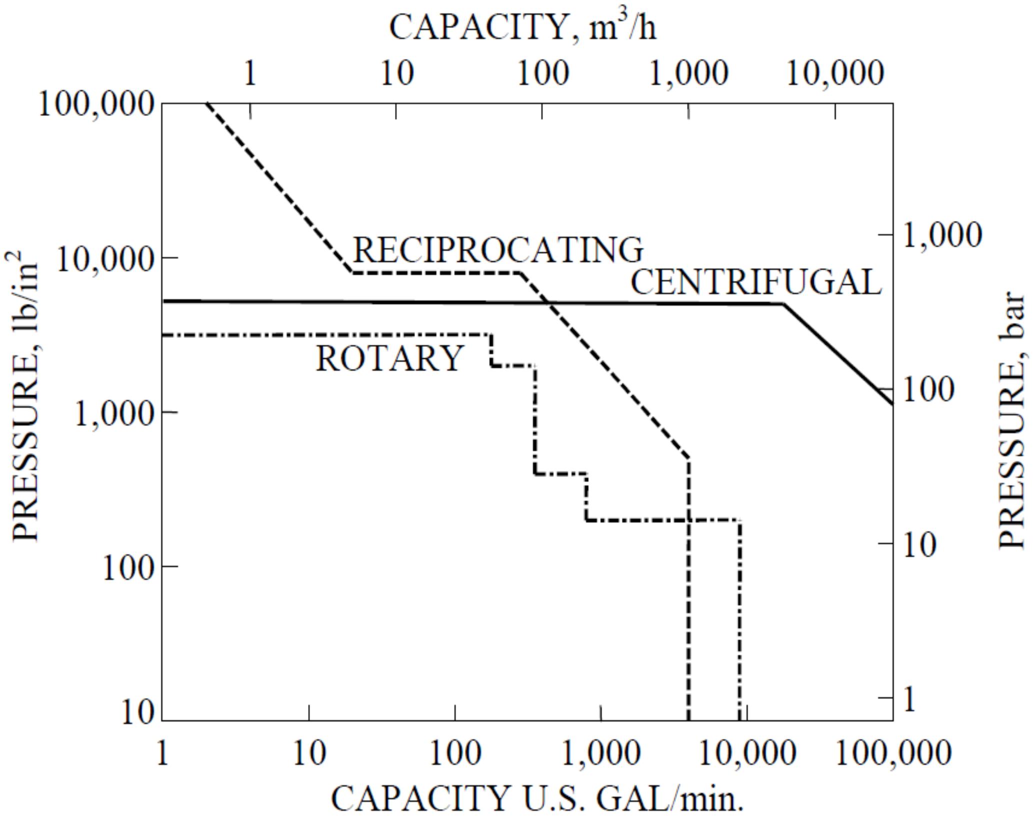
Factor	Centrifugal	Positive Displacement
Mechanics	Impellers pass on velocity from the motor to the liquid which helps move the fluid to the discharge port	Traps a certain amount of liquid and forces it from the suction to the discharge port.
Performance	The flow rate varies with a change in pressure	Flow rate remains constant as change in pressure.
Viscosity	The flow rate decreases as the viscosity increases, even moderate thickness, due to frictional losses inside the pump	The internal clearances allow higher viscosity handling.
		Flow rate increases with increasing viscosity.

Centrifugal Vs Positive Displacement Pumps

Factor	Centrifugal	Positive Displacement
Efficiency	Pump efficiency peaks at a specific pressure - any variations decrease the efficiency dramatically.	Efficiency is less affected by pressure. Positive displacement pumps can be run at any point on their curve without damage or efficiency loss.
Suction lift	Standard centrifugal pumps cannot create suction lift.	Positive displacement pumps create a vacuum on the inlet side, making them capable of creating suction lift.
Shearing	The high-speed motor can lead to shearing of liquids - centrifugal pumps are not recommended for shear sensitive mediums.	The low internal velocity means little shear is applied to the pumped medium - therefore, positive displacement pumps are appropriate for shear-sensitive fluids.

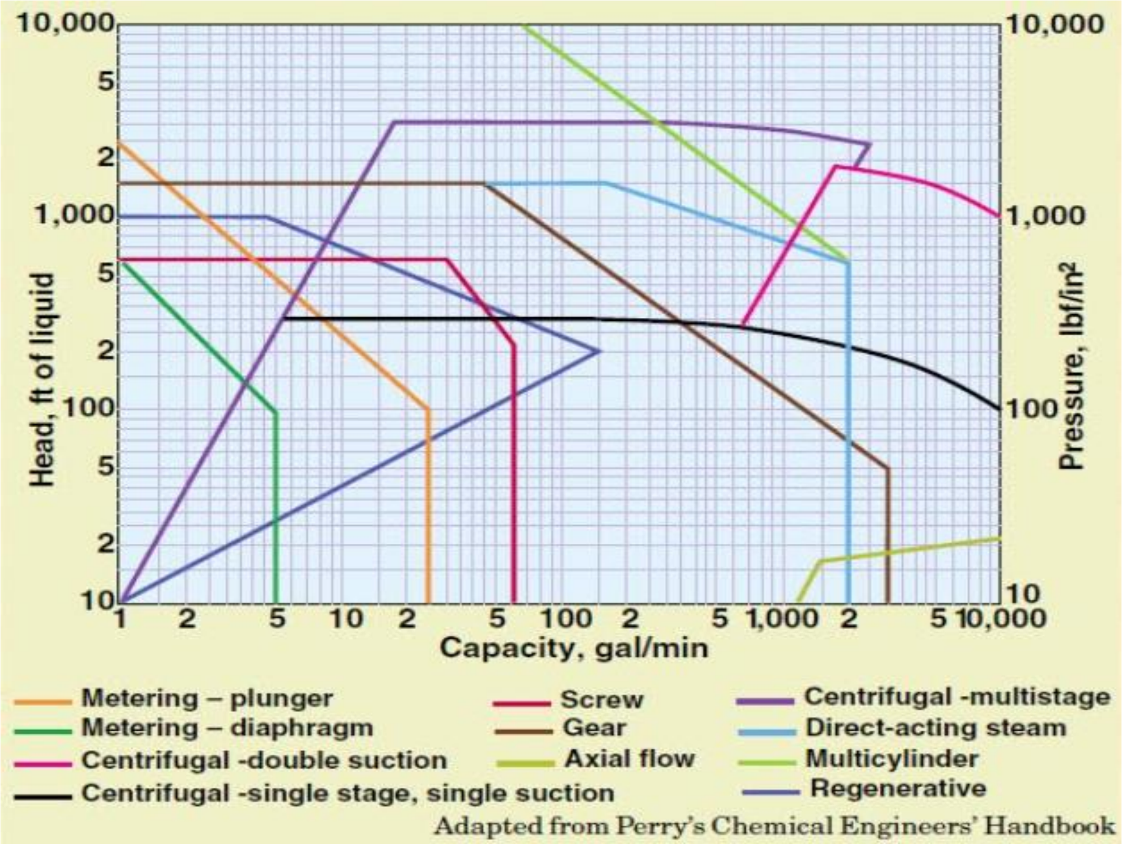
The pump type selection is influenced by such factors as:

- The fluid characteristics
- Flow rate
- Required head
- Reliability
- Availability of utilities
- Operating cost
- Investment cost



Pump Selection Chart

Pump Selection



Pump Selection Chart

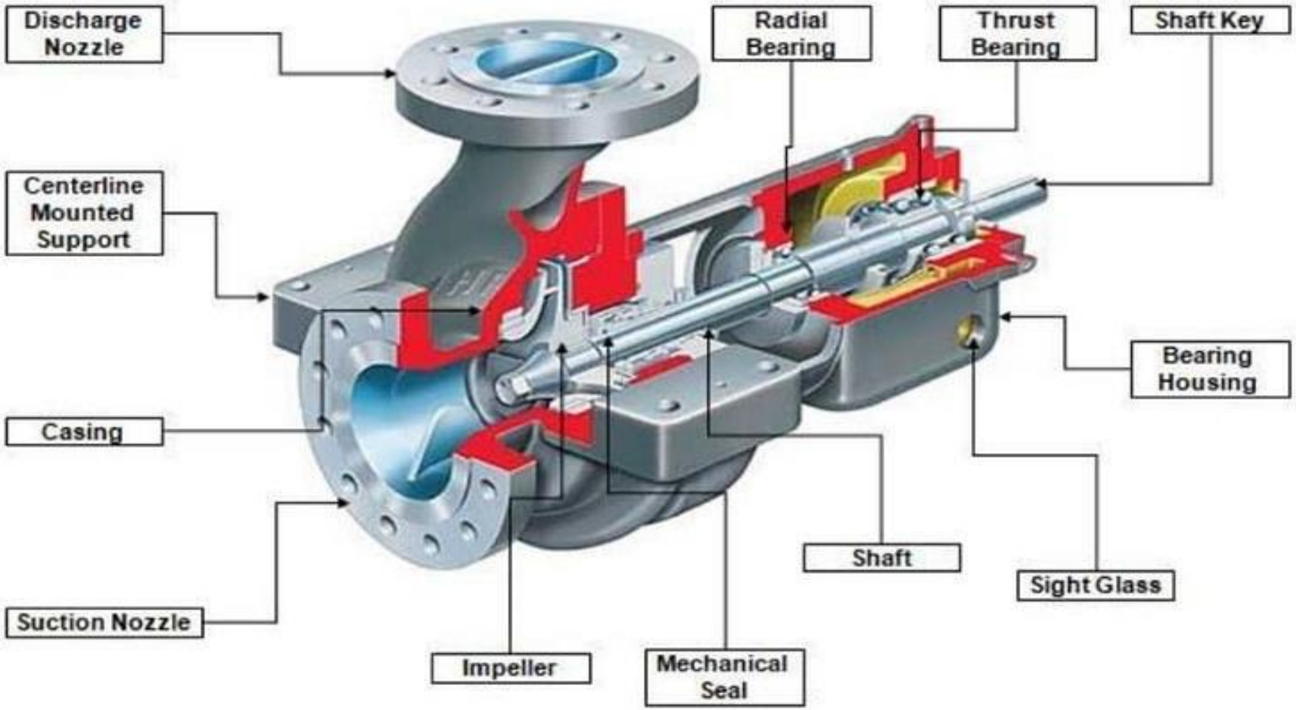
Where a chart allows more than one class of pump, the selection shall be centrifugal, rotary, then reciprocating, depending on factors below:

- Flow regulation
- Liquid viscosity
- Energy consumption

Within the displacement pump group, where both rotary and reciprocating pumps are allowed, the choice is rotary then reciprocating, subject to two general limitations:

- Low viscosity
- Abrasives

Centrifugal Pump

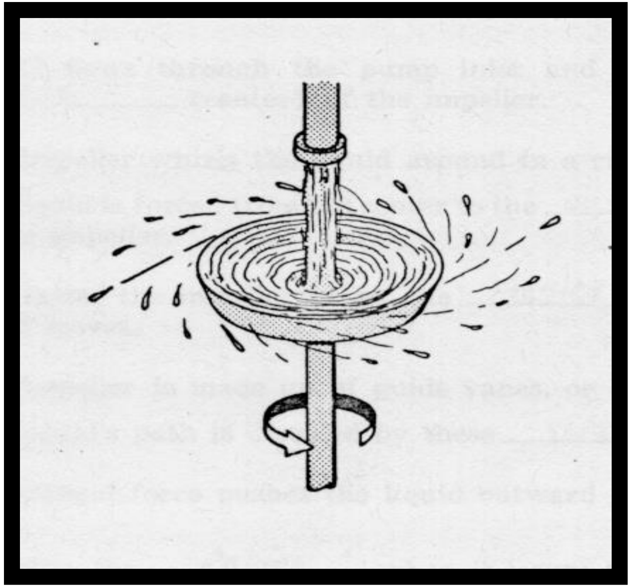


- A centrifugal pump is a mechanical device that converts energy to hydraulic work.

- Energy is supplied by a driver such as an electric motor, turbine, or engine.

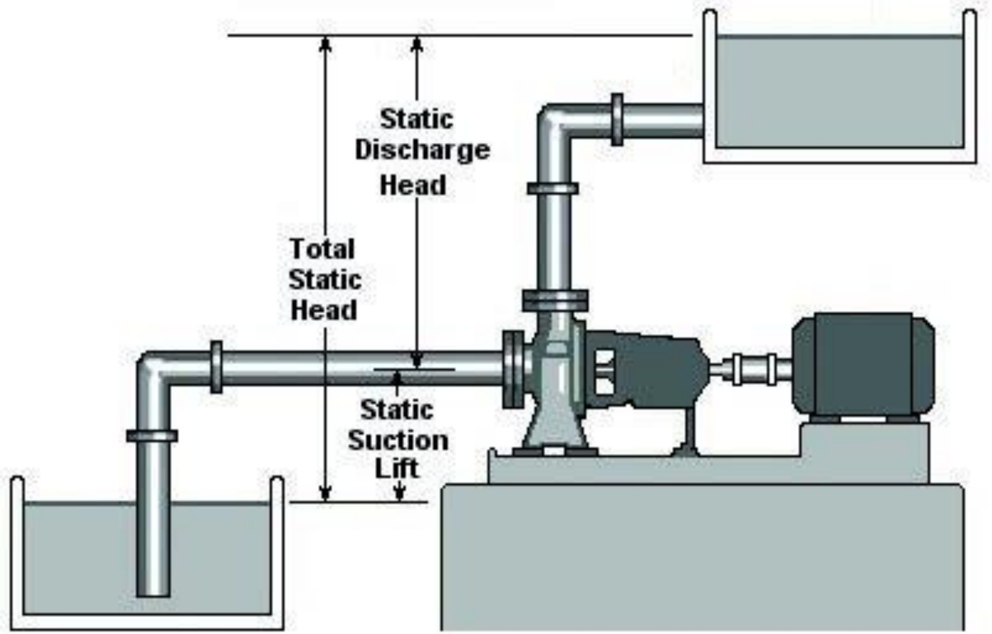
- Hydraulic work is the movement of a liquid mass through a distance.

Fundamentals and Principles of Operation Centrifugal Pump

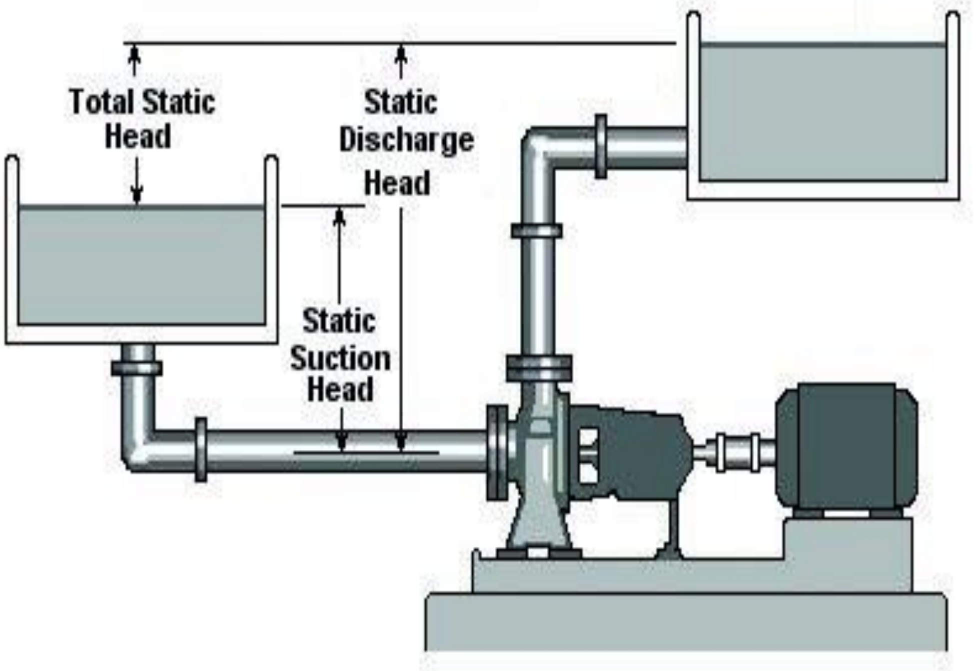


- When liquid is spun around in a circle, it accelerates outward from the center of the circle due to centrifugal force

- Representation of static discharge head, static suction lift and total static head



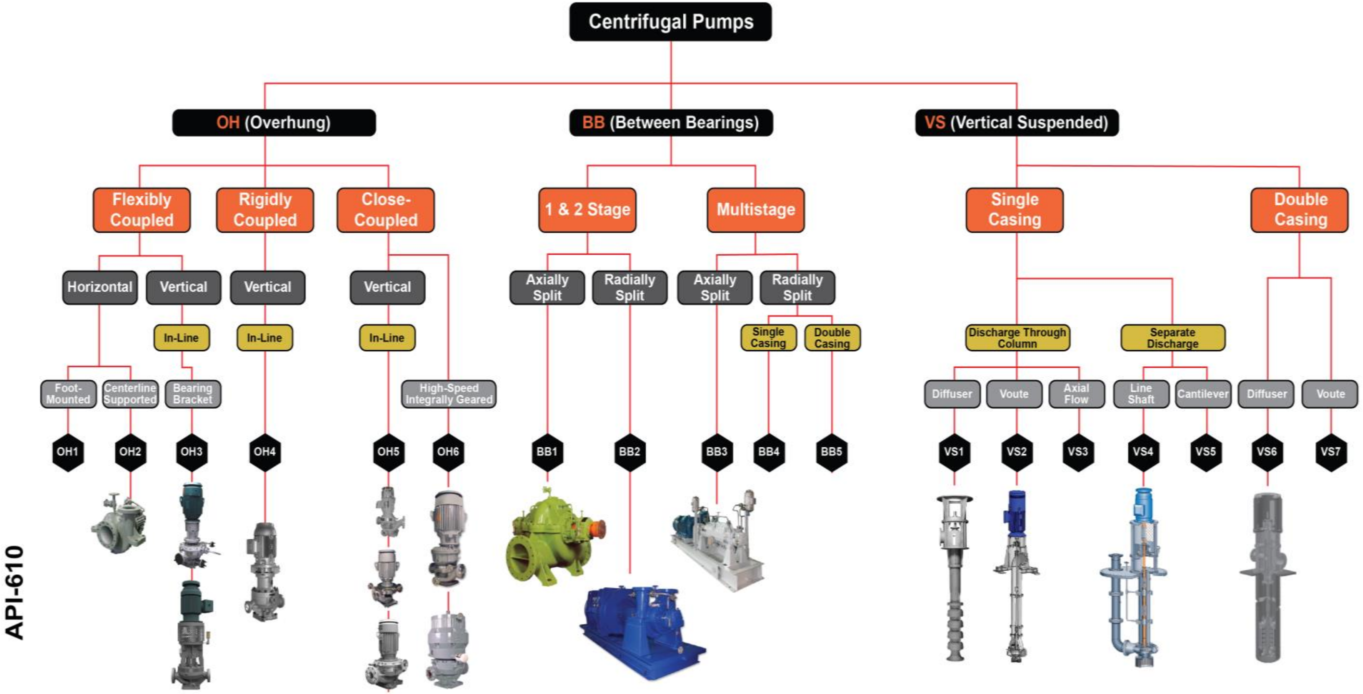
- Representation of static discharge head, static suction lift and total static head



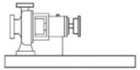
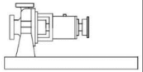
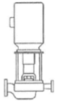
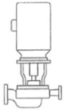
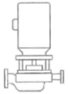
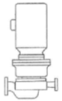
- Several terminologies that used for centrifugal pump are as follows:
  - Head—Resistance to Flow
  - Friction Head (hf)
  - Velocity Head (hv)
  - Pressure Head
  - Total Dynamic Suction Lift (hs)
  - Total Dynamic Discharge Head (hd)

Centrifugal Pump - Categories

- Based on API 610 standard



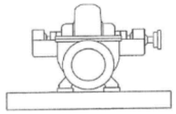
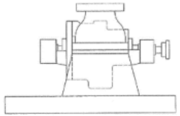
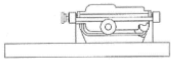
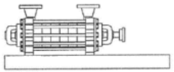
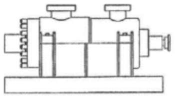
API 610 Pump - OH type

Type	Description	Installation		Mounting		Coupling		Drive			Discharge		Typical Applications	Image
		Hor	Ver	Foot	CLine	Flex	Rigid	Long	Close	Gearbox	Inline	Top		
OH1	A flexibly long coupled horizontal, foot mounted, single stage, end suction, overhung pump. OH1 pumps, according to API 610 specifications, are long coupled, however Amarinth can also provide pumps that are close coupled.	●		●		●		●				●	-Produced water -MEG reclamation -Boiler feed	
OH2	A flexibly long coupled horizontal, centerline mounted, single stage, end suction, overhung pump. OH2 pumps, according to API 610 specifications, are long coupled, however Amarinth can also provide pumps that are close coupled.	●			●	●		●				●	-Amine -Booster pump -Fuel transfer	
OH3	A flexibly long coupled vertical inline, single stage, overhung pump. The pump can be mounted to a support frame or within the pipeline.		●	○	○	●		●			●		-Gas drum -Sour water -Sea water	
OH4	A rigidly close coupled vertical inline, single stage, overhung pump. The motor is mounted directly to the pump housing. The pump can be mounted to a support frame or within the pipeline.		●	○	○		●		●		●		-Water injection -Fuelling -Crude oil pipeline	
OH5	A flexibly long coupled vertical inline, single stage, overhung pump. The pump can be mounted to a support frame or within the pipeline.		●	○	○		●		●		●		-Hydrocarbon -Oily water -MEG water	
OH6	A horizontal or vertical, single stage, end suction overhung, pump that has an integral gearbox driven by the motor with a rigid coupling mounted to the pump housing.	○	○	○	○		●		●	●	●		-High pressure feed -Reverse osmosis -Boiler feed	

● = Standard

○ = Optional

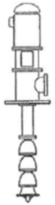
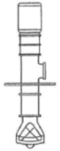
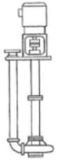
API 610 Pump - BB type

Type	Casing				Impeller		Typical Applications	Image
	Single	Double	Axial Split	Radial Split	1/2 Stage	Multistage		
BB1	An axially split single casing, one or two stage pump with bearings on both ends of the rotating assembly. The pump is mounted to a baseplate and driven by a motor via a flexible coupling.						- Cooling water - Sea water transfer - Produced water	
	●		●		●			
BB2	A radially split single casing, one or two stage pump with bearings on both ends of the rotating assembly. The pump is mounted to a baseplate and driven by a motor via a flexible coupling.						- Boiler feed - Booster - Petrochemical processing	
	●			●	●			
BB3	An axially split single casing, multistage pump with bearings on both ends of the rotating assembly. The pump is mounted to a baseplate and driven by a motor via a flexible coupling.						- Water injection - High pressure boiler feed - Dewatering	
	●		●			●		
BB4	A radially split single casing, multistage pump with bearings on both ends of the rotating assembly. The pump is mounted to a baseplate and driven by a motor via a flexible coupling. Sometimes called segmental-ring pump or ring-section pump.						- Reverse osmosis - High pressure boiler feed - Feed water pump	
	●			●		●		
BB5	A radially split double casing, multistage pump with bearings on both ends of the rotating assembly. The pump is mounted to a baseplate and driven by a motor via a flexible coupling. Sometimes referred to as "barrel pumps". BB5 pumps can be made to handle very high pressures.						- Offshore crude shipping - Ethylene shipping - Onshore & offshore water flood	
		●		●		●		

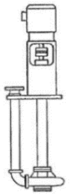
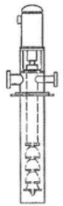
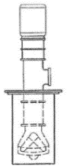
● = Standard

Centrifugal Pump - Categories

API 610 Pump - VS type

Type	Casing				Impeller				Discharge		Typical Applications	Image
	Single	Double	Volute	Diffuser	Single	Multi	Axial	Radial	Column	Separate		
VS1	A vertically suspended diffuser pump with a single casing and an axial impeller with its discharge through the lineshaft column that suspends the bowl assemblies. The pump is mounted to a support plate and driven by a flexible coupling.										-Sea water lift Pipeline transfer -Condensate extraction	
	●			●	○	○	○	●	●			
VS2	A vertically suspended volute pump with a single casing and an axial impeller with its discharge through the lineshaft column that suspends the casing. The pump is mounted to a support plate and driven by a flexible coupling.										-Sea water intake -Cooling water -Loading & unloading	
	●		●		●	○	●		●			
VS3	A vertically suspended volute pump with a single casing and an axial impeller with its discharge through the lineshaft column. The pump is mounted to a support plate and driven by a flexible coupling.										-Raw water intake -Water treatment -Cooling water	
	●		●		●		●		●			
VS4	A vertically suspended, single stage, volute pump with a single casing and a radial impeller. The discharge column is separate to the lineshaft column. The pump is mounted to a support plate and driven by a flexible coupling.										-Sour water -Hydrocarbon condensate -Flare knock out drum	
	●				●			●		●		

API 610 Pump – VS type

Type	Casing				Impeller				Discharge		Typical Applications	Image
	Single	Double	Volute	Diffuser	Single	Multi	Axial	Radial	Column	Separate		
VS5	A vertically suspended, single stage, volute pump a single casing and a radial impeller. The discharge column is separate to the lineshaft column which is a **cantilever design**. The pump is mounted to a support plate and driven by a flexible coupling.										- Slurry - Water treatment - Solids handling	
	●		●		●			●		●		
VS6	A vertically suspended diffuser pump with a double casing and an axial impeller with its discharge through the lineshaft column that suspends the bowl assemblies. The pump is mounted to a support plate and driven by a flexible coupling.										- Condensate extraction - Pipeline booster - Crude oil loading	
		●		●	○	○	●		●			
VS7	A vertically suspended, volute pump with a double casing and an axial impeller with its discharge through the lineshaft column that suspends the bowl assemblies. The pump is mounted to a support plate and driven by a flexible coupling.										- Pipeline booster - Condensate - Desalination	
		●			○	○	●		●			

● = Standard

○ = Optional

Flexible and Rigid Coupling

Flexible Coupling

Rigid Coupling

- Relevant industry operating experience suggests API 610 pumps are considered cost effective when pumping liquids at condition exceeding any one of the parameter below.

— discharge pressure (gauge)	1 900 kPa (275 psi; 19,0 bar)
— suction pressure (gauge)	500 kPa (75 psi; 5,0 bar)
— pumping temperature	150 °C (300 °F)
— rotative speed	3 600 r/min
— rated total head	120 m (400 ft)
— impeller diameter, overhung pumps	330 mm (13 in)

- API 610 is normally specified where the pumped product is dangerous, hot, high pressure, flammable, toxic and for critical services

KEY SPECIFICATION REQUIREMENTS

- Pump design life of 25 years
- Designed to run uninterrupted for three years
- 40 Bar minimum design pressure
- Oil lube bearings
- 25,000hr L10 minimum bearing life
- Renewable wear rings
- Shaft rigidity: Maximum deflection 50 μm (0.002 in) at the seal faces
- Tough vibration criteria
- Material certification & testing
- Performance tested

API 610 Centrifugal Pump Types – OH, BB & VS

API 610 is the standard for the centrifugal pump used in petroleum industries. It has categorized the pump based on the construction.. Overhung, Between Bearing, and Vertically Suspended are three main categories of API 610 Centrifugal Pump types

OH1

The image shown here is OH1 (Overhung) type API 610 Centrifugal pump types. This is a single-stage overhung with a foot-mounted base plate design. It is a horizontal pump with a flexible coupling. You can see in the image that the leg supports it at the opposite end of the suction.

OH2

This type of pump is centerline supported. You can see that there is no leg support at the bearing end as compared to the OH1 type in the image below. It is also single stage end suction pump with single bearing housing. During operation, this bearing housing helps to absorb the force imposed on the pump shaft. It also ensures the proper position of the impeller during the operation

OH3

OH3 pump is flexibly coupled single-stage and in-line pump with overhung impeller. It has a separate bearing bracket. It comes with integral bearing housing, which helps in absorbing pump load. The motor is directly mounted on the pump. The image below shows the OH3 type of pump.

OH4

The only difference between OH3 and OH4 is the use of a rigid coupling method in OH4 compared to flexible coupling in OH3.

OH5

OH5 type pump is a closed coupled pump. The impeller of the pump is directly attached to a driver on the same shaft. It is a vertical, in-line, and single-stage pump.

OH6

OH6 is a high-speed pump as it uses speed increasing gearbox. The impeller is mounted directly on the gear shaft. The gearbox is connected with a driver by a flexible coupling. It is a single-stage overhung pump that can be installed both vertically and horizontally.

BB1

BB1 (Between Bearing) is a horizontally installed one or two-stage pump. The casing of this pump is an axially split type.

BB2

The difference between BB1 and BB2 is the way the casing is split. In BB2, the casing is radially split type.

BB3

A multistage between bearing pumps with Axially Split cashing design is designated as an API BB3 Type pump. This pump used flexible coupling to connect the drive.

BB4

In this API pump design, each stage of the pump is like a ring and connected through tie rode around them. If you see the image, it will be clear why this pump is also called a ring section pump. Each stage is a radially split design and installed on the shaft supported by bearings at both ends.

BB5

BB5 type pump is known as Barrel Pump due to its barrel-like design. It is used in high-pressure services. It is a multistage, double casing, a radially split design that uses flexible coupling.

VS1

VS1 type pump is a single casing vertically suspended type design. It is used as a wet pit or diffuser pump. The column of a pump is used as a discharge from the pump.

VS2

VS2 type pump uses volute casing design as compared to VS1. Other factors are similar to the VS1 type pump

VS3

VS3 type pump is axial flow, and single casing vertically suspended type design. Pump column over which pump assembly is mounted, used as discharge from the pump

VS4

This type of pump has a separate discharge column. It has a volute casing design. The vertically suspended shaft can be supported through intermediate bearings

VS5

VS5 also has a separate discharge column. The difference is in the vertically suspended shaft. In the case of VS5, there will be no intermediate bearings. The pump shaft is a cantilever and supported by a top bearing.

VS6

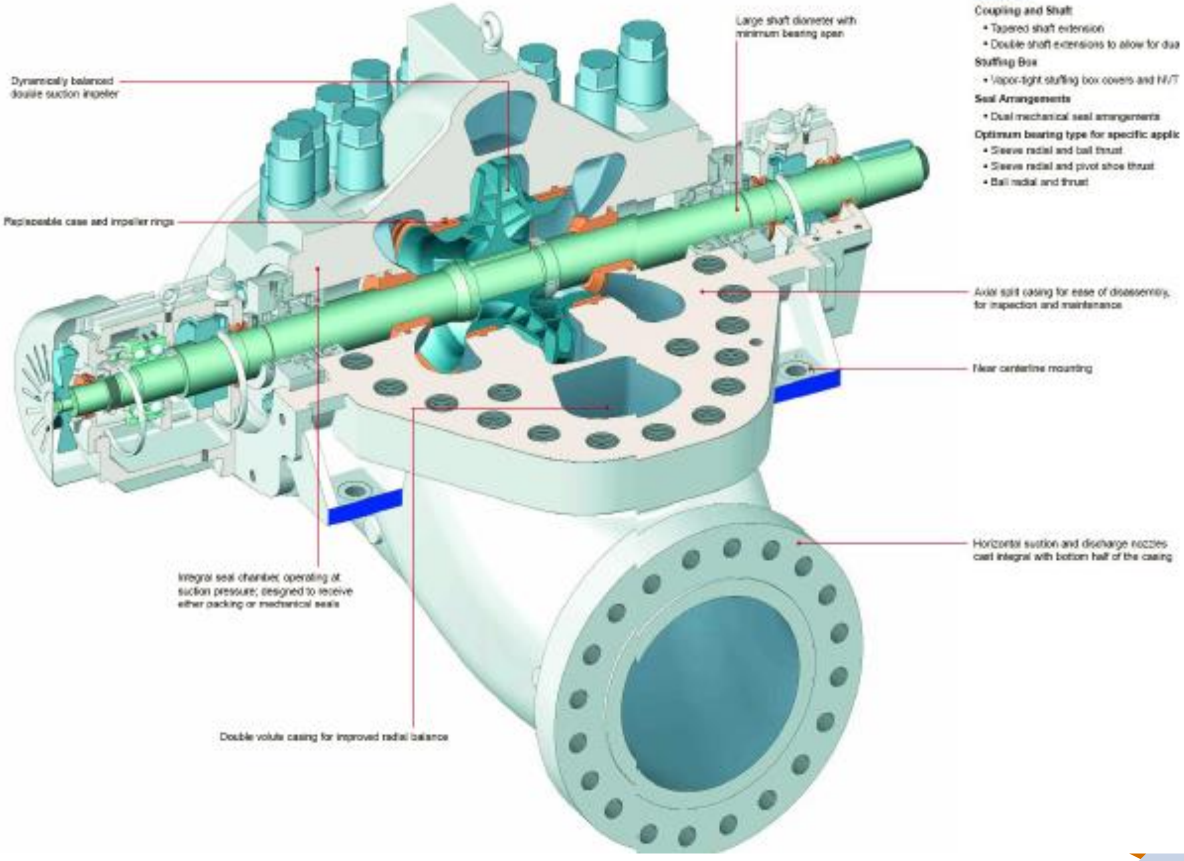
VS6 pump has a double casing. It is also known as a can pump due to this design. It is a vertically suspended pump with discharge through the pump column. This design is used to increase NPSH in some cases by installing a pump underground.

VS7

The last API 610 centrifugal pump type is VS7. VS7 type pump uses volute casing design as compared to VS6. Other factors are similar to VS6..

Centrifugal Pump – Design Consideration BB1

HSB Design Features and Options



Options

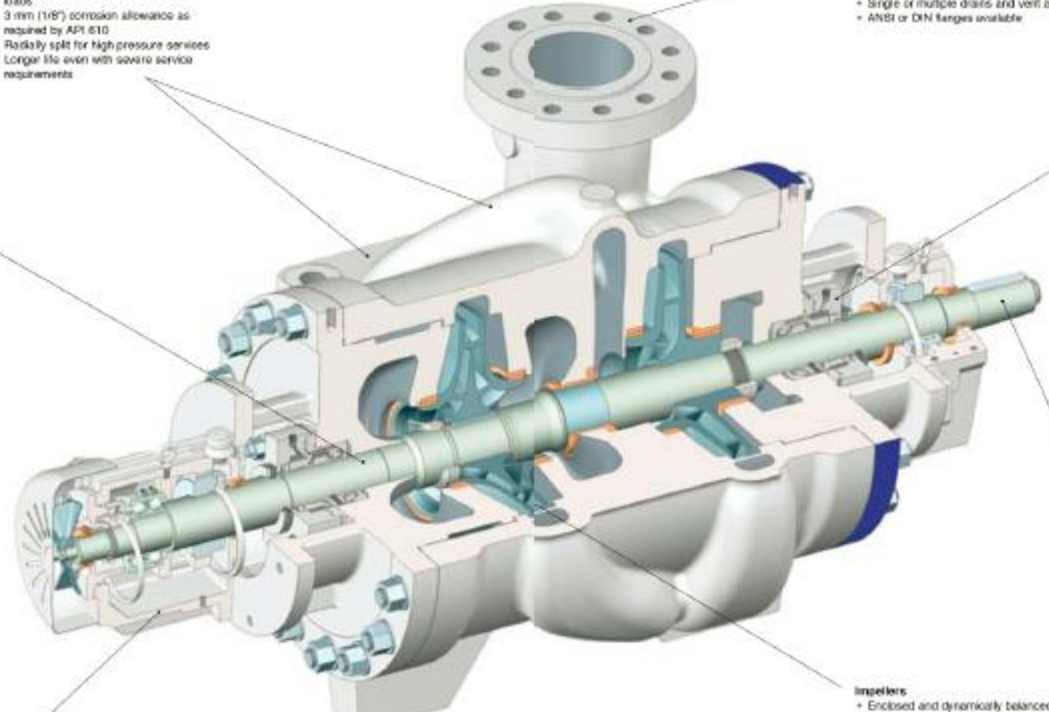
Coupling and Shaft
- Tapered shaft extension
- Double shaft extensions to allow for dua

Stuffing Box
- Vapor-tight stuffing box covers and N/T

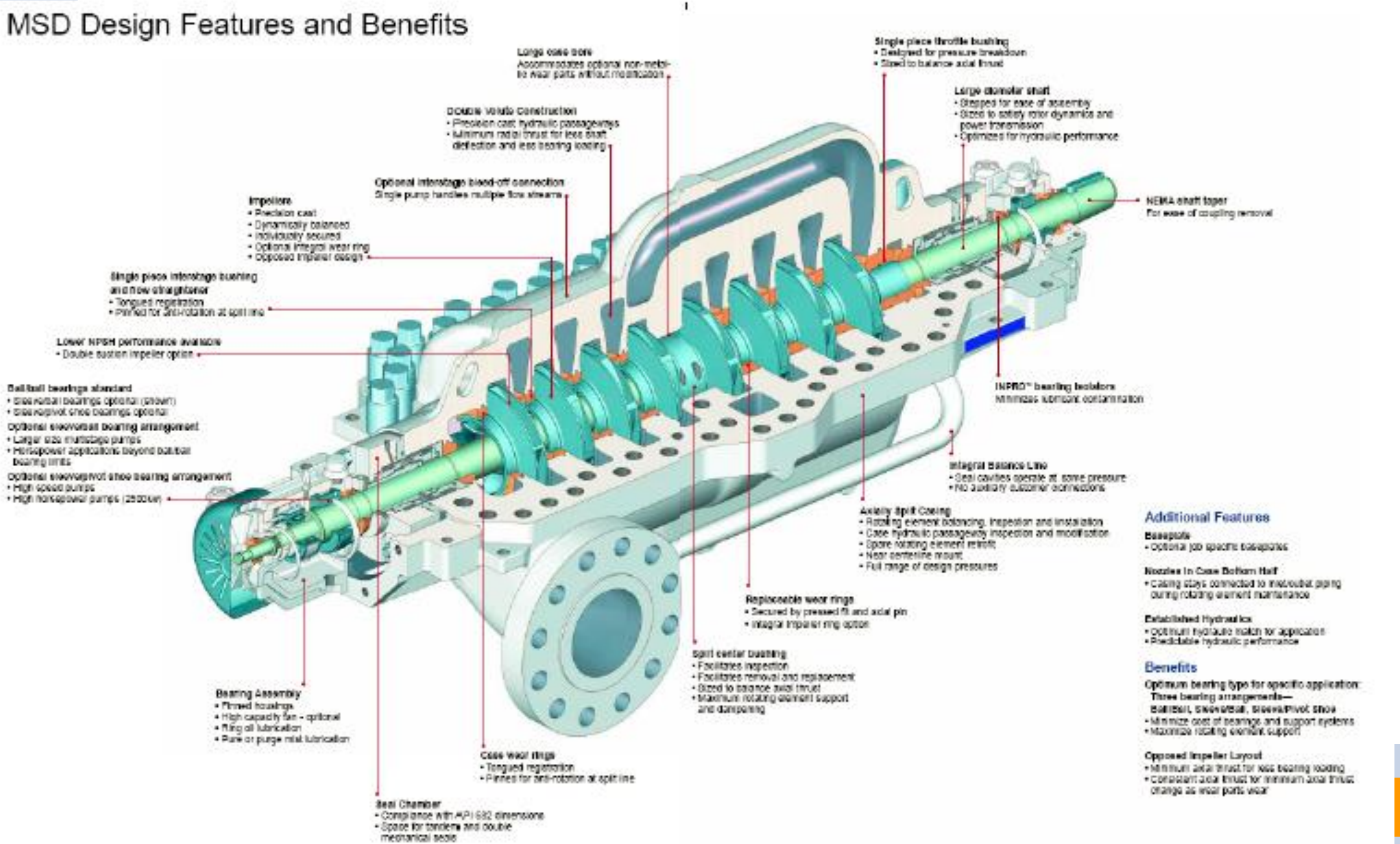
Seal Arrangements
- Dual mechanical seal arrangements

Optimum bearing type for specific applic
- Sleeve radial and ball thrust
- Sleeve radial and pivot shoe thrust
- Ball radial and thrust

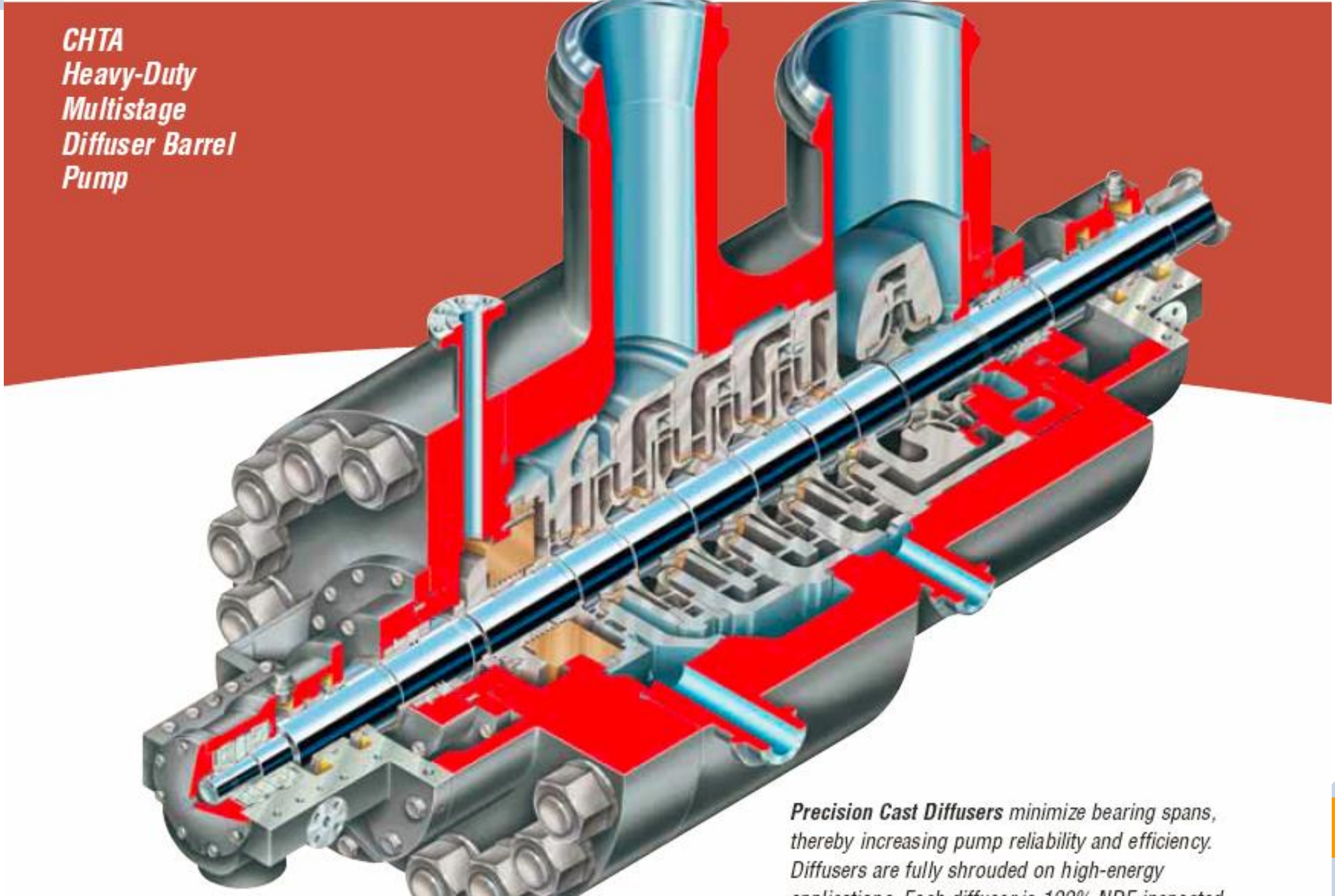
Centrifugal Pump – Design Consideration BB2



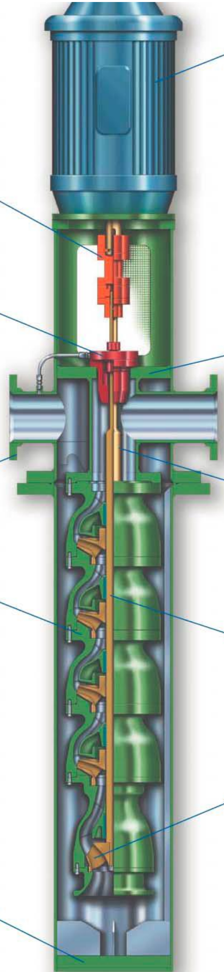
Centrifugal Pump – Design Consideration BB3



Centrifugal Pump – Design Consideration BB5



Centrifugal Pump – Design Consideration VS6



Coupling
Adjustable flanged coupling fitted as standard. Design allows easy access for maintenance and adjustments. Meets rigid construction requirements.

Seal
Various sealing arrangements are available to suit individual applications from single or double mechanical seals to graphite impregnated packing rings.

Flanges
ANSI flanges are provided with ratings from 150# to 600# depending on the application. The suction flange can be provided with ANSI, plain end or Victaulic connections. Suction and discharge connections can also be provided with RTJ or ISO flanges.

Bowls
Stage bowls have heavy-duty side walls and thick double drilled O-ring sealed faces for a standard 69 bar/1,000 psi rating (depending on pump size). Higher pressure designs are available. Materials selected to suit the application. Bowl bearings are formed from bronze or carbon bushes. Bearings are product lubricated.

Can
Fabricated design. Baseplates also match ANSI standard flange dimensions. As a minimum, cans are rated to the same design pressure as the suction flange and are pressure tested to 1.5 time the design pressure.

Driver
Solid shaft drivers.Thrust bearing in driver sized for all static and dynamic loads.

Column Assembly
(Not shown.) Used when extra length is needed to achieve adequate NPSHR at the suction impeller. Close bearing spacing eliminates critical speed problems. Heavy-duty shafts assist rigidity. Flanged rising column joints are used for strength and simplicity of maintenance.

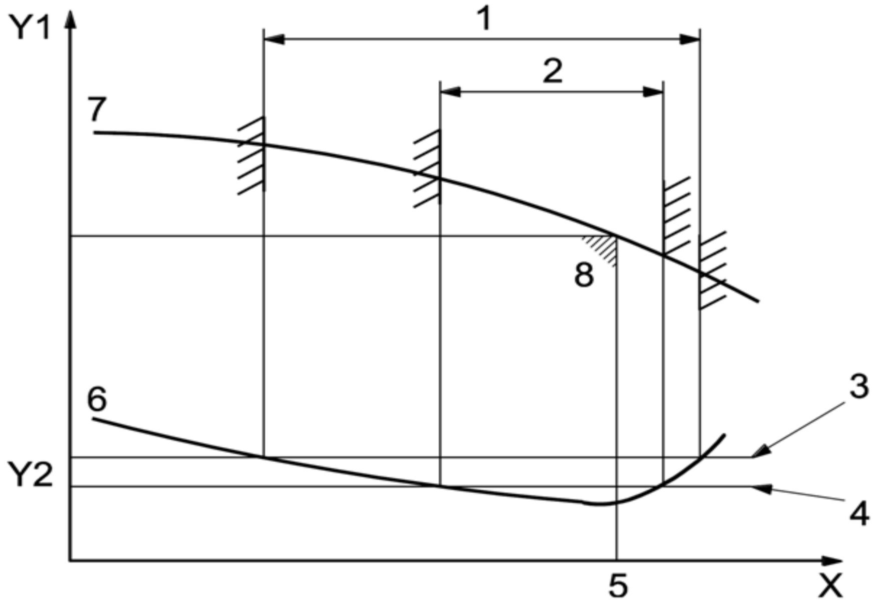
Discharge Head
Stress relieved steel fabricated steel construction. Fully pressure tested. Extra heavy-duty baseplates.

Top Shaft
Attaches to the coupling and main shaft assembly. Material selected to match the duty. In typical API applications the shaft is designed as a single piece unit.

Pump Shaft
Available in various materials to suit the application. Dimensioned to transmit maximum torque and thrust loads. Machined to meet the requirements of ANSI 58.1 and AWWA E101.

Q Stage
Low NPSHR first stage designs available to minimize pump and can length. All Q impellers are manufactured from 316SS for maximum performance and minimum wear. The optional Q-Stage drastically lowers NPSH requirements and thus allows for shorter can and pump lengths.

Pump Curve

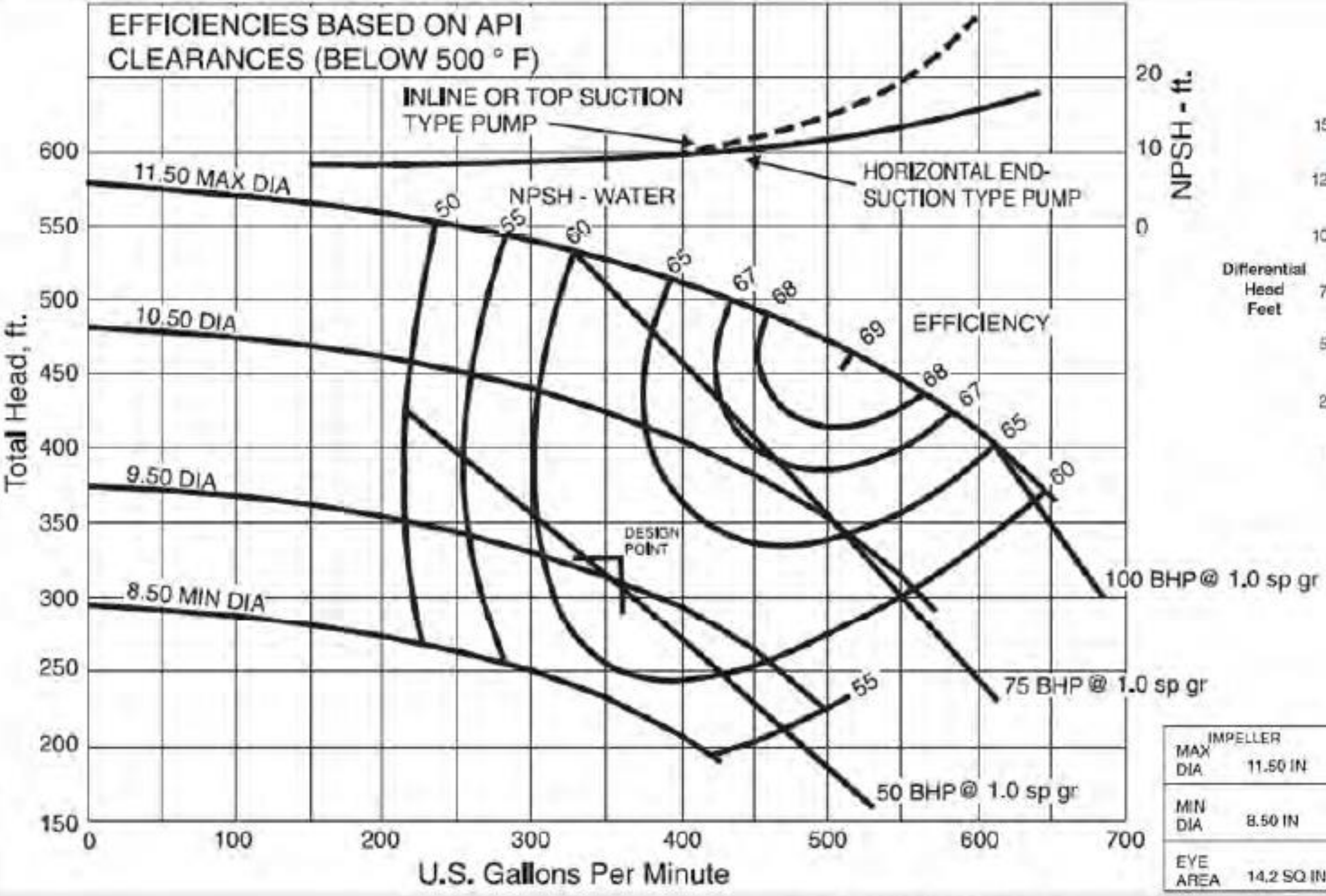


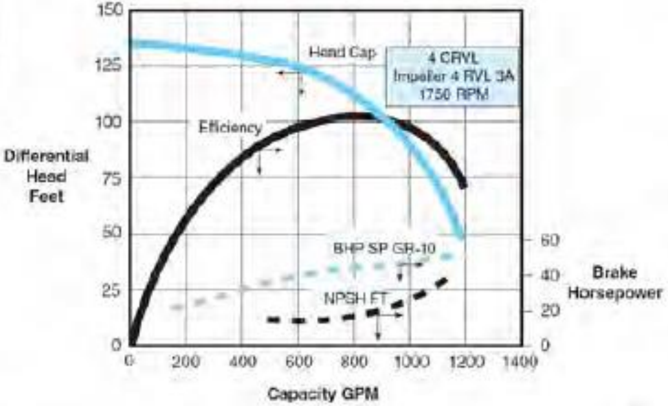
Key

X flowrate
Y1 head
Y2 vibration
1 allowable operating region of flow
2 preferred operating region of flow
3 maximum allowable vibration limit at flow limits
4 basic vibration limit
5 best efficiency point, flowrate
6 typical vibration vs. flowrate curve showing maximum allowable vibration
7 head-flowrate curve
8 best efficiency point, head and flowrate

Centrifugal Pump – Sample Pump Curve

Pump Curve





MAX DIA IMPELLER	11.50 IN	3 X 4 X 11.5 SINGLE STAGE PUMP		
MIN DIA	8.50 IN	DIA IMPELLER 9.75 IN	IMPELLER PATT	3,560 RPM
EYE AREA	14.2 SQ IN	NPSH REQUIRED 9 FT	REFERENCE	CURVE NO. CA-307-3

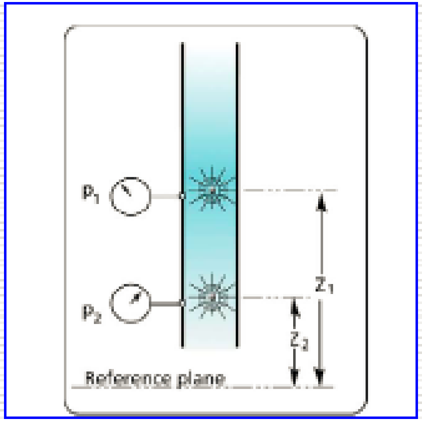
Centrifugal Pump – Pressure & Head Relationship

- Pressure (P) = SG x g x Head (H)

- **H = P / (SG x g)**
- **P = H x g x SG**

Where

H	=	head, in meter
P	=	pressure, kPa
SG	=	specific gravity of liquid
g	=	9.8 m/sec²

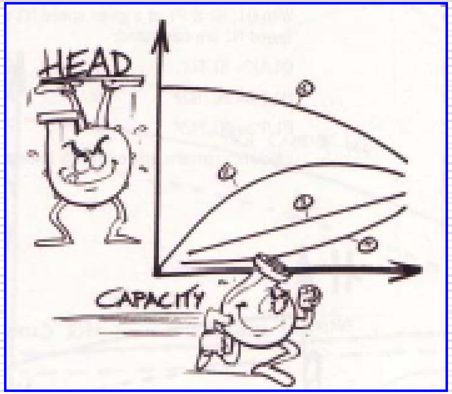


- **H = P x 2.31 / SG**

- **P = $\dfrac{\text{H x SG}}{2.31}$**

Where

H	=	head, in feet
P	=	pressure, in PSI
SG	=	specific gravity of liquid
2.31	=	conversion factor



Efficiency Centrifugal Pumps

$$\text{Pump Efficiency} = \frac{\text{Output}}{\text{Input}} = \frac{\text{WHP (Water Horse Power)}}{\text{BHP (Brake Horse Power)}}$$

$$\text{WHP} = \frac{\text{Head} \times \text{Flow} \times \text{Specific Gravity}}{3960}$$

$$\text{BHP} = \frac{\text{Head} \times \text{Flow} \times \text{Specific Gravity}}{3960 \times \text{efficiency}}$$

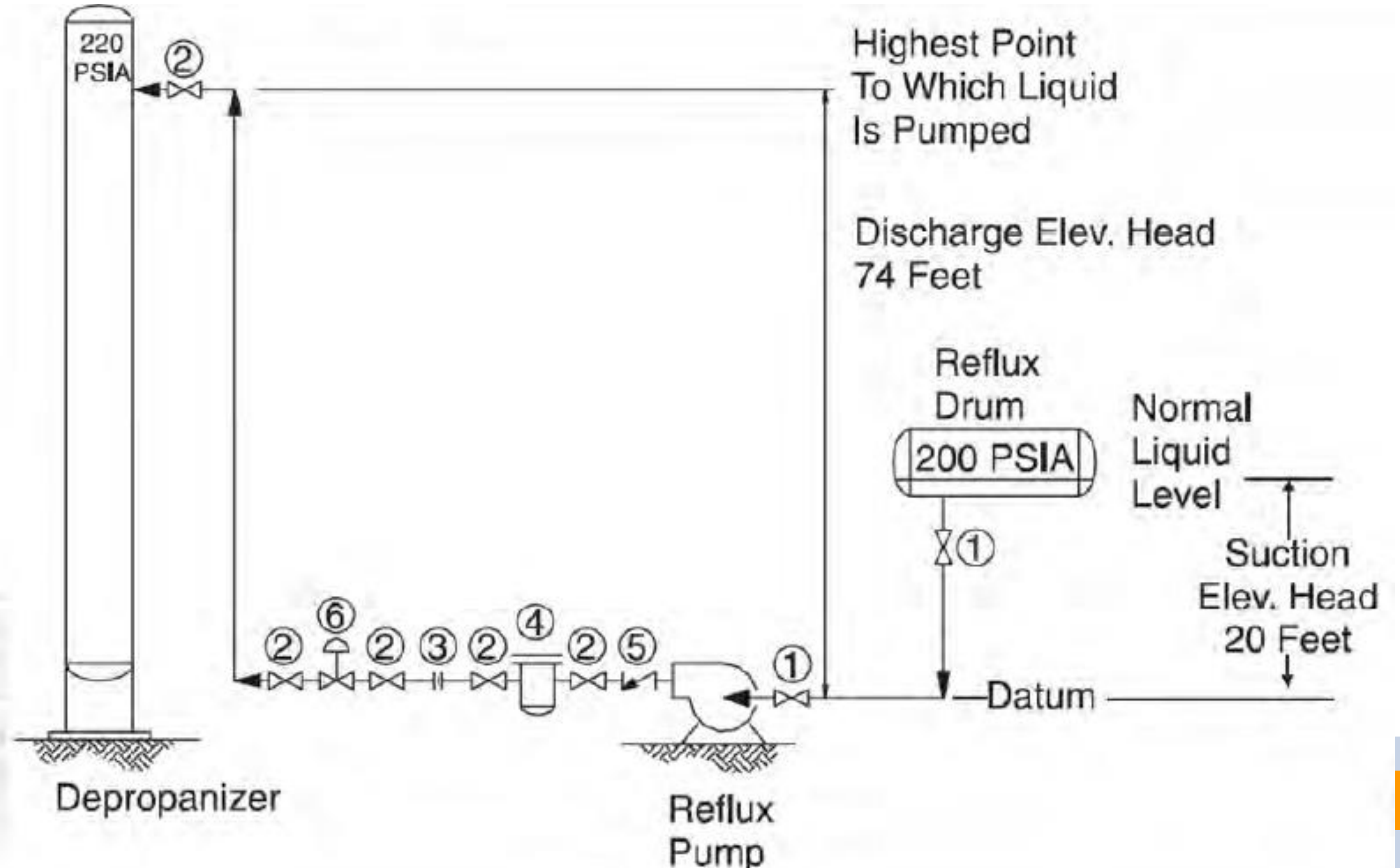
Head is in **feet** and flow is gallons per minute **GPM**
Efficiency as a decimal

For centrifugal pumps in US-C units

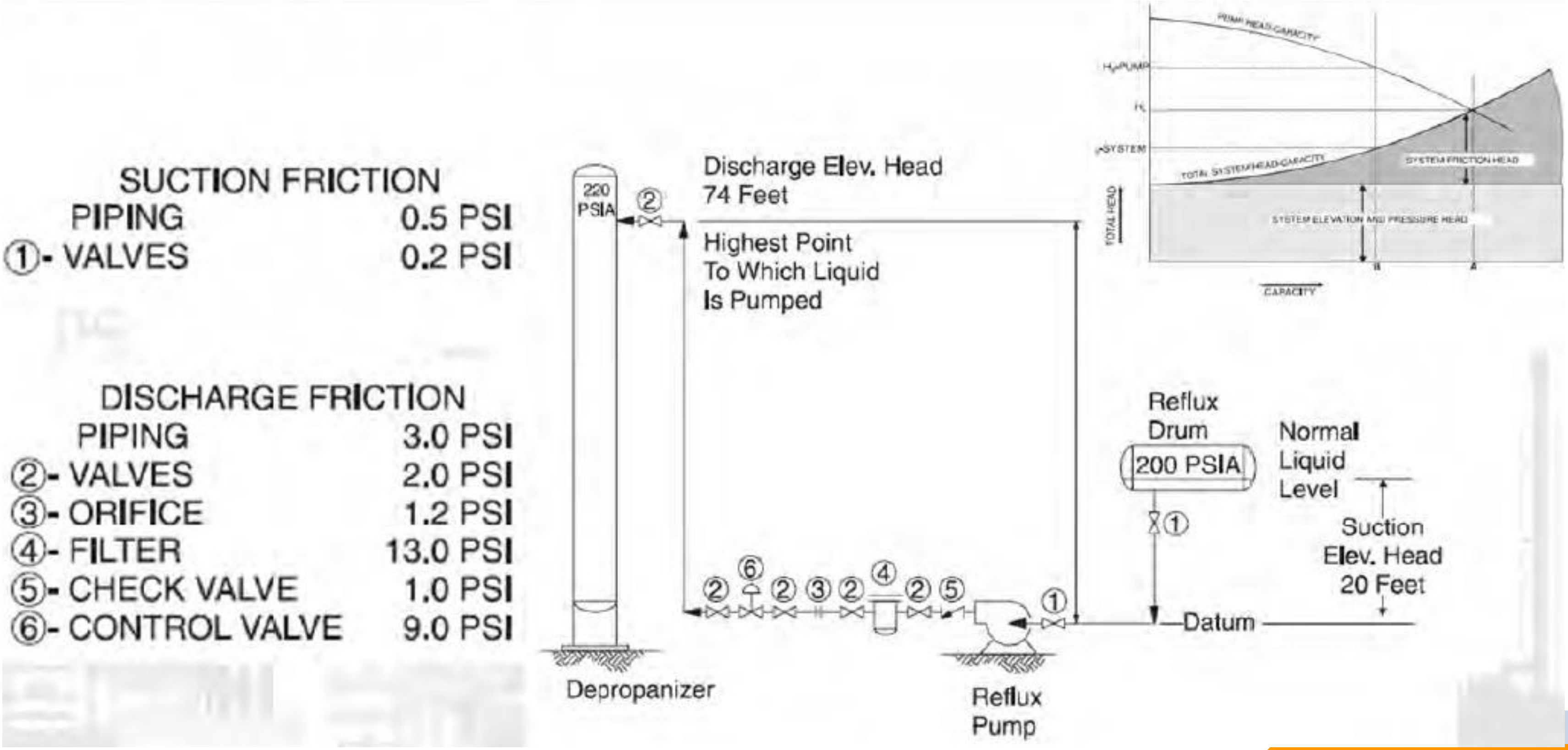
Assuming required operation

- Liquid: Propane, is to be pumped from a reflux drum to a depropanizer
- Max Flowrate, Q= 350 gpm
- The pressures in the vessels are 200 and 220 psia respectively
- Specific Gravity, SG: 0.485
- Efficiency, e: 62.5

Centrifugal Pump – Sample Reflux Pump Calculation



Centrifugal Pump – Sample Reflux Pump Calculation



Absolute Total Pressure at Pump Suction

Reflux drum		200.0 psia
Elevation	20 ft. • 0.485/2.31 =	+ 4.2 psi
Friction	piping	- 0.5 psi
	valves	- 0.2 psi
		203.5 psia
		= 188.8 psig

Absolute Total Pressure at Pump Discharge

Tower		220.0 psia
Elevation	74 ft • 0.485/2.31 =	+15.5 psi
Friction	piping	+3.0 psi
	valves	+2.0 psi
	orifice	+1.2 psi
	filter	+13.0 psi
	check valve	+1.0 psi
	control valve	+9.0 psi
		264.7 psia
		= 250.0 psig

Differential pressure $= 250.0 - 188.8 \qquad = 61.2$ psi

Differential head = H $= \dfrac{(61.2)(2.31)}{0.485} \qquad = 292$ ft

10% safety factor $\qquad \underline{+30 \text{ ft}}$

Required differential head (H) $\qquad 322$ ft

Calculation of Hydraulic Power

$$\text{hyd hp} = \frac{(Q)(H)(\text{sp.gr.})}{3960}$$

$$\text{hyd hp} = \frac{(360)(322)(0.485)}{3960} = 14.2 \text{ hp}$$

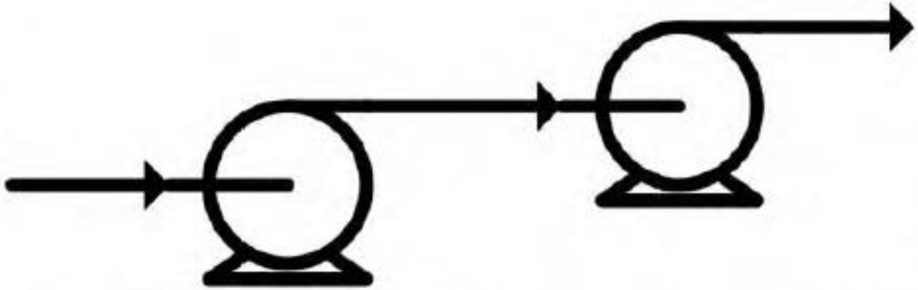
Calculation of Actual Horsepower

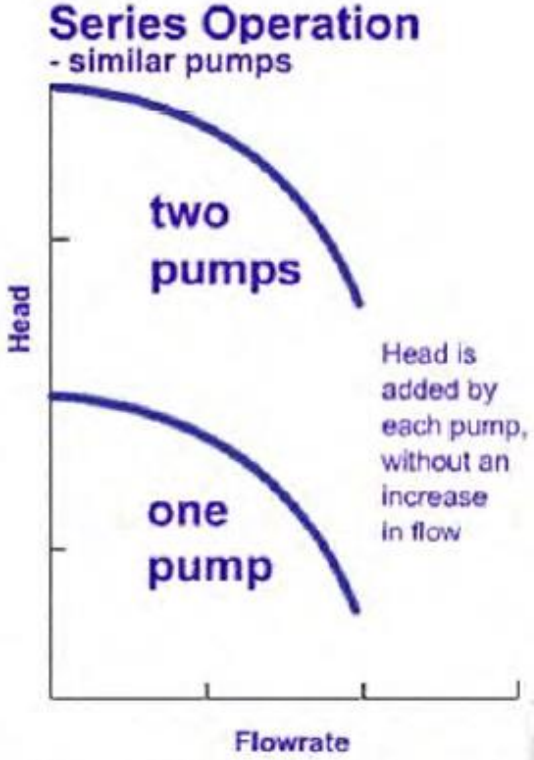
$$\text{bhp} = \frac{\text{hyd hp}}{e}$$

The efficiency at rated capacity and required head is 62%.

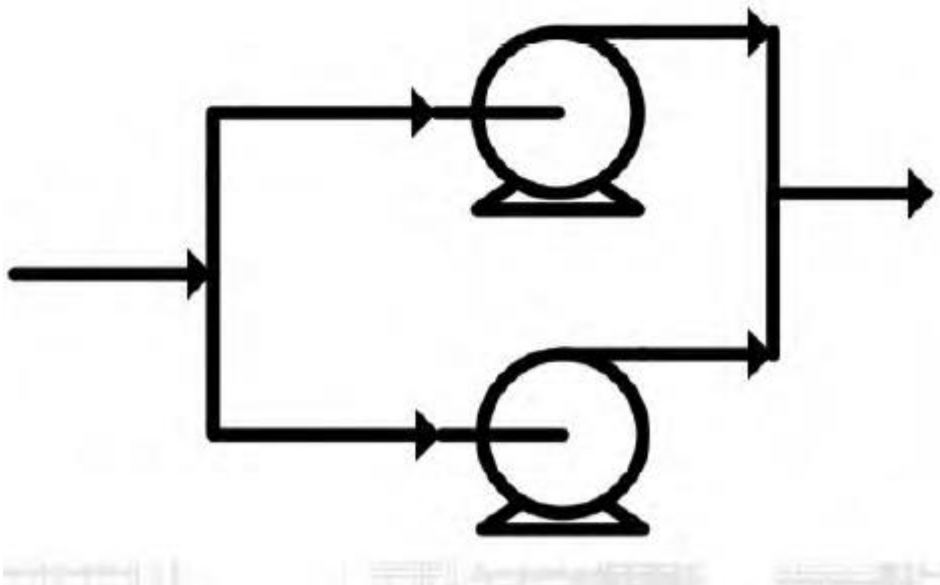
$$\text{bhp} = \frac{14.2}{0.62} = 22.9 \text{ bhp}$$

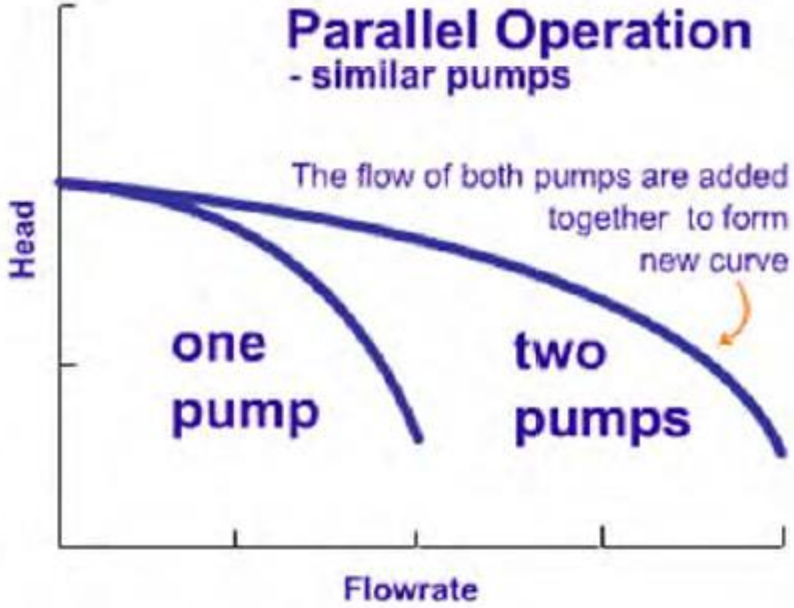
Series Pumps





Pararell Pumps

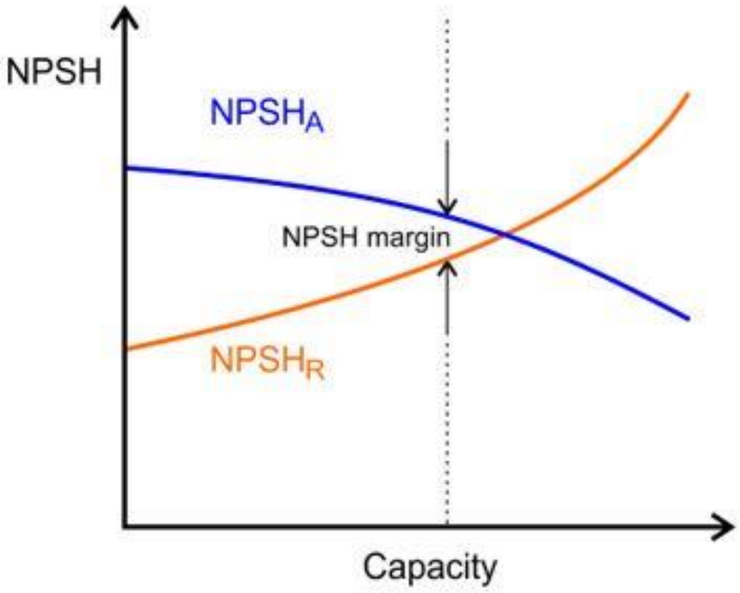




NPSH

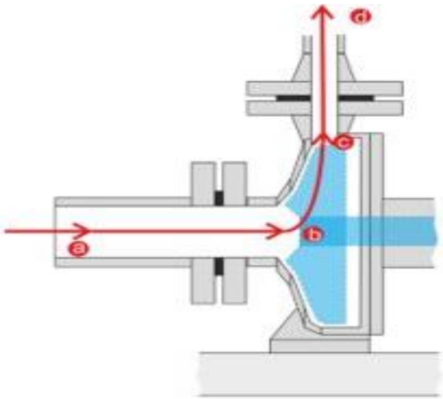
- NPSH stands for Net Positive Suction Head and is a measure of the pressure experienced by a fluid on the suction side of a centrifugal pump.
- The purpose of NPSH is to identify and avoid the operating conditions which lead to vaporization of the fluid as it enters the pump – a condition known as flashing.

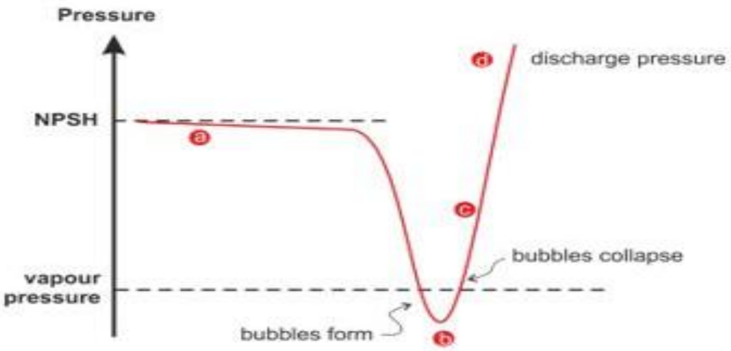
- NPSH is normally considered in two forms:
  - NPSH-R (NPSH Required)
  - NPSH-A (NPSH Available)



Variation of NPSH-R and NPSH-A with capacity (discharge flow)

- Cavitation





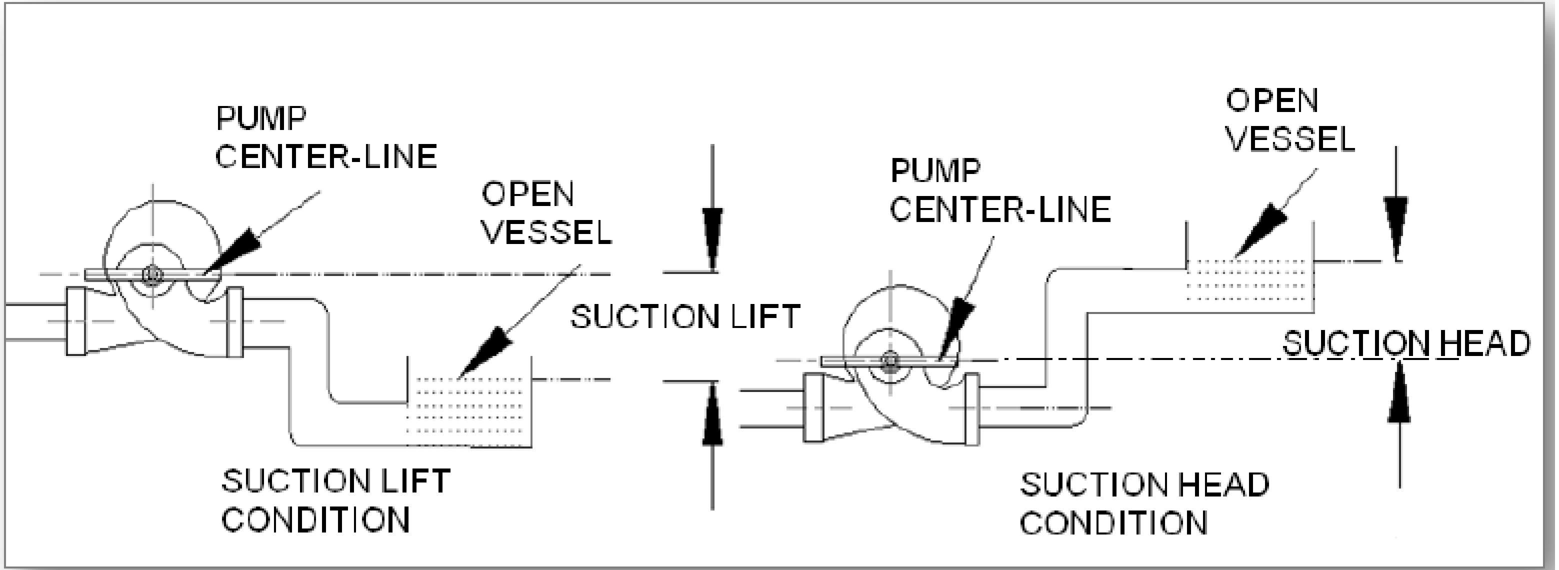
Pressure gradient through a centrifugal pump experiencing cavitation:

fluid enter the pump (a);

pressure drops below vapor pressure at impeller (b),

pressure rises as fluid out to discharge (d) and bubbles condense and collapse (c)

Centrifugal Pump – NPSH Calculation

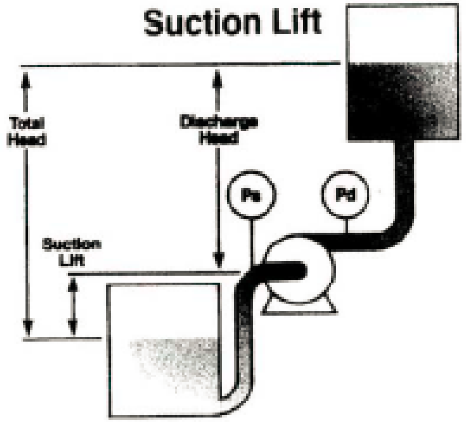


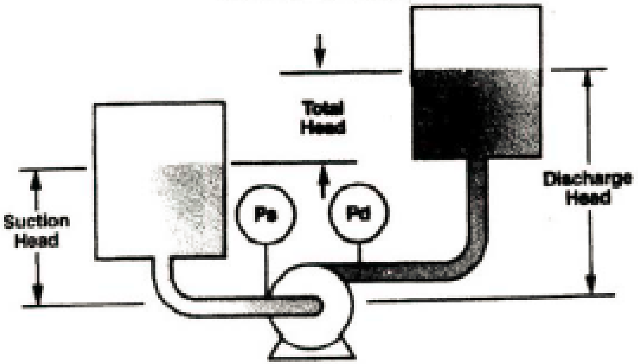
NPSHa (M) = ATMOSPHERIC PRESSURE(M) – SUCTION LIFT(M) – FRICTIONAL HEAD LOSS(M) - V.P (M)	NPSHa (M) = ATMOSPHERIC PRESSURE(M) + SUCTION HEAD(M) – FRICTIONAL HEAD LOSS(M) - V. P (M)

- NPSH Safety margin = 10 % of Calculated or 1 meter minimum.
- **NPSHA > NPSHR + Safety Margin**
- The NPSHA should normally be at least 0.6 m (2 ft) above the NPSHR in normal applications (stable operation with fluid at low vapor pressure).

Centrifugal Pump – NPSH Calculation

- NPSHa = Ha $\pm$ Hs - Hf – Hvp
  - Ha = atmospheric or vessel pressure (ft or m of liquid being pumped)
  - Hs = static lift or head
  - Hf = piping friction losses
  - Hvp = vapor pressure
  - All parameters should be in same unit.





Centrifugal Pump – Parameters Affecting NPSHA

- Suction pipe length
- Suction pipe diameter
- Liquid specific gravity
- Internal surface of suction pipe
- Liquid surface altitude
- Vapor contamination
- Suction pipe leaks
- Suction pressure
- Liquid temperature liquid viscosity
- Liquid vapor pressure

Centrifugal Pump – How To Improve NPSHA

- Shorten the suction pipe length
- Increase suction pipe size
- Decrease suction liquid temperature
- Decrease suction negative altitude
- Increase suction positive altitude
- Stop the piping suction leak

WHEN ONLY IMPELLER DIA. CHANGES & SPEED REMAINS THE SAME	WHEN ONLY SPEED CHANGES & IMPELLER DIA. REMAINS THE SAME	WHEN BOTH DIA & SPEED CHANGE
$Q_2 = Q_1 \times (D_2/D_1)$	$Q_2 = Q_1 \times (N_2/N_1)$	$Q_2 = Q_1 \times (D_2/D_1) \times (N_2/N_1)$
$H_2 = H_1 \times (D_2/D_1)^2$	$H_2 = H_1 \times (N_2/N_1)^2$	$H_2 = H_1 \times \{ (D_2/D_1) \times (N_2/N_1) \}^2$
$BKW_2 = BKW_1 \times (D_2/D_1)^3$	$BKW_2 = BKW_1 \times (N_2/N_1)^3$	$BKW_2 = BKW_1 \times \{ (D_2/D_1) \times (N_2/N_1) \}^3$

- Q1, H1, BKW1, D1 & N1 ARE CAPACITY, HEAD, INPUT POWER IN KW, IMPELLER DIA. & SPEED AT INITIAL CONDITION.
- Q2, H2, BKW2, D2 & N2 ARE CAPACITY, HEAD, INPUT POWER IN KW, IMPELLER DIA. & SPEED AT CHANGED CONDITION.

Centrifugal Pump – AFFINITY LAWS

WHEN ONLY IMPELLER DIA. CHANGES & SPEED REMAINS THE SAME	WHEN ONLY SPEED CHANGES & IMPELLER DIA. REMAINS THE SAME	WHEN BOTH DIA & SPEED CHANGE
$Q_2 = Q_1 \times (D_2/D_1)$	$Q_2 = Q_1 \times (N_2/N_1)$	$Q_2 = Q_1 \times (D_2/D_1) \times (N_2/N_1)$
$H_2 = H_1 \times (D_2/D_1)^2$	$H_2 = H_1 \times (N_2/N_1)^2$	$H_2 = H_1 \times \{ (D_2/D_1) \times (N_2/N_1) \}^2$
$BKW_2 = BKW_1 \times (D_2/D_1)^3$	$BKW_2 = BKW_1 \times (N_2/N_1)^3$	$BKW_2 = BKW_1 \times \{ (D_2/D_1) \times (N_2/N_1) \}^3$

- Q1, H1, BKW1, D1 & N1 ARE CAPACITY, HEAD, INPUT POWER IN KW, IMPELLER DIA. & SPEED AT INITIAL CONDITION.
- Q2, H2, BKW2, D2 & N2 ARE CAPACITY, HEAD, INPUT POWER IN KW, IMPELLER DIA. & SPEED AT CHANGED CONDITION.

No.	Codes and Standards	Document Title
1.	API 610	Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries
2.	API 682	Pump-Shaft Sealing Systems for Centrifugal and Rotary Pumps
3.	ASME B 16.5	Pipe flanges and flanges fitting
4.	ASME B73.1	Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process
5.	ASME B73.2	Specification for Vertical In-Line Centrifugal Pumps for Chemical Process
6.	ISO 5199 (Part 2)	Technical Specification for Centrifugal Pump – Class II

Design Requirement Centrifugal Pump

a. API 610, ASME B73.1, ISO except where modified by project specification(s).

b. design has a successful record proven field

c. NPSHr shall be less than NPSH available by 1 meter. Except by OWNER Approval.

d. capable of operating at 110% of rated flow

e. Inducers shall not be used for horizontal pumps

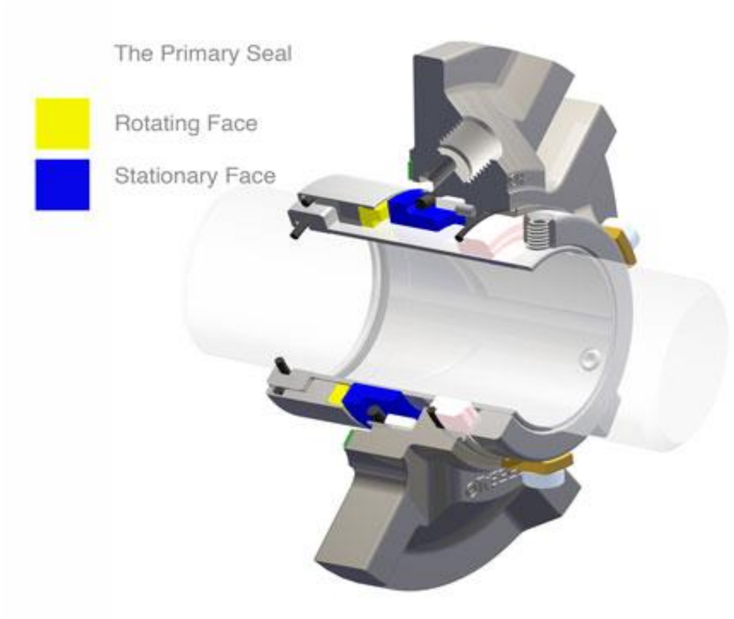
f. Drain valves shall be located as close to the pump.

g. Flange classes as per ASME B16.5.

Accessories of Centrifugal Pump

- Mechanical Seals
- Bearing and Bearing Housing
- Driver
- Coupling & Guard
- Instrumentation
- Auxiliary Piping
- Baseplate
- Name Plate

Sealing System and Bearing



Bearing

Bearing

Function of Bearing:

- **Function 1:** Reduce friction and make rotation more smooth
- **Function 2:** Protect the part that supports the rotation, and maintain the correct position for the rotating shaft

Bearing

Approximate bearing load

Approximate relative load, speed and misalignment capabilities

	Radial load	Axial load	Speed	Misalign-ment
Single row deep groove ball bearing	x	x	xxxx	xx
Double row angular contact ball bearing	xx	xx	xxx	x
Single row angular contact ball bearing pair	xx	xxxx	xxx	x
PumPac® bearing set	xx	xxxx (one direction)	xxx	x
Cylindrical roller bearing	xxx	—	xxx	x
Spherical roller bearing	xxxx	xx	xx	xxxx
Taper roller bearing set	xxxx	xxxx	xx	x
Spherical roller thrust bearing	—	xxxx	xx	xxxx

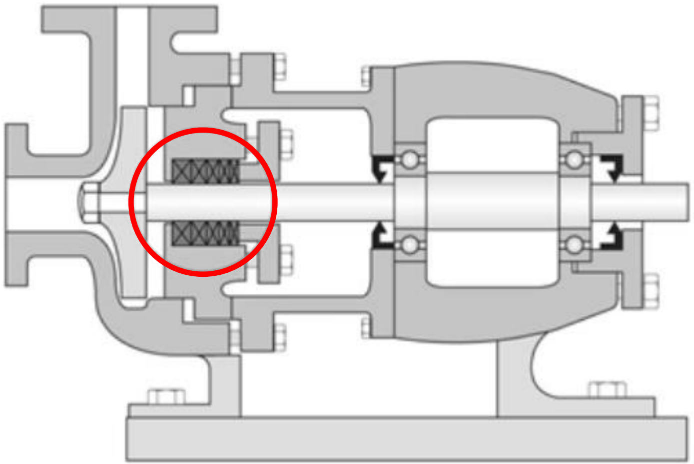
— No capacity
X Low
XX Moderate
XXX High
XXXX Very high

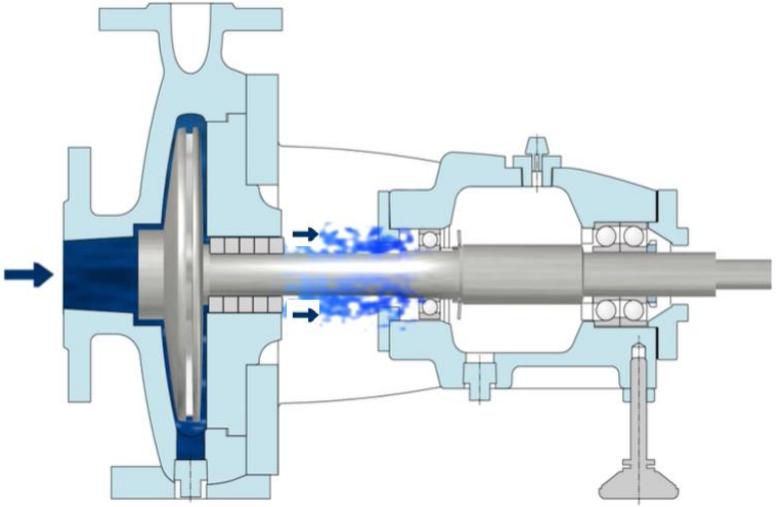
Bearing rating life shall refer to ISO 281:1990

The ASME/ANSI B73.1 Standard specifies rating lives L10h greater than 17,500 h

The API Standard 610 Standard specifies rating lives rating lives greater than 25,000 h

Sealing System of Dynamic Pumps





Sealing System of Dynamic Pumps

Sealing System of Dynamic Pumps

Sealing System of Dynamic Pumps

- TRADITIONAL METHOD:
  - Gland Packing

Gland Packing - Disadvantages

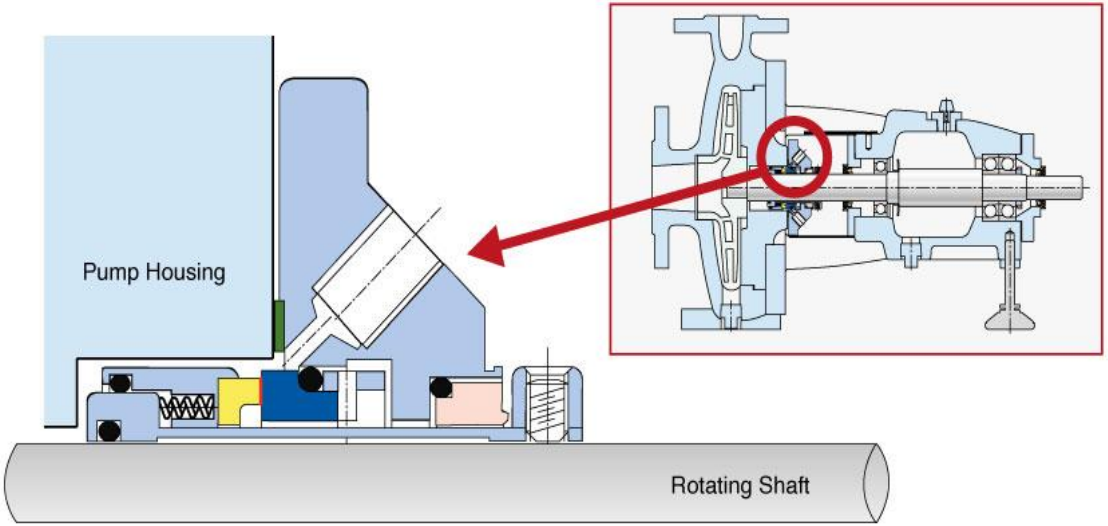
- Increased leakage
- Needs to be flushed with large volumes of water
- Pump needs more drive power
- Wear a groove into shaft

>>> Mechanical seals are designed to overcome these drawbacks.

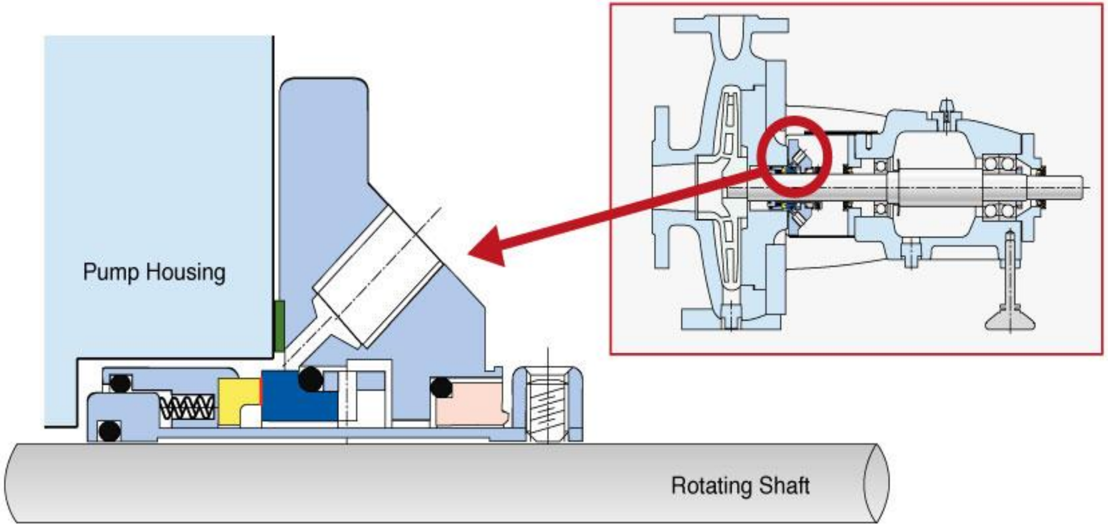
Sealing System of Dynamic Pumps

Sealing System of Dynamic Pumps

- MECHANICAL SEAL



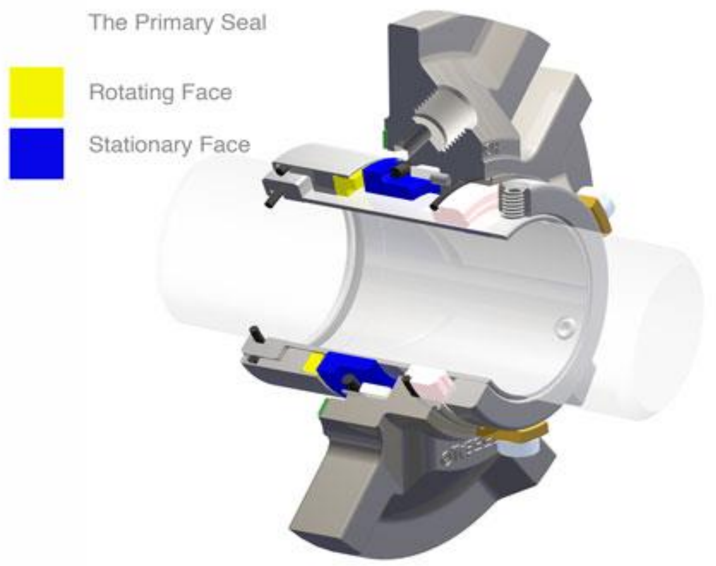
Sealing System of Dynamic Pumps



Sealing System of Dynamic Pumps

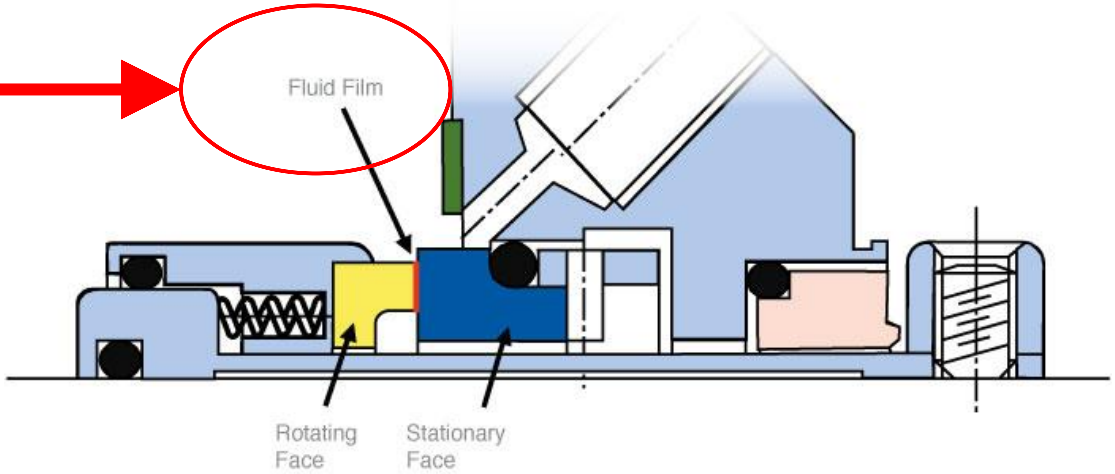
Highlighted in red, left the stationary part and right the rotary portion

Sealing System of Dynamic Pumps



Sealing System of Dynamic Pumps

Fluid Film



Sealing Plan Categories

Process side

Plan 01	Internal circulation in pump
Plan 02	Dead ended, clean medium
Plan 03	Tapered seal chamber bore
Plan 11	Circulation, pressure increase
Plan 12	Circulation, pressure increase + strainer
Plan 13	Circulation, venting
Plan 14	Circulation, venting, Plan 11+13, vertical pumps
Plan 21	Circulation via cooler
Plan 22	Circulation via cooler, strainer
Plan 23	Forced loop via cooler
Plan 31	Circulation, cyclone separator
Plan 41	Circulation, cyclone separator + cooler
Plan 32	External flush

Between seals

Plan 52	Buffer liquid reservoir
Plan 53A	Barrier liquid, reservoir
Plan 53B	Barrier liquid, bladder accumulator
Plan 53C	Barrier liquid, piston accumulator
Plan 54	External barrier liquid system
Plan 55	External buffer liquid system
Plan 71	Tapped connections for purchaser's use
Plan 72	Buffer gas system
Plan 74	Barrier gas system
Plan 75	Leakage collection and alarm, reservoir
Plan 76	Vapor leakage to flare

Atmospheric side

Plan 51	Dead-end quench reservoir, vertical pumps
Plan 61	Tapped connections for purchaser's use
Plan 62	External quench
Plan 65A	Leakage collection and alarm, reservoir
Plan 65B	Leakage collection and alarm, reservoir
Plan 66A	Leakage detection and alarm, two bushings
Plan 66B	Leakage detection and alarm, orifice plug

Engineered

Plan 99	Engineered to customer's specifications

Sealing Plan Application

- General HC service > Plan 11
- Hot / Clean HC service > Plan 23
- Hot oil service > Plan 32 / Plan 53 or 54
- Acid Service > Plan 32 / Plan 53 or 54 or Plan 74
- Dirty Service > Plan 31 / Plan 32 for single, Plan 54 for dual

Reciprocating Pump

Reciprocating Pump

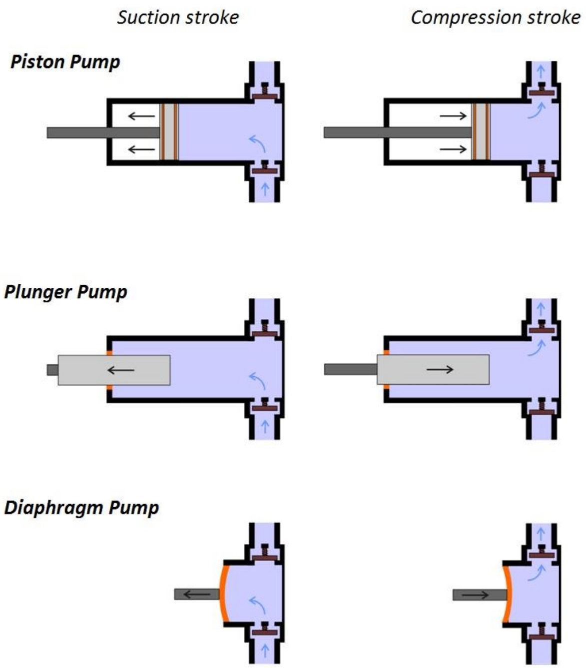


Figure 1. Basic reciprocating pump designs

No.	Codes and Standards	Document Title
1.	API 674	Positive Displacement Pumps-Reciprocating
2.	ASME B 16.5	Pipe flanges and flanges fitting
3.	AGMA	American Gear Manufacturer Association
4.	ASME Section VIII	Boiler and Pressure Vessel

Design Requirement Reciprocating Pump

a. API 674, or manufacture standard, except where modified by project specification(s).
b. design has a successful record proven field service
c. suitable for open installation on tropical climate, and corrosive water vapor and frequent rains & strong winds.
d. Inlet and outlet connections shall be flanged or machined and studded.
e. oil level sight gauge shall be provided
e. Pump shall be designed to run safety to the trip and external relief valve set pressure, plus 10 percent.
f. The maximum allowable speed shall not exceed those values given in the related standard.
g. The cylinder shall be designed for at least 120% of the rated design pressure.
h. The valves for each cylinder shall be accessible
j. For design temperature over 500 ‘F, special consideration for gasket material selection shall taken.
k. high vapor pressure (greater than 14.7 psia at pumping temperature) use a double packing gland assembly

Accessories of Reciprocating Pump

- Coupling & Guard
- Driver
- Instrumentation
- Gear Box
- Pulsation Suppression Devices
- Baseplate/Skid
- Nameplate

Controlled Volume Pump

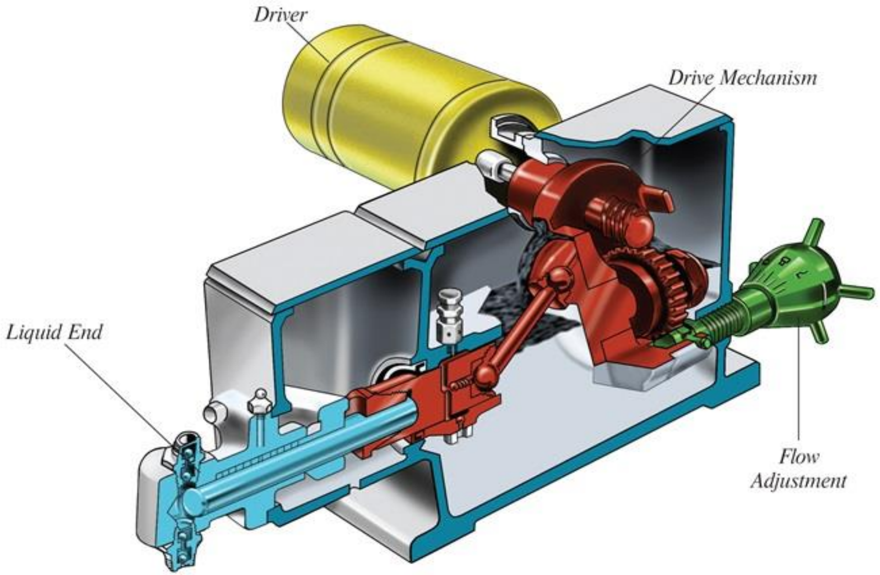
Controlled Volume Pump

Metering pumps are generally used in applications where one or more of the following conditions exist:

- Low flow rates in ml/hr or GPH are required
- High system pressure exists
- High accuracy feed rate is demanded
- Dosing is controlled by computer, microprocessor, DCS, PLC, or flow proportioning
- Corrosive, hazardous, or high temperature fluids are handled
- Viscous fluids or slurries need to be pumped

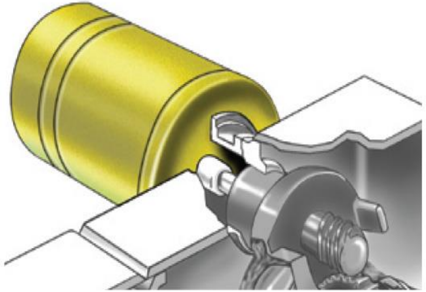
Important part for controlled volume pump component:

- Driver
- Liquid End
- Driver Mechanism
- Flow Adjustments

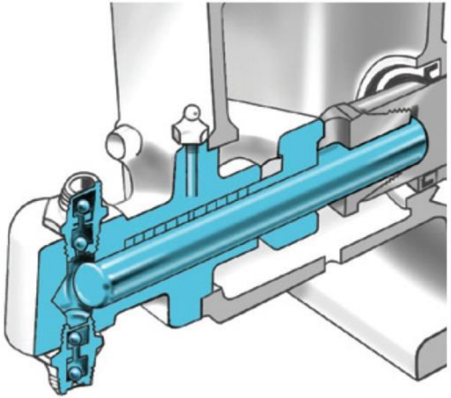


Controlled Volume Pump – Important Terms

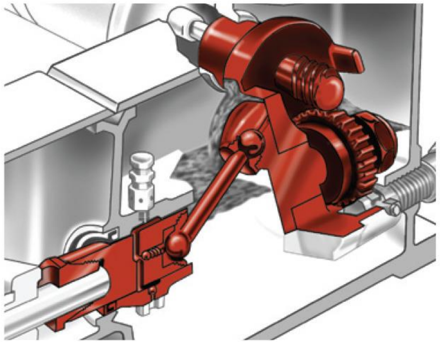
Important part for controlled volume pump component:



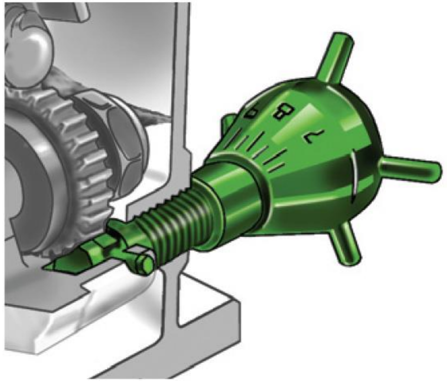
Driver



Liquid End

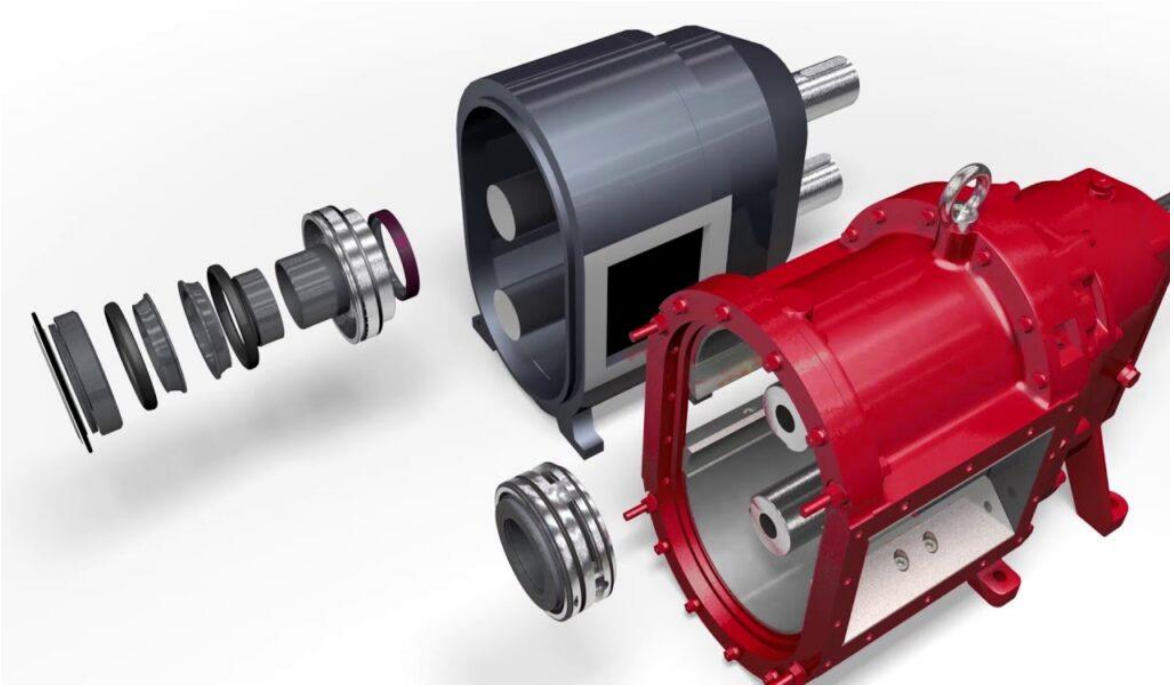


Driver Mechanism



Flow Adjustments

Rotary Pump



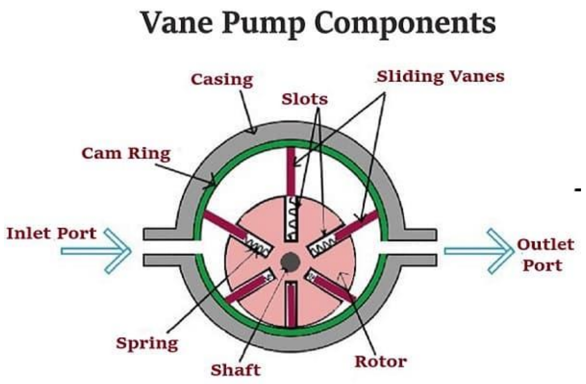
Rotary pumps

Rotary Pump

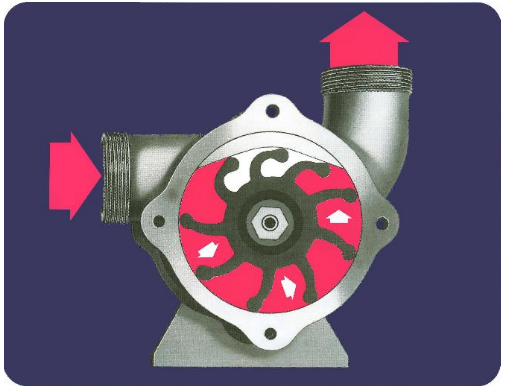
9 Different Types of Rotary Pumps are:

1. Vane Pumps
2. Flexible Member Pumps
3. Rotary Piston Pump
4. Peristaltic Pumps
5. Progressive Cavity Pumps
6. Gear Pumps
7. Lobe Pumps
8. Circumferential Piston Pumps
9. Screw Pumps

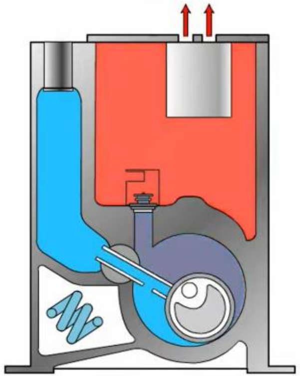
Rotary Pump



Vane pumps

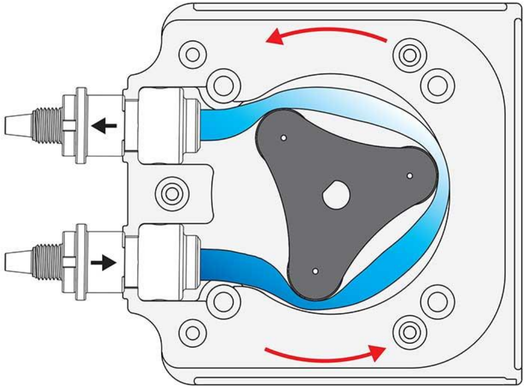


Flexible Member Pumps

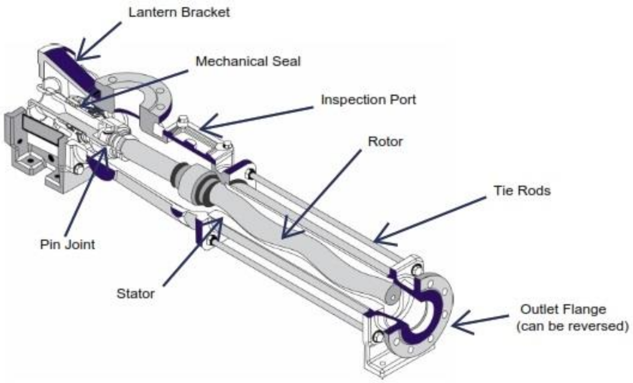


Rotary Piston Pump

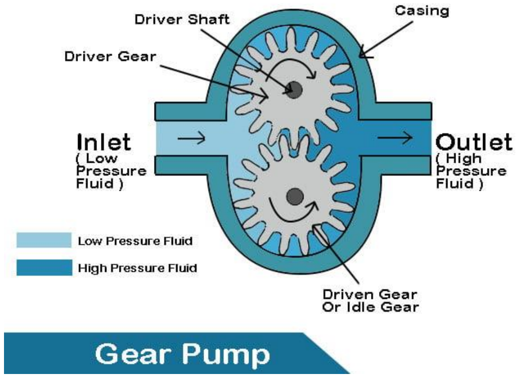
Rotary Pump



Peristaltic Pumps

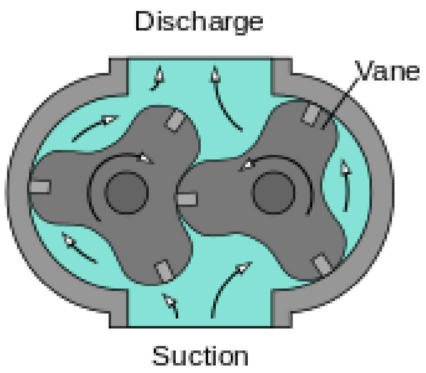


Progressive Cavity Pumps

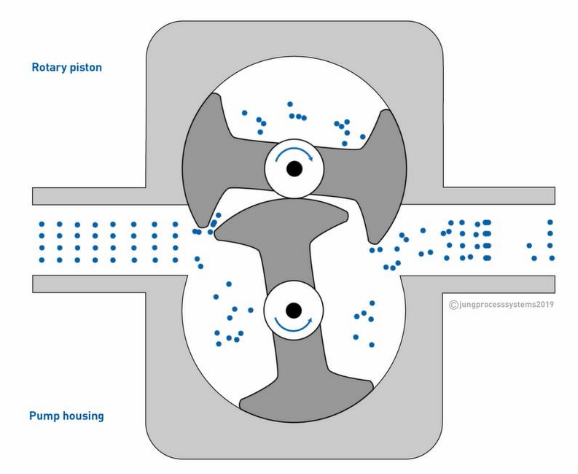


Gear Pumps

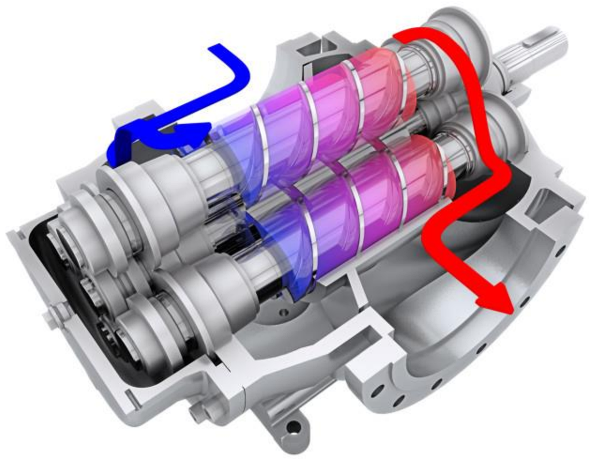
Rotary Pump



Lobe Pumps



Circumferential Piston Pumps

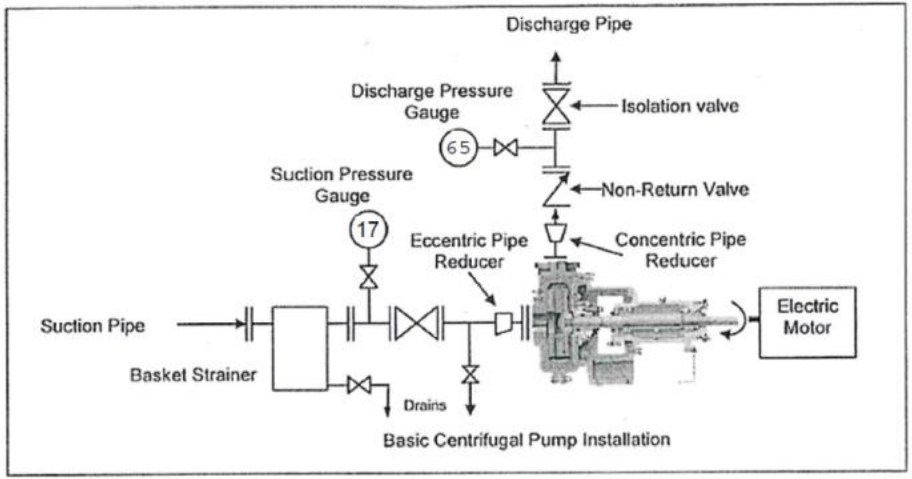


Screw Pumps

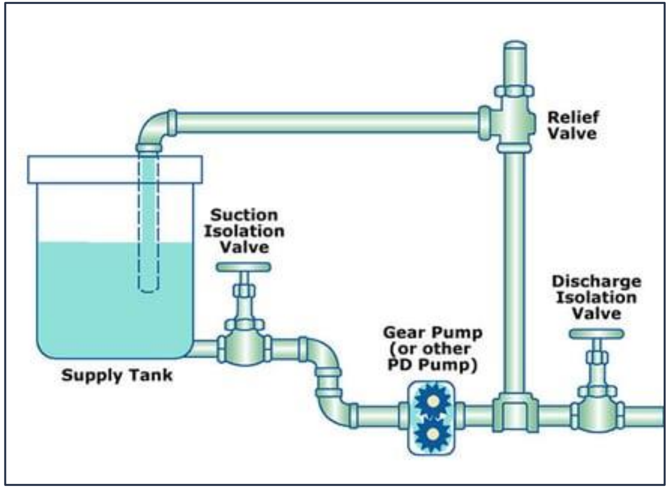
Rotary Pump Important Terms

- ❑ **Slip**
  - quantity of leaks
- ❑ **Volumetric Efficiency**
  - used by many manufacturers to express the amount of slip
- ❑ **Mechanical Efficiency**
  - Normally ranges from 60% to 70%,

Pump Operation



Centrifugal Pump Start Up



PDP Pump (Rotary/Reciprocating) Start Up

Centrifugal Pump Start Up:

1. Open the suction valve.

2. Ensure any recirculation or cooling lines are open.

3. Fully close or partially open the discharge valve, depending on system conditions.

4. Start the driver (Electric Motor).

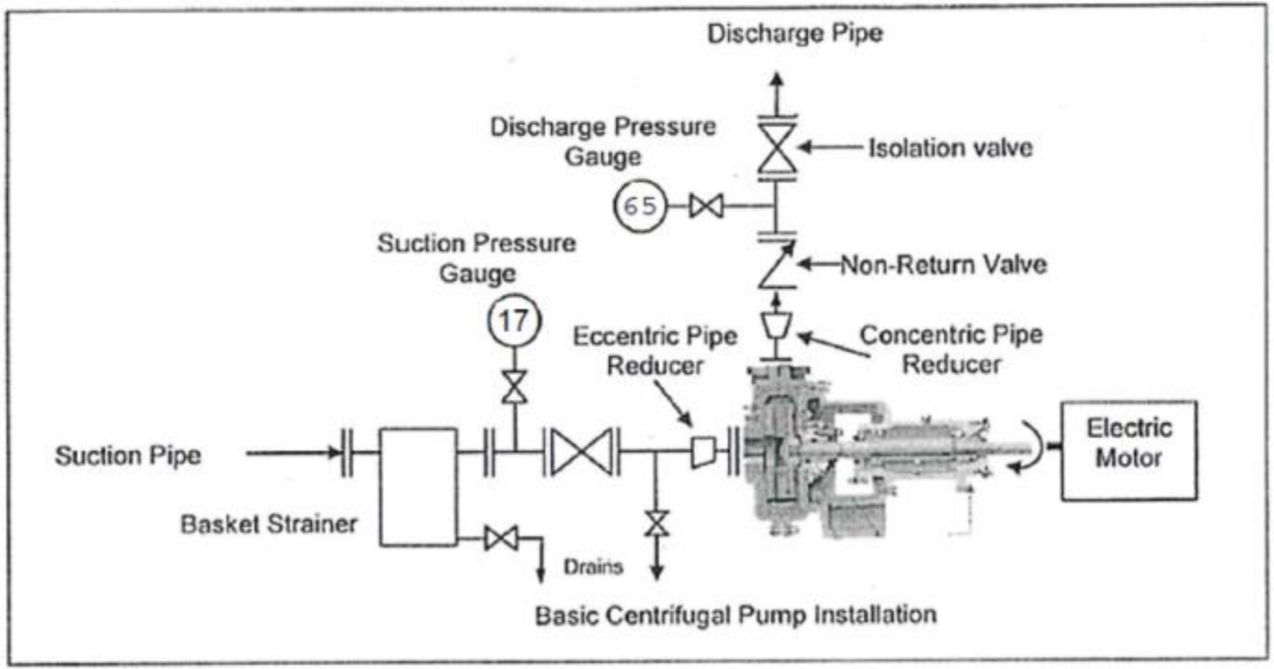
5. Slowly open the discharge valve until the pump reaches the desired flow.

6. Check the pressure gauge to ensure that the pump quickly reaches the correct discharge pressure.

7. If the pump fails to reach the correct pressure, driver shall be stopped. Before restarting the driver, it needs to be ensured that the pump is primed.

8. Monitor bearing temperature vibration and the noise of the pump while it is operating. If the pumps exceed normal levels, then consider shutting down the pump immediately and correct the problem.

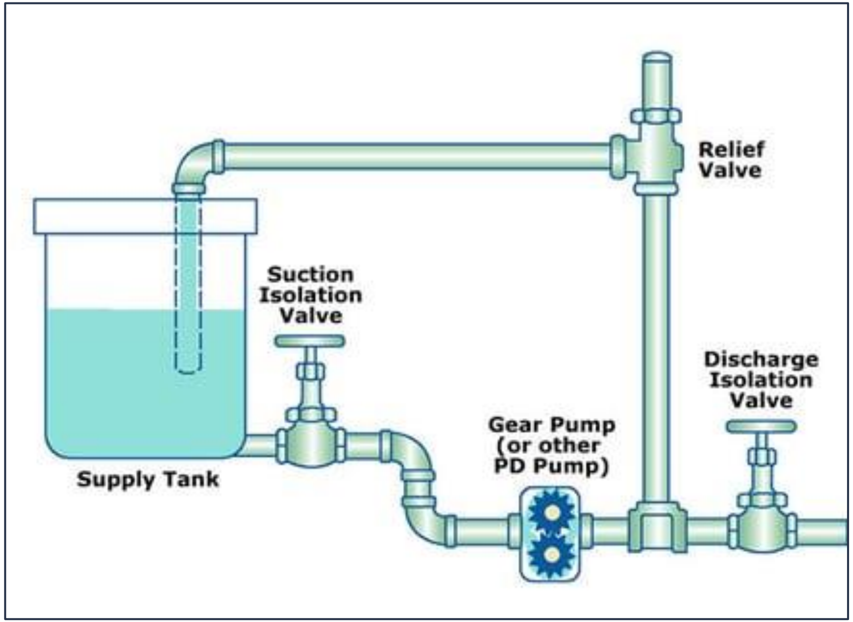
Centrifugal Pump Typical Arrangment:



PDP Pump (Rotary/Reciprocating) Start Up::

1. Ensure the suction and discharge valves must be opened
2. Ensure drain in pump and piping is closed
3. Ensure Oil level is sufficient
4. Although PDP is self-priming, it's better to fill the pump casing with fluid before starting
5. Start up the PDP pump (energize driver (electric motor))
6. After starting, close discharge valve slowly while watching pressure gauge to make sure relief valve or unloader is operating properly. Adjust relief valve to desired pressure.
7. Monitor the pump condition to ensure no parameter exceed normal levels

PDP Pump Typical Arrangment:



Pump Operation Tips:

After Successful start-up, its also important to consider following aspect to ensure smooth pump operation:

- Follow Instructions
- Routine Component Checks
- Monitor Pump Condition
- Maintain Accessibility
- Use the Pump as Designed

Pump Maintenance

Pump Maintenance

Pump maintenance is needed to restore performance, reliability and ensure process performance is restored to original design criteria.

There are 3 types maintenance:

1) Corrective (Reactive) Maintenance
2) Preventative (Semi Proactive) Maintenance
3) Monitoring (Proactive & Predictive)

Corrective (Reactive) Maintenance

Corrective Maintenance is undertaken when failure has occurred. The unit may be leaking, efficiency reduced, pump stopped, or motor tripped, leading to loss of production resulting in an urgent situation where parts must be sourced and fitted quickly.

Preventative (Semi Proactive) Maintenance

Preventative Maintenance is inspection and repair scheduled at specific intervals (daily, weekly, monthly, yearly) or based on the number of hours run. Visual inspections are made externally and internally by dismantling the unit, replacing seals such as gaskets and mechanical seals, with pump parts checked for wear.

<u>A typical preventative Maintenance Checklist Consists of:</u>

- Differential Pressure Check
- Vibration Check.
- Noise Check
- Excess Temperature Check
- Corrosion Check
- Gaskets / Leakage Check
- Wearing Part Tolerance Check
- Motor Basic Check.
- Mechanical Seal (barrier fluid) – Check

Monitoring (Proactive & Predictive)

The ideal situation is to ensure components are replaced before failure but not so far in advance that they have experienced little wear with valuable time spent on inspecting components which are otherwise fine.

This can be achieved through a monitoring device, where when the right data is collected, pump failure can be anticipated between 3 and 12 months in advance with an 80-95% accuracy.

Centrifugal Pump Maintenance

Overview of Centrifugal Pump most common parts:

- Casing (Volute)
- Impeller
- Motor (drive)
- Shaft (rotor)
- Shaft Seals
- Bearings

Centrifugal Pump Maintenance

Typical problems that may occur in the Pump:

- Cavitation
- Wear of the impeller
- Corrosion
- Surge or back surge
- Overheating of the pump
- Leakage
- Lack of prime

Centrifugal Pump Maintenance

Typical routine centrifugal pump maintenance program :

- Routine Maintenance:
  - As often as possible, it can be daily item or weekly.
- Quarterly Maintenance
  - 4 time every year
- Annual Maintenance
  - One time every year

Routine Maintenance

- Bearing And Lubricant Condition
- Shaft Seal Condition
- Overall Pump Vibration
- Pump Discharge Pressure

Quarterly Maintenance

- Integrity of the pump's foundation
- Check/change the oil after
- Greased every three months
- Shaft alignment
- Bearing vibration spectrum

Annual Maintenance

- Bearing Frame And Foot - inspect for cracks, roughness, rust or scale
- Shaft And Sleeve - inspect for grooves or pitting
- Casing – inspect for signs of wear, corrosion or pitting
- Impeller – inspect the impeller for wear, erosion or corrosion damage
- Frame Adapter – inspect for cracks, warping or corrosion damage
- Bearing Housing – inspect for signs of wear, corrosion, cracks or pits
- Seal Chamber/Stuffing Box Cover – check for pitting, cracks, erosion or corrosion
- Shaft – check the shaft for any evidence of corrosion or wear and straightness

Several reason for mechanical seal failure:

- Dry Running
- Chemical Attack
- Cavitation
- Excess Heat
- Incorrect Fitting
- Shaft Movement due to bearing Wear
- Worn Shaft or Wear
- Solid Ingress

Reciprocating Pump Maintenance

Implementation of a preventive maintenance plan keeps pump running at optimal levels and protects your product investment. Use the below checklist to schedule regular product inspections and part replacements to extend your products lifecycle.

Reciprocating Pump Maintenance – Maintenance Check List

Daily Checklist

- Check: Noise, bearings temperature, oil ports

Weekly Checklist

- Check: oil level, Leaks

Monthly Checklist

- Check: excess grease

Quarterly Checklist

- Check: grease seals, damaged seals, rotor, shaft shoulder, Gear, bearings, movement

Rotary Pump Maintenance

The checklist for rotary pump can also refer to the checklist for reciprocating above. Additional tips in maintaining rotary vane pumps are as follows

Maintenance Tips

- Change Oil Regularly
- Replace the Filter
- Keep the Temperature Low
- Change the Vane (Rotating Element)

Basic Pump Troubleshooting

Troubleshooting Centrifugal Pump

The following section provides a basic guide to dealing with potential problems which may occur

Centrifugal Pump Potential Problems

1) Little or no discharge
2) Loss of suction
3) Motor Overheats and Shuts Off (Overload)
4) Pump leaks at shaft
5) Pump vibrates and/or makes excessive noise
6) Pump will not deliver water or develop pressure
7) Pump will not prime
8) Pump will not start or run

Troubleshooting Reciprocating Pump

The following section provides a basic guide to dealing with potential problems which may occur

Reciprocating Pump Potential Problems

1) Knocking in the Power End
2) High Oil Temperature
3) Oil Seal Leakage
4) Low suction pressure
5) Short valve life
6) Low discharge pressure
7) Erratic or Nonexistent Discharge
8) Shirt plunger/packing life
9) Discharge piping vibration

Basic Pump Troubleshooting

Troubleshooting Rotary Pump

The following section provides a basic guide to dealing with potential problems which may occur

Rotary Pump Potential Problems

1. No Flow
2. Under Capacity
3. Irregular Discharge
4. Low Discharge Pressure
5. Pump will not prime
6. Prime lost after starting
7. Pump stalls after starting
8. Pump Overheats
9. Motor Overheats
10. Excessive Power absorbed
11. Noise and Vibrations
12. Rotor Wear
13. Syphoning
14. Seizure
15. Mech. Seal Leakage
16. Package Gland Package

Problem: No flow	Under capacity	Irregular discharge	Low discharge pressure	Pump will not prime	Prime lost after starting	Pump stalls when starting	Pump overheats	Motor overheats	Excessive power absorbed	Noise and vibration	Rotor wear	Syphoning	Seizure	Mechanical seal leakage	Packed gland leakage	Probable Causes	Solutions
✓																Incorrect direction of rotation.	Reverse motor.
✓																Pump not primed.	Expel gas from suction line and pumping chamber and introduce fluid.
✓	✓	✓	✓		✓					✓						Insufficient NPSH available.	Increase suction line diameter. Increase suction head. Simplify suction line configuration and reduce length. Reduce pump speed.
	✓	✓	✓		✓					✓						Fluid vaporising in suction line.	Increase suction line diameter. Increase suction head. Simplify suction line configuration and reduce length. Reduce pump speed.
✓	✓	✓		✓	✓					✓						Air entering suction line.	Remake pipework joints.
	✓	✓		✓	✓					✓						Strainer or filter blocked.	Service fittings.
	✓				✓	✓	✓	✓	✓					✓		Fluid viscosity above rated figure.	Increase fluid temperature. Decrease pump speed. Check seal face viscosity limitations.
	✓															Fluid viscosity below rated figure.	Decrease fluid temperature. Increase pump speed.
							✓			✓	✓		✓	✓		Fluid temperature above rated figure.	Cool the pumphead. Reduce fluid temperature. Check seal face and elastomer temperature limitations.
						✓		✓	✓							Fluid temperature below rated figure.	Heat the pumphead. Increase fluid temperature.
										✓	✓		✓	✓		Unexpected solids in fluid.	Clean the system. Fit strainer to suction line. If solids cannot be eliminated, consider fitting double mechanical seals.
✓	✓	✓			✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	Discharge pressure above rated figure.	Check for obstructions i.e. closed valve. Service system and change to prevent problem recurring. Simplify discharge line to decrease pressure.
							✓	✓	✓				✓			Gland over-tightened.	Slacken and re-adjust gland packing.
	✓	✓			✓					✓					✓	Gland under-tightened.	Adjust gland packing.
														✓	✓	Seal flushing inadequate.	Increase flush flow rate. Check that flush fluid flows freely into seal area.
	✓							✓	✓	✓						Pump speed above rated figure.	Decrease pump speed.
	✓															Pump speed below rated figure.	Increase pump speed.

Troubleshooting Rotary Pump

Rotary Pump Troubleshooting – Potential Problems

Problem																Probable Causes	Solutions
No flow	Under capacity	Irregular discharge	Low discharge pressure	Pump will not prime	Prime lost after starting	Pump stalls when starting	Pump overheats	Motor overheats	Excessive power absorbed	Noise and vibration	Rotor wear	Syphoning	Seizure	Mechanical seal leakage	Packed gland leakage		
	✓						✓	✓	✓	✓	✓		✓			Pump casing strained by pipework.	Check alignment of pipes. Fit flexible pipes or expansion fittings. Support pipework.
										✓	✓		✓			Flexible coupling misaligned.	Check alignment and adjust mountings accordingly.
							✓	✓	✓	✓	✓		✓			Insecure pump driver mountings.	Fit lock washers to slack fasteners and re-tighten.
							✓	✓	✓	✓	✓		✓			Shaft bearing wear or failure.	Refer to pump supplier for advice and replacement parts.
							✓	✓	✓	✓			✓			Worn un-synchronised timing gears.	Refer to pump supplier for advice and replacement parts.
							✓	✓	✓	✓	✓		✓			Insufficient gearcase lubrication.	Refer to pump supplier's instructions.
✓	✓						✓	✓	✓	✓	✓		✓			Metal to metal contact of rotors.	Check rated and duty pressures. Refer to pump supplier.
	✓		✓													Worn rotors.	Fit new rotors.
	✓									✓						Rotorcase cover relief valve leakage.	Check pressure setting and re-adjust if necessry. Examine and clean seating surfaces. Replace worn parts.
	✓									✓						Rotorcase cover relief valve chatter.	Check for wear on sealing surfaces, guides etc - replace as necessary.
	✓															Rotorcase cover relief valve incorrectly set.	Re-adjust spring compression - valve should lift approx. 10% above duty pressure.
✓				✓												Suction lift too high.	Lower pump or raise liquid level.
														✓	✓	Pumped media not compatible with materials used.	Use optional materials.
												✓				No barrier in system to prevent flow passing back through pump.	Ensure discharge pipework higher than suction tank.
														✓	✓	Pump allowed to run dry.	Ensure system operation prevents this. Fit single flushed or double flushed mechanical seals. Fit flushed packed gland.
										✓						Faulty motor.	Check and replace motor bearings.
	✓															Too large pumphead clearances.	Fit new rotors and ensure clearances are as per recommendations.
✓																Rotors missing i.e. after service.	Fit rotors.

Troubleshooting Rotary Pump

Troubleshooting Electric Motor

The following section provides a basic guide to dealing with potential problems which may occur.

Troubleshooting Electric Motor

Problem	Possible cause	Corrective action
Motor does not start, neither coupled nor decoupled	Power cables are interrupted.	Check the control panel and the motor power supply cables.
	Blown fuses.	Replace blown fuses.
	Wrong motor connection.	Correct the motor connection according to connection diagram.
	Locked rotor.	Check motor shaft to ensure that it rotates freely.
The motor starts at no-load, but fails when load is applied. It starts very slowly and does not reach the rated speed.	Load toque is too high during start-up.	Do not start the motor on load.
	Too high voltage drop in the power cables	Check the installation dimensioning (transformer, cable cross section, relays, circuit breakers, etc.)
Abnormal / excessive noise	Defective transmission component or defective driven machine.	Check the transmission force, the coupling and the alignment.
	Misaligned / unleveled base.	Align / level the motor with the driven machine
	Unbalanced components or unbalanced driven machine	Balance the machine set again
	Different balancing methods used for motor and coupling balancing (halve key, full key)	Balance the motor again
	Wrong motor direction of rotation	Reverse the direction of rotation
	Loose bolts	Retighten the bolts
	Foundation resonance	Check the foundation design
	Damaged bearings	Replace the bearings

Motor overheating	Insufficient cooling	Clean air inlet and outlet and cooling fins
		Check the minimum required distance between the fan cover and nearest walls. See item 7
		Check air temperature at inlet
	Overload	Measure motor current, evaluate motor application and if required, reduce the load
	Number of starts per hour is too high or the load inertia moment is too high	Reduce the number of starts per hour
	Power supply voltage too high	Check the motor power supply voltage. Power supply voltage must not exceed the tolerance specified in item 7.2
	Power supply voltage too low	Check the motor power supply voltage and the voltage drop. Power supply voltage must not exceed the tolerance specified in item 7.2
	Interrupted power supply	Check the connection of the power cables
	Voltage unbalance at the motor terminals	Check for blown fuses, wrong commands, voltage unbalance in the power line, phase fault or interrupted power cables
	Direction of rotation is not compatible with the unidirectional fan	Check if the direction of rotation matches the rotation arrow indicated on end shield

Bearing overheating	Excessive grease / oil	Clean the bearing and lubricate it according to the provided recommendations
	Grease / oil aging	
	The used grease / oil does not matches the specified one	
	Lack of grease / oil	Lubricate the bearing according to the provided recommendations
	Excessive axial or radial forces due to the belt tension	Reduce the belt tension
		Reduce the load applied to the motor

Thank You

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