Welcome to

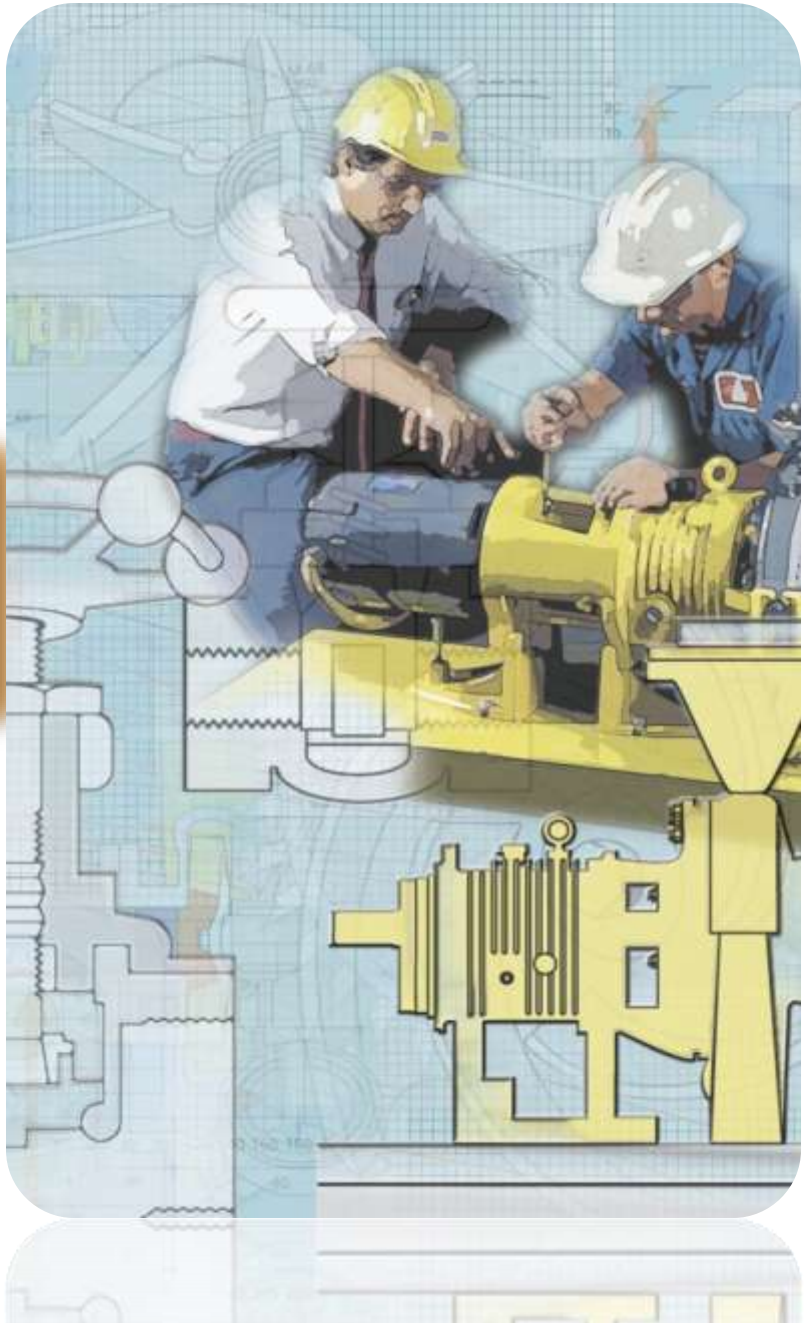
Pump
Installation & Maintenance

by Fayek Shakran

Course Objective

- identify pump classifications
- describe the purpose of pump parts.
- define various pump terms.
- explain pump operation.
- describe the components of a pump curve.
- Describe a simple pumping system.
- describe typical pump failures and their causes

Introduction



Introduction

Pump Definition

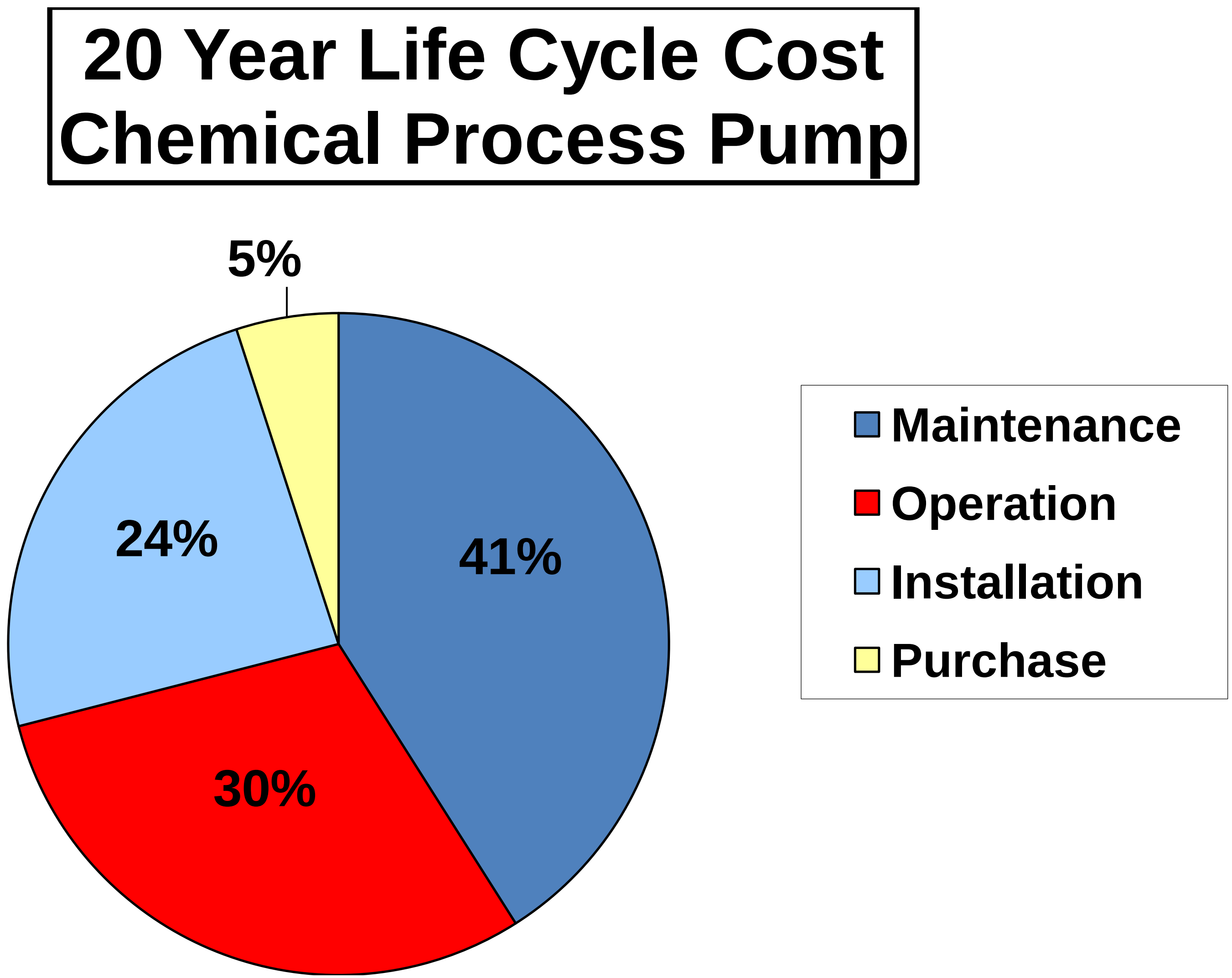
Pump is defined as a mechanical device that rotates or reciprocates to move fluid from one place to another

Purpose of a pump:

A pump is designed to:
transfer fluid from one point to another.
~from low pressure areas to higher pressure Areas.
~from lower elevations to higher Elevations.
~From local locations to distant locations.

Life Cycle Cost

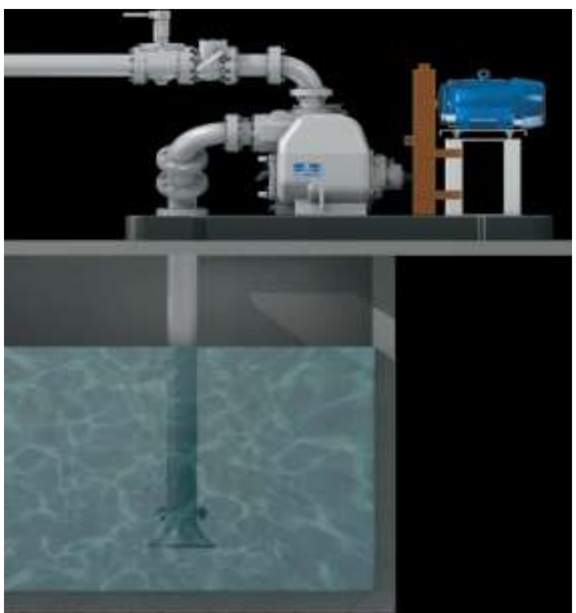
Energy and maintenance costs during the life of a pump system are usually more than10 times its purchase price

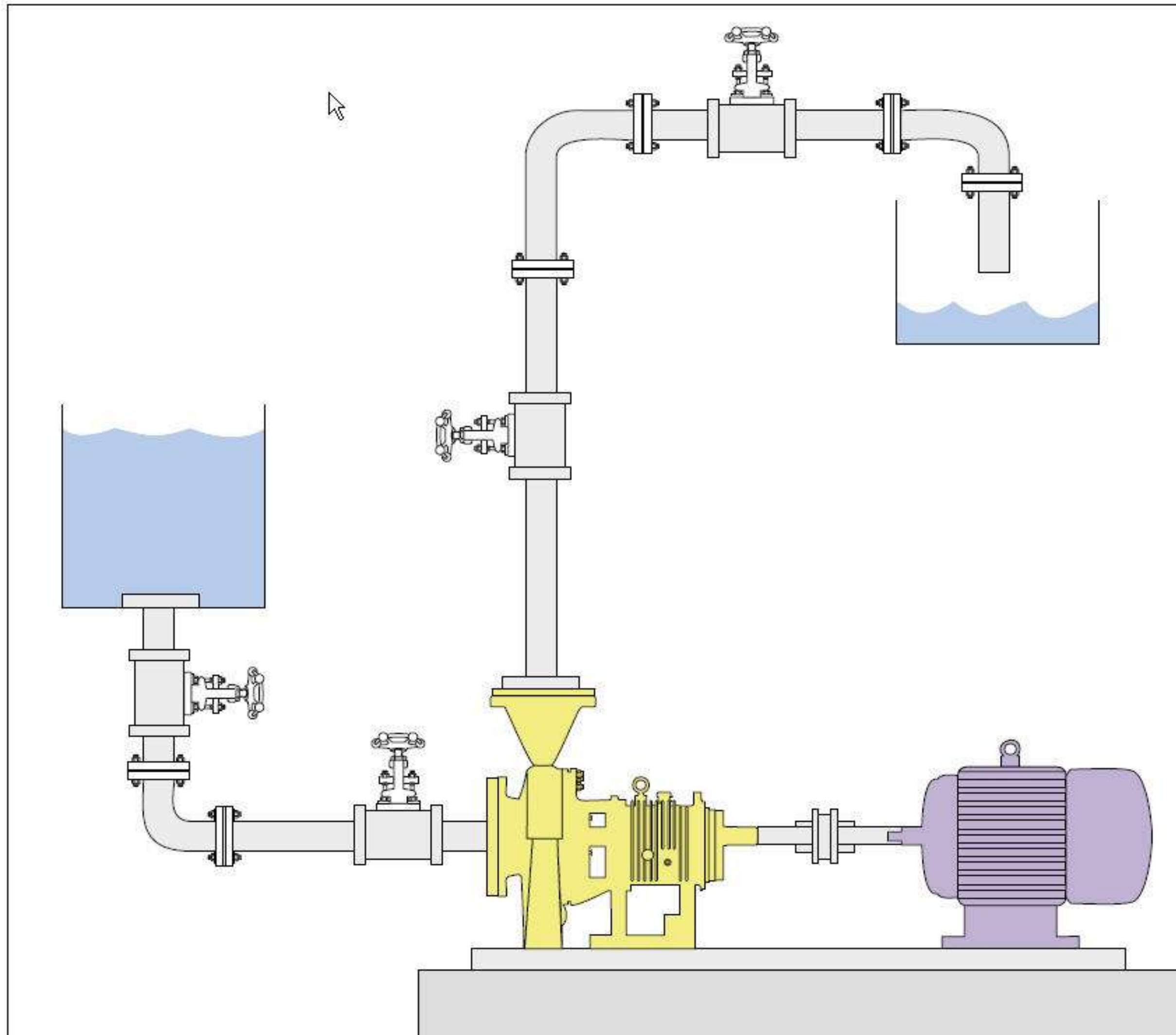


Pumping System Basics

Typical pumping systems contain five basic components:

Pumps.
prime movers.
Piping.
Valves.
end-use equipment.





Pumps Types

Pumps are available in a wide range of types, sizes, and materials, two categories described—positive displacement and centrifugal.

Centrifugal pumps have a variable flow/pressure relationship.

positive displacement pumps have a fixed displacement volume. Consequently, the flow rates they generate are directly proportional to their speed.

Positive displacement pump

Positive Displacement Pumps

Positive displacement pumps work on the principle that – No two objects can occupy the same space at the same time

A solid will displace a volume of fluid equal to its own volume

Reciprocating element (piston – plunger)

Rotating element (Vans , Screws or Gears)

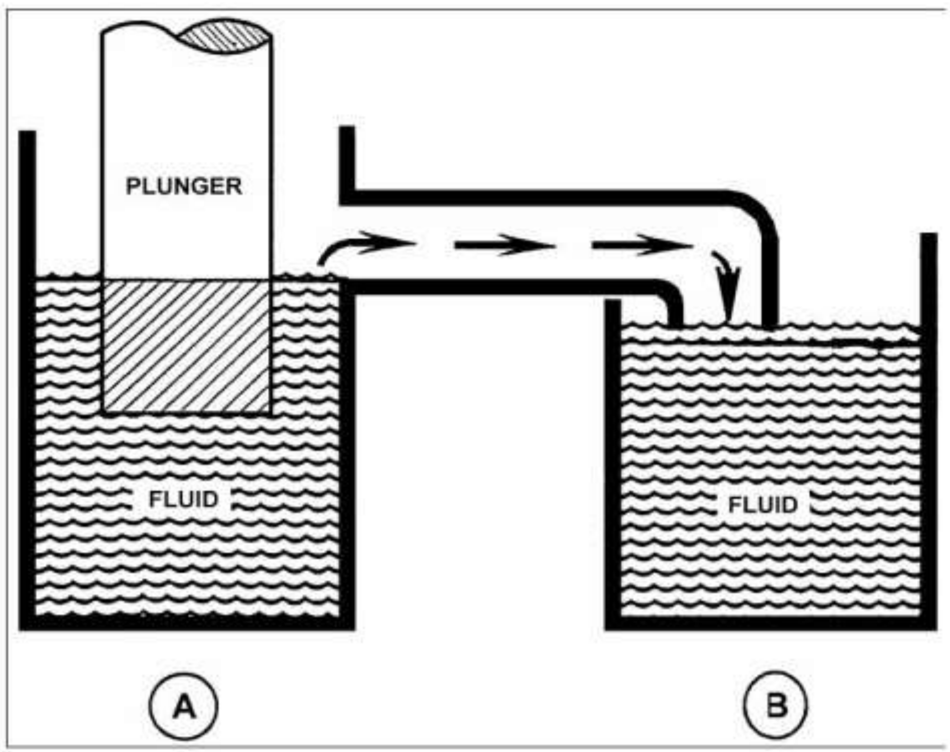


Fig. 3.1-1 Fluid Displacement

Positive Displacement Pumps

<u>Discharge flow / rate can be controlled by:</u>

- ~ Change the speed of the prime mover.
- ~ Use of bypass lin.
- ~ Change of the piston stroke length.

Types of Positive Displacement Pumps

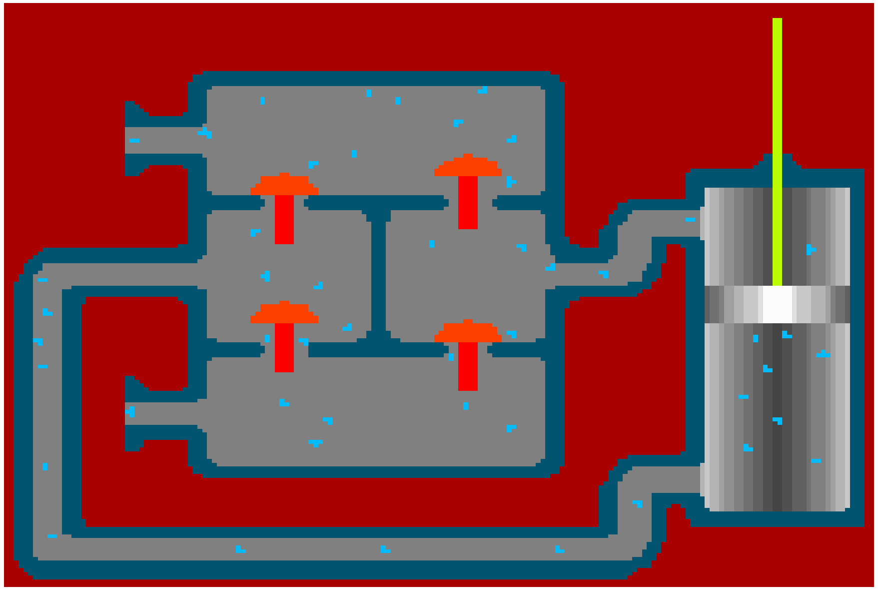
Reciprocating Pumps

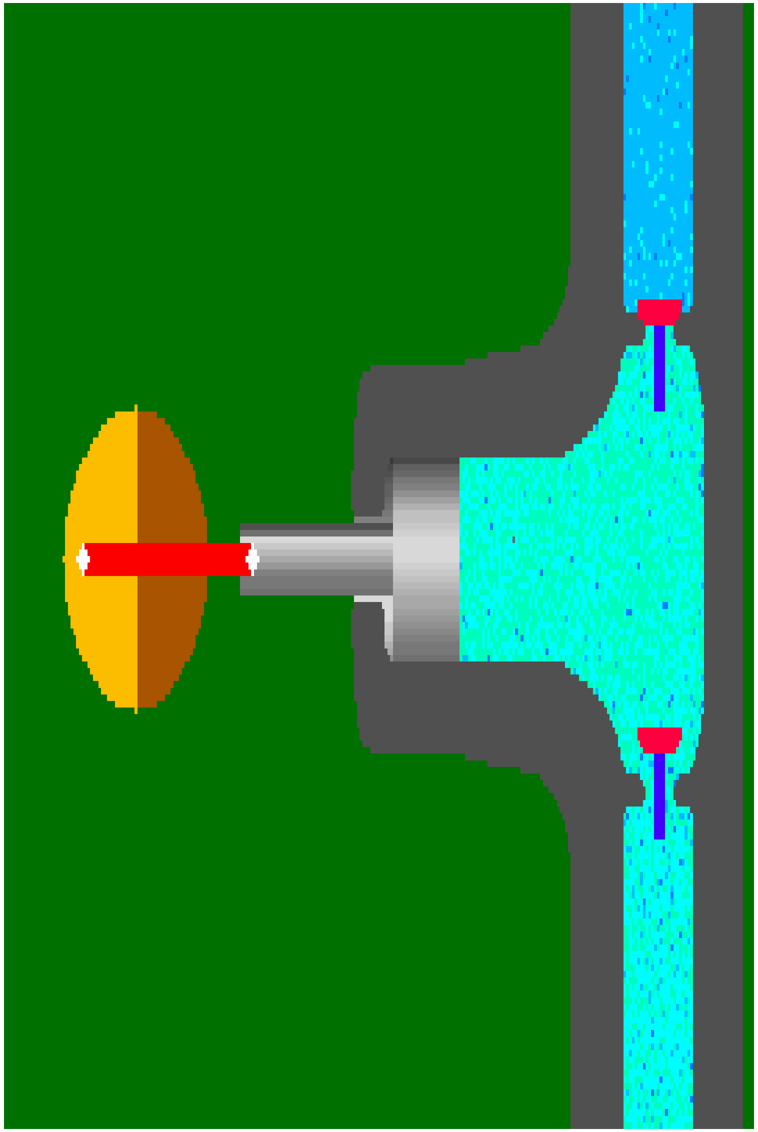
Rotary Pumps

Reciprocating Pumps

<u>Three main types:</u>

- **Piston Type.**
- **Plunger Type.**
- **Diaphragm Type.**





Piston Type Reciprocating Pump

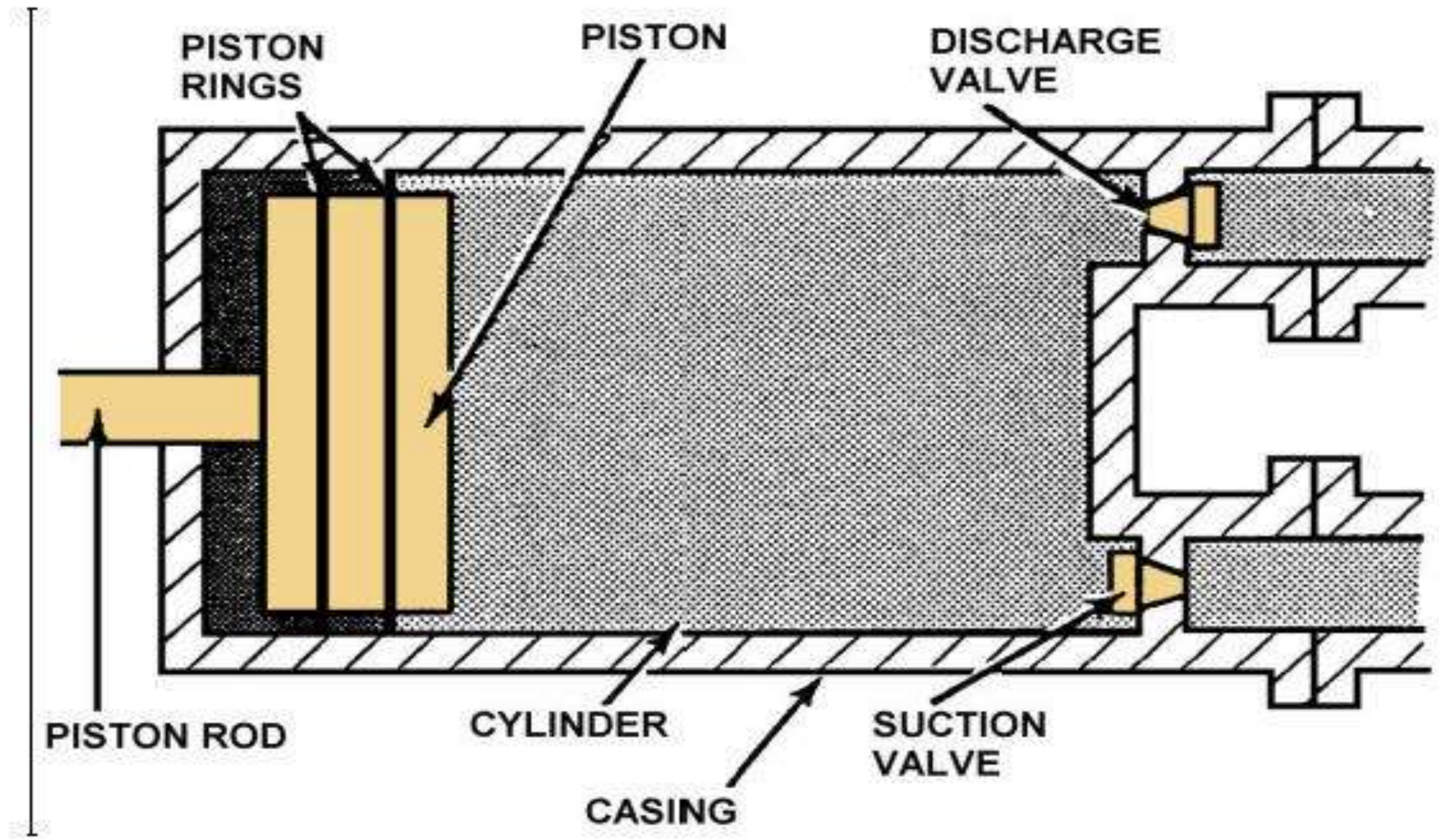


Fig. 3.1-3 Piston Type Reciprocating Pump

Each complete movement of the piston along the length of the cylinder is called A STROKE

Used as portable backup pumps for the removal of surplus process fluids

Plunger Type Reciprocating Pump

Very similar to piston type pumps and either vertical or horizontal acting

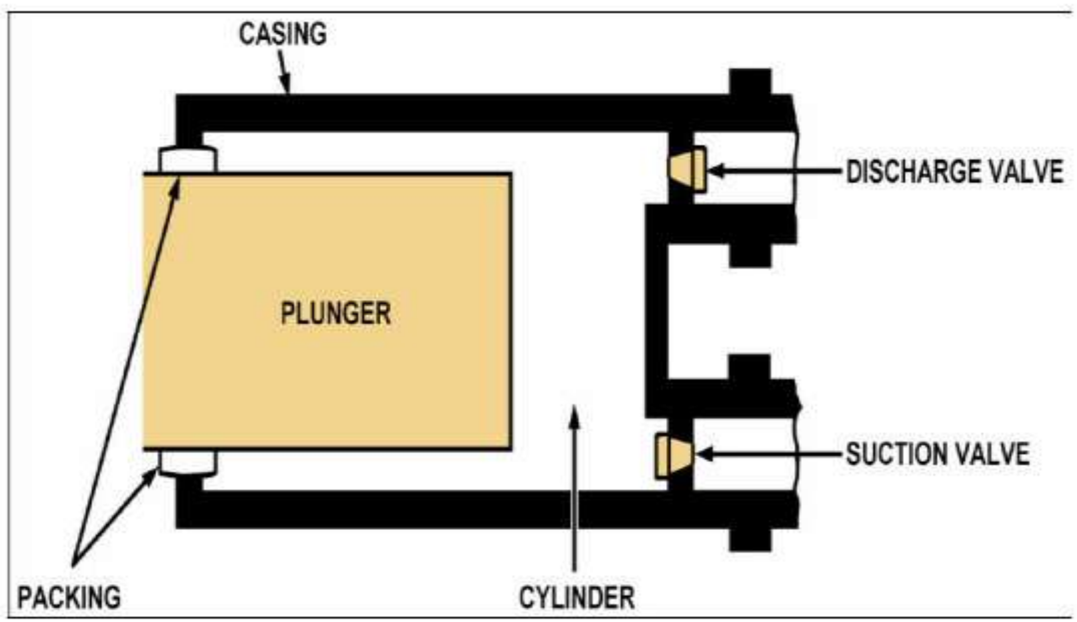
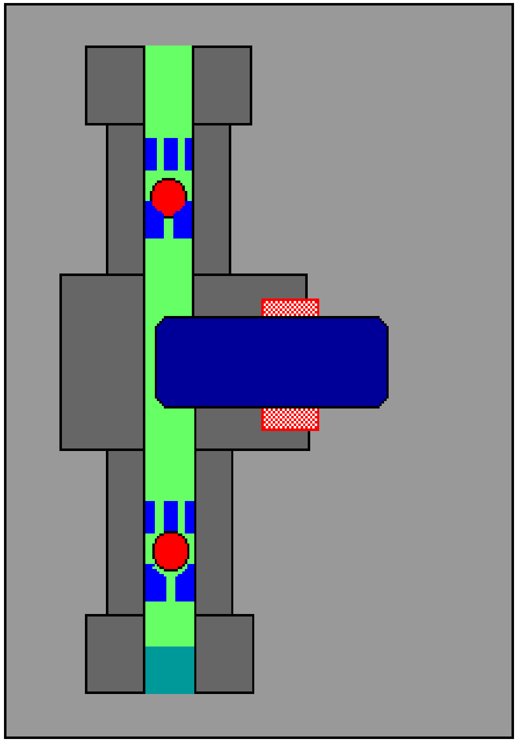


Fig. 3.1-4 Plunger Type Reciprocating Pump



What is the difference between piston and plunger pumps?

Diaphragm Pump

Get their name from the flexible diaphragm

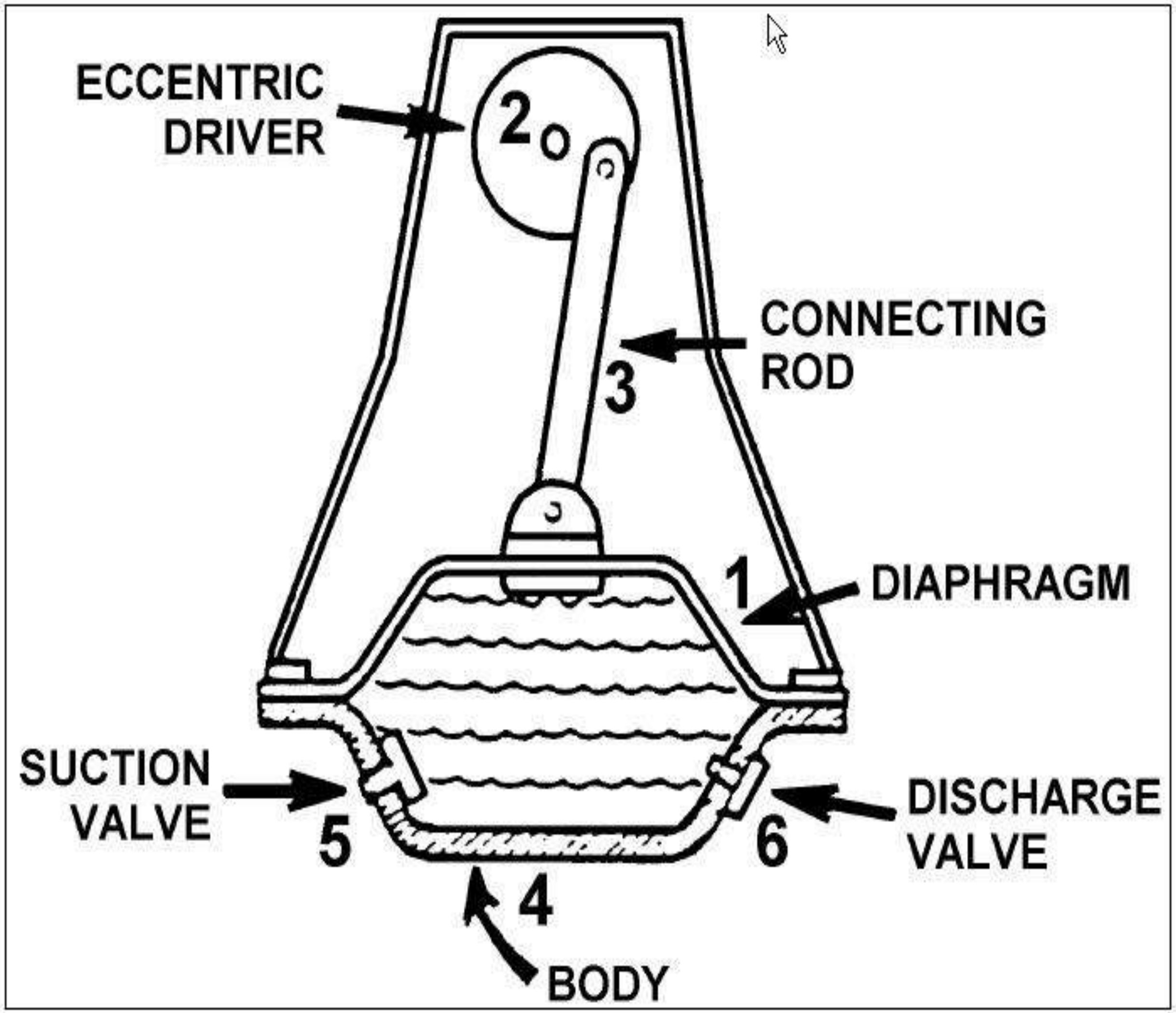
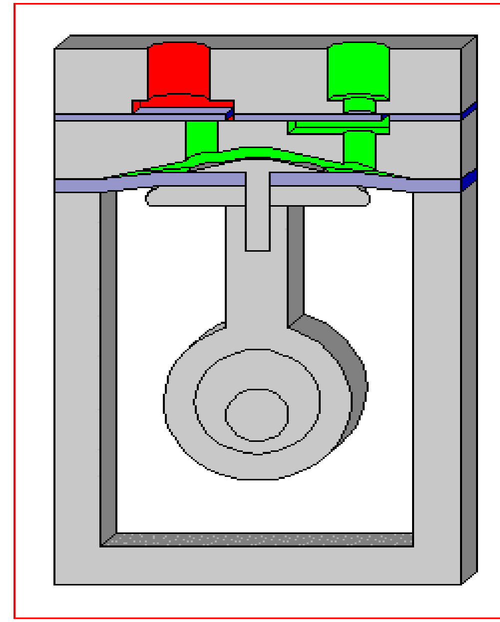
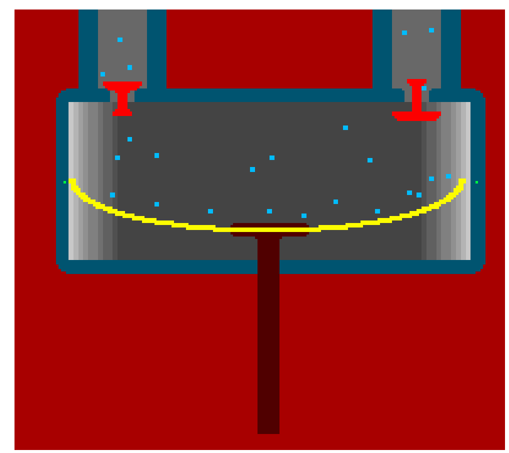


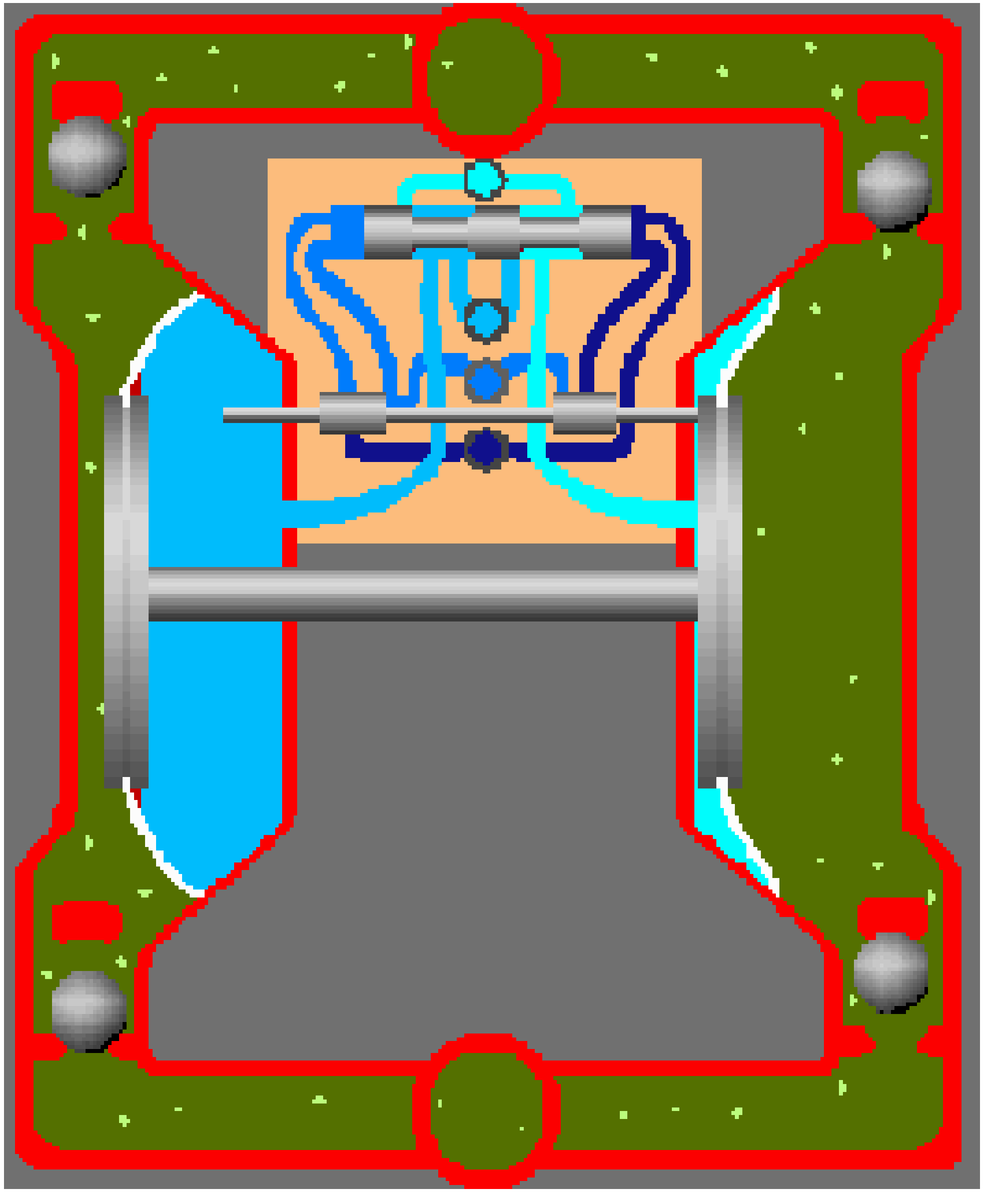
Fig. 3.1-5 Diaphragm Pump





Diaphragm Pump

Double-Diaphragm Pump



Diaphragm Pump

A perfect seal, it makes **Diaphragm Pump** ideal for:

1~ pumping chemicals.

2~ Controlled metering.

A diaphragm is usually made of a flexible rubber materials often covered with a thin metal disc where the connecting rod is attached.

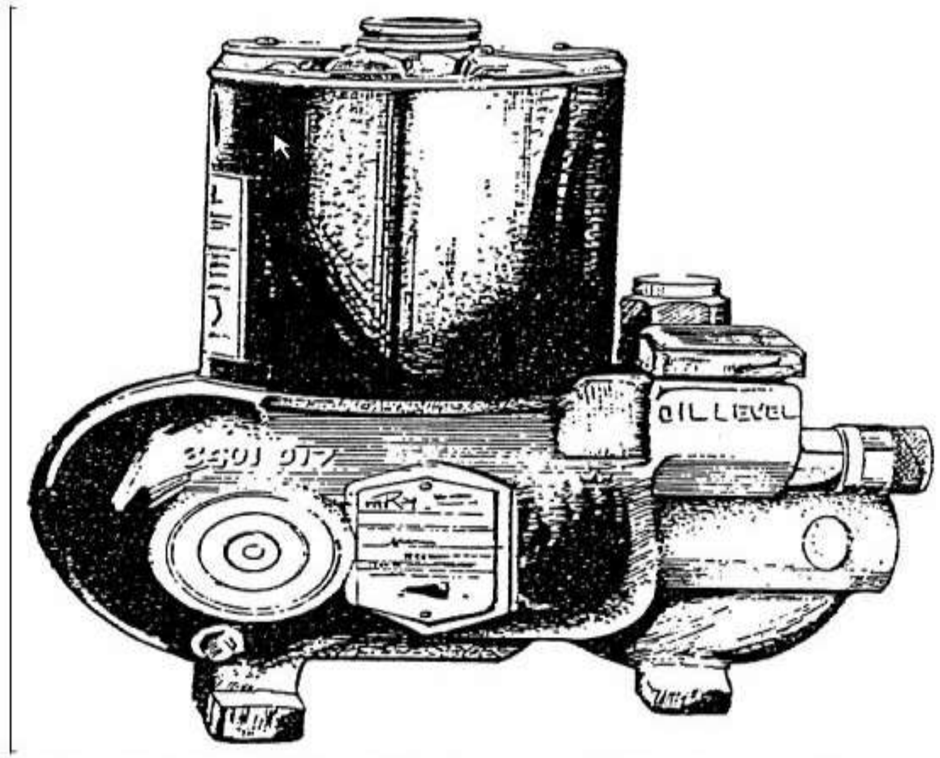
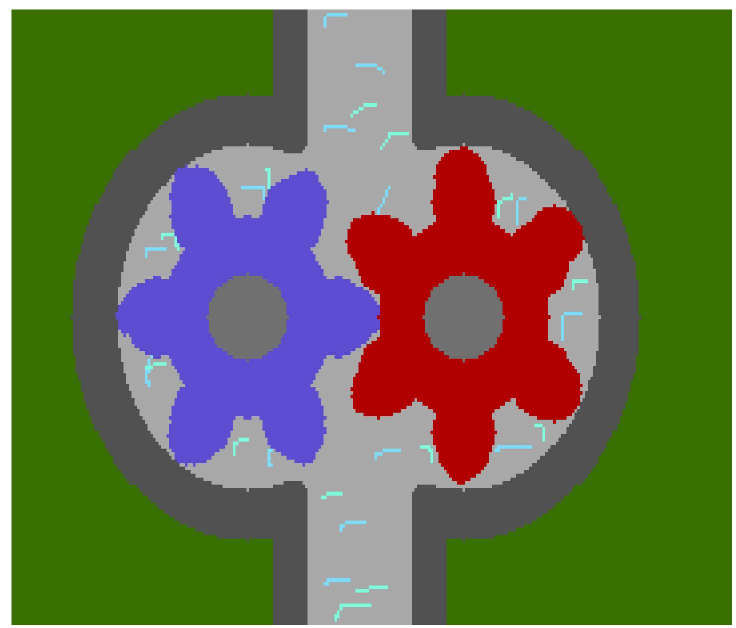


Fig. 3.1-6 Positive Displacement Diaphragm Pump

Rotary Pumps

Types of Rotary Pumps
~Gear Pump.
~Sliding Vane Pump.
~Rotary Lobe Pump.
~Rotary Screw Pump.



Gear Pump / External

consists of two intermeshing gears, one driven and one idling, in a close-fitting casing

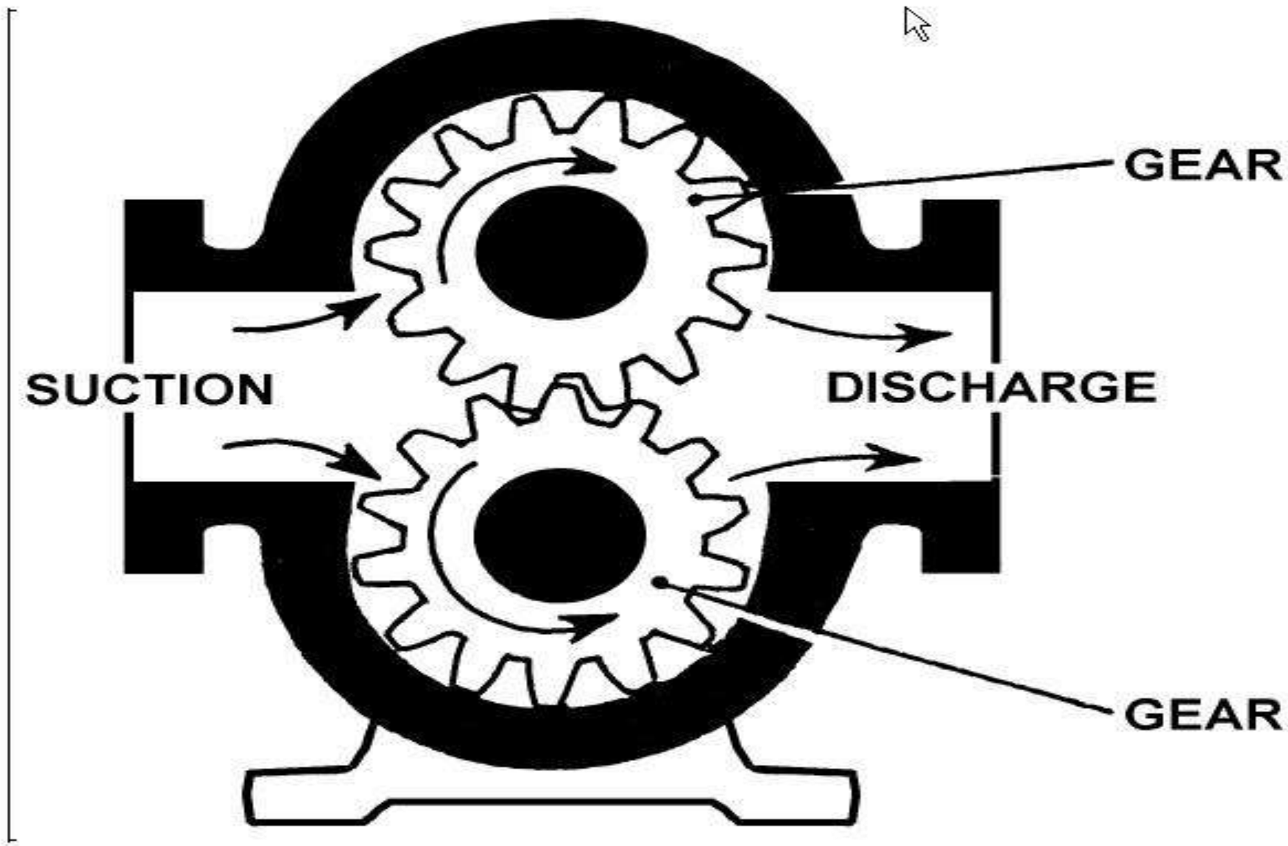
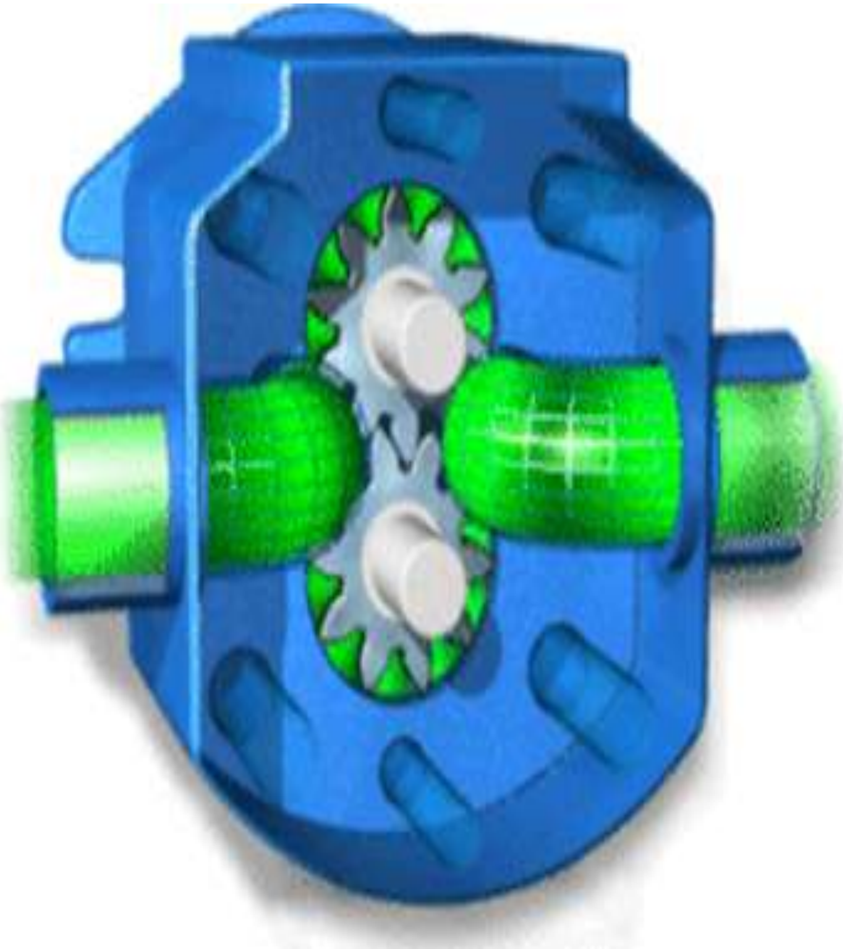
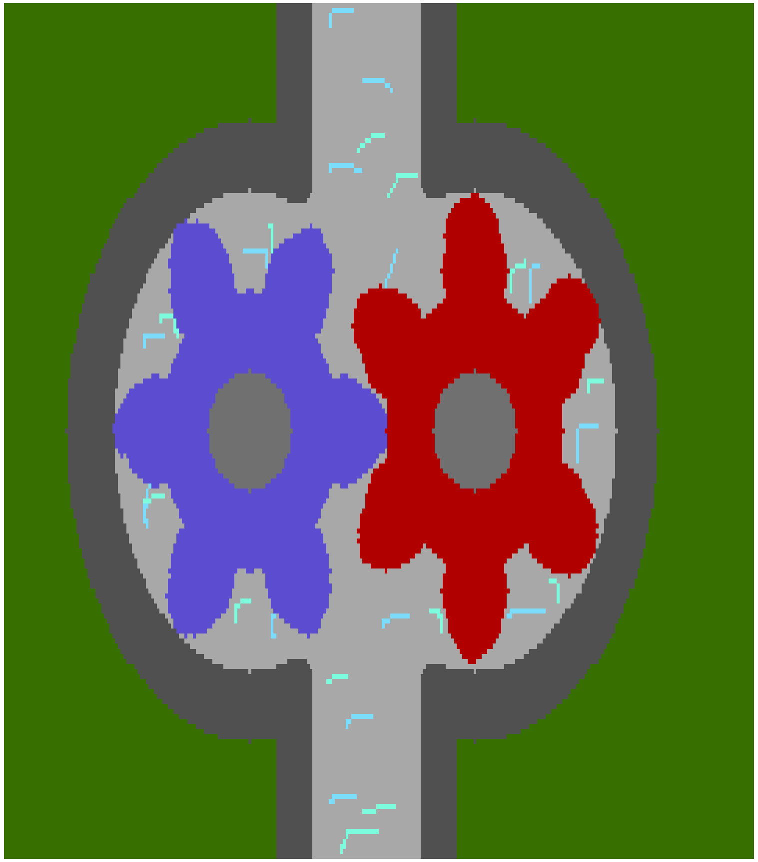


Fig. 3.2-1 External Gear Pump

Gear Pump / External





Gear Pump / Internal

Internal gear pump has a small (driven) gear mounted eccentrically inside a larger idler gear that rotates inside a circular casing.

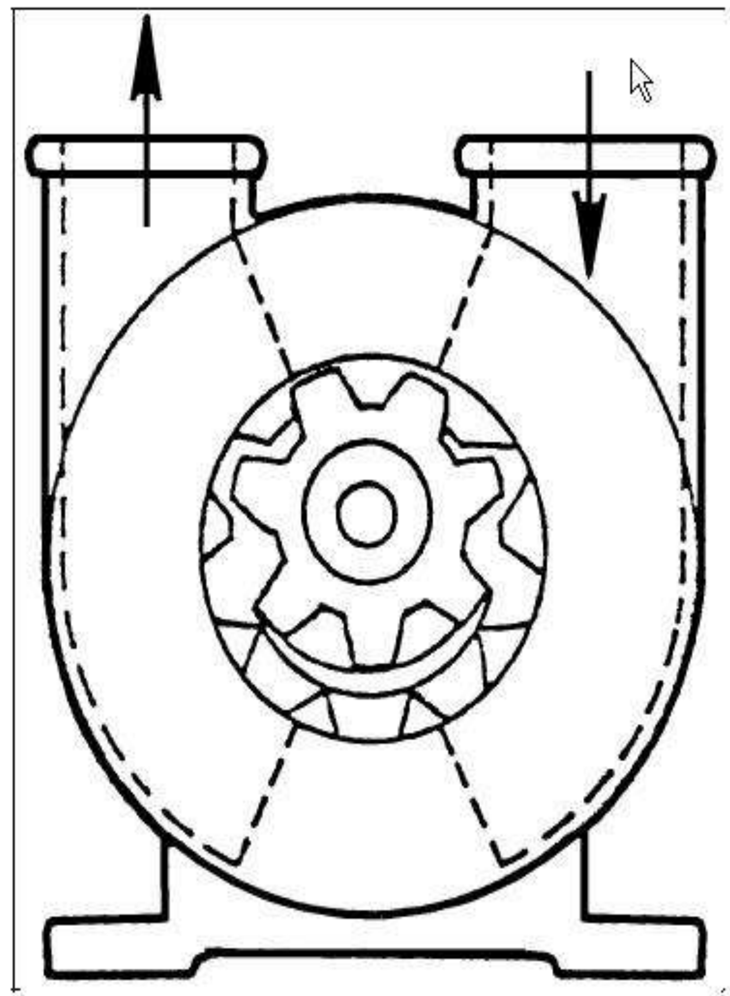
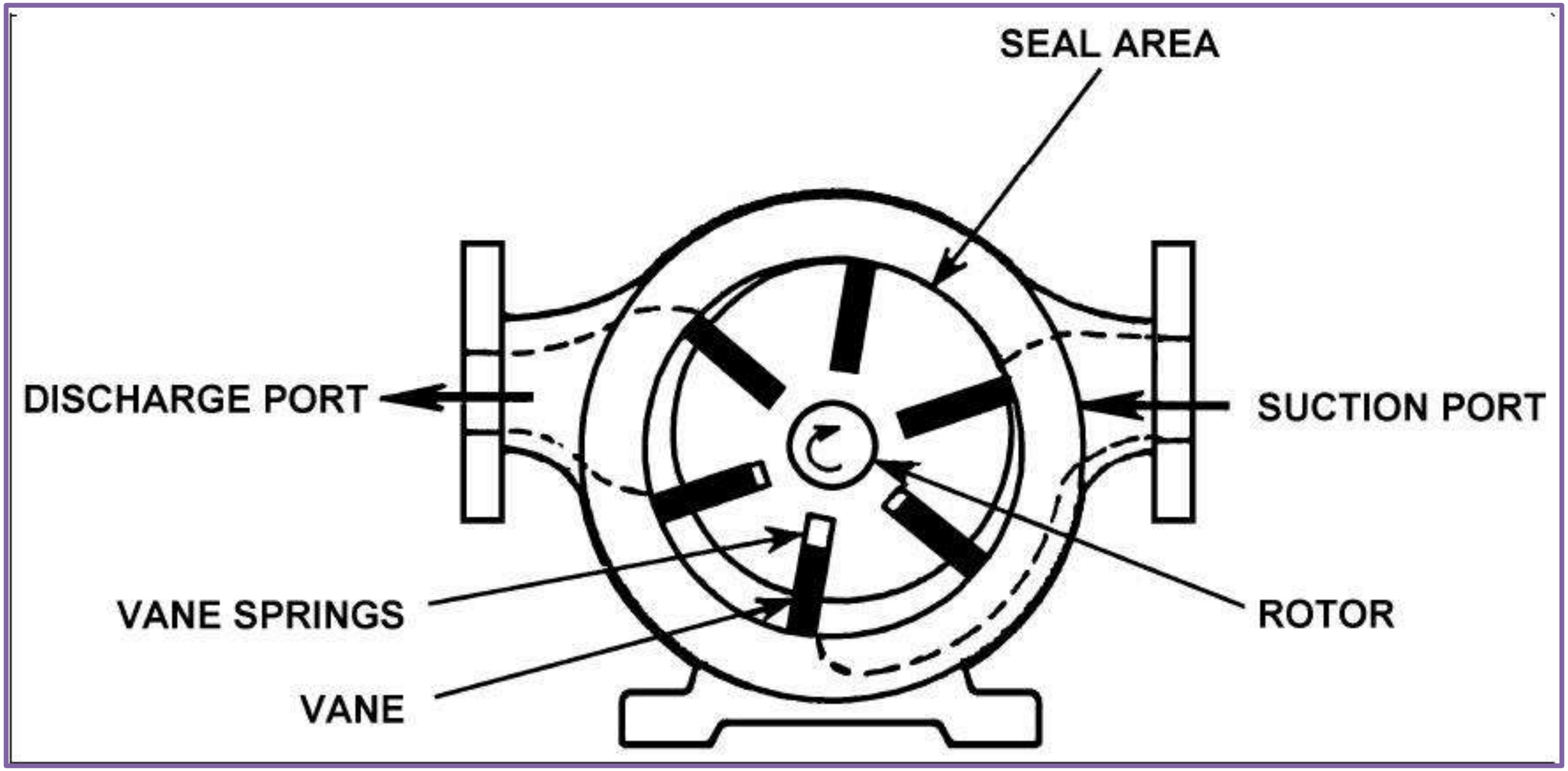


Fig. 3.2-3 Internal Gear Pump

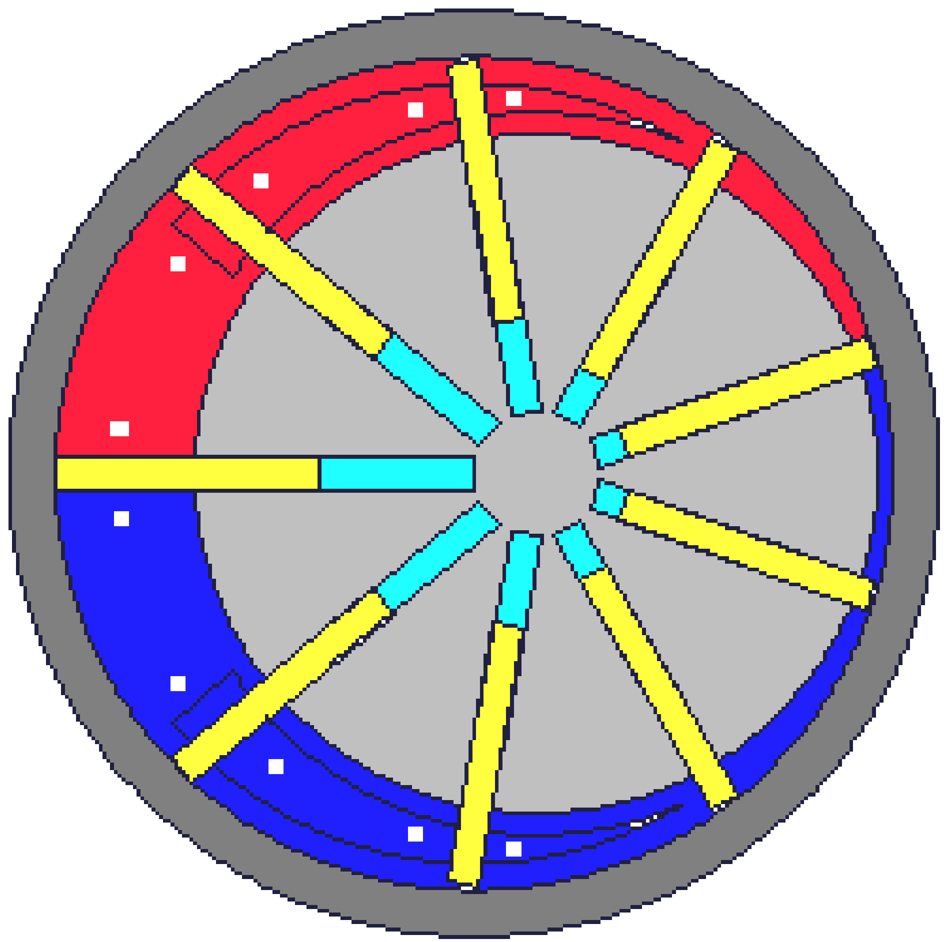
Vane Pump

The common **vane type pump consists of a rotor with a radial slots machined into it.** The rotor is mounted off-center and rotates inside a circular casing.

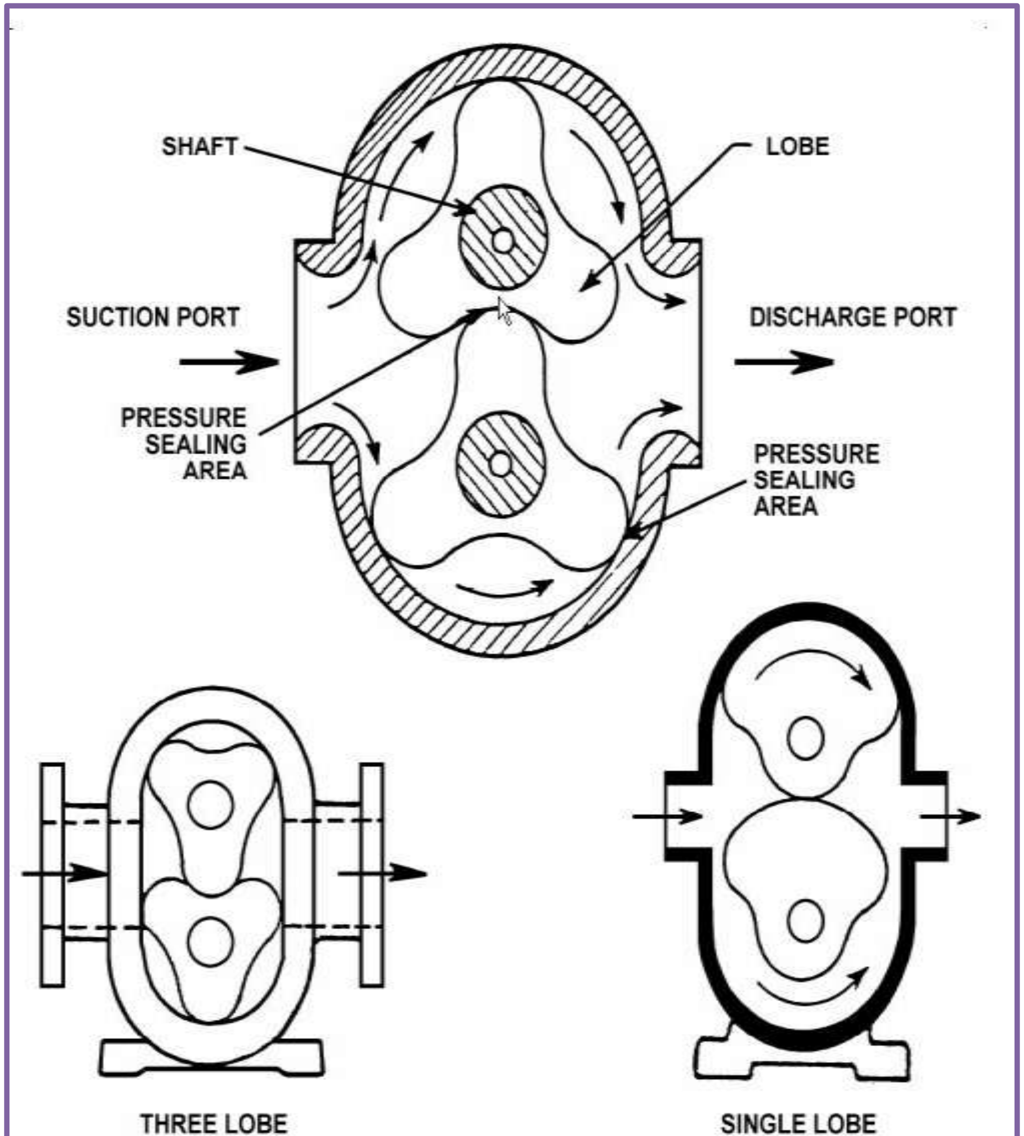


Vane Pump

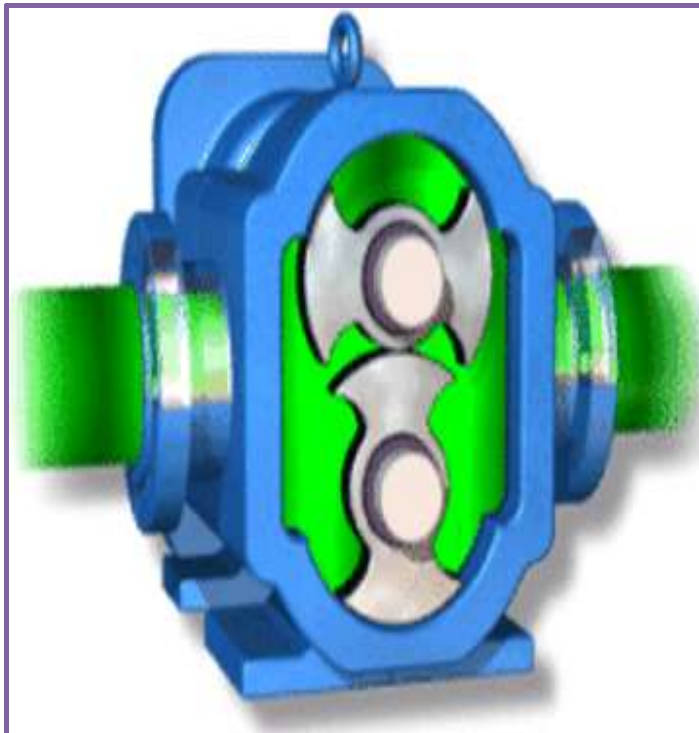
Liquid is drawn in through the suction side and squeezed out under pressure through the discharge side.



Rotary Lobe Pump



The **rotary lobe pump** works on a similar principle to the gear pump



Rotary Screw Pump

Rotary screw pumps are special types of rotary positive displacement pumps in which the flow through the pumping elements is truly axial.

Screw pumps are also called **axial flow pumps**

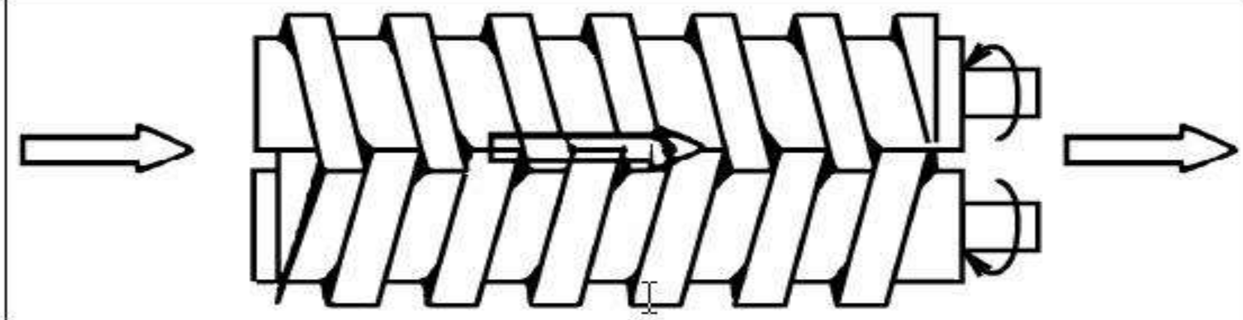


Fig. 3.2-7A Screw Pump — Axial Flow

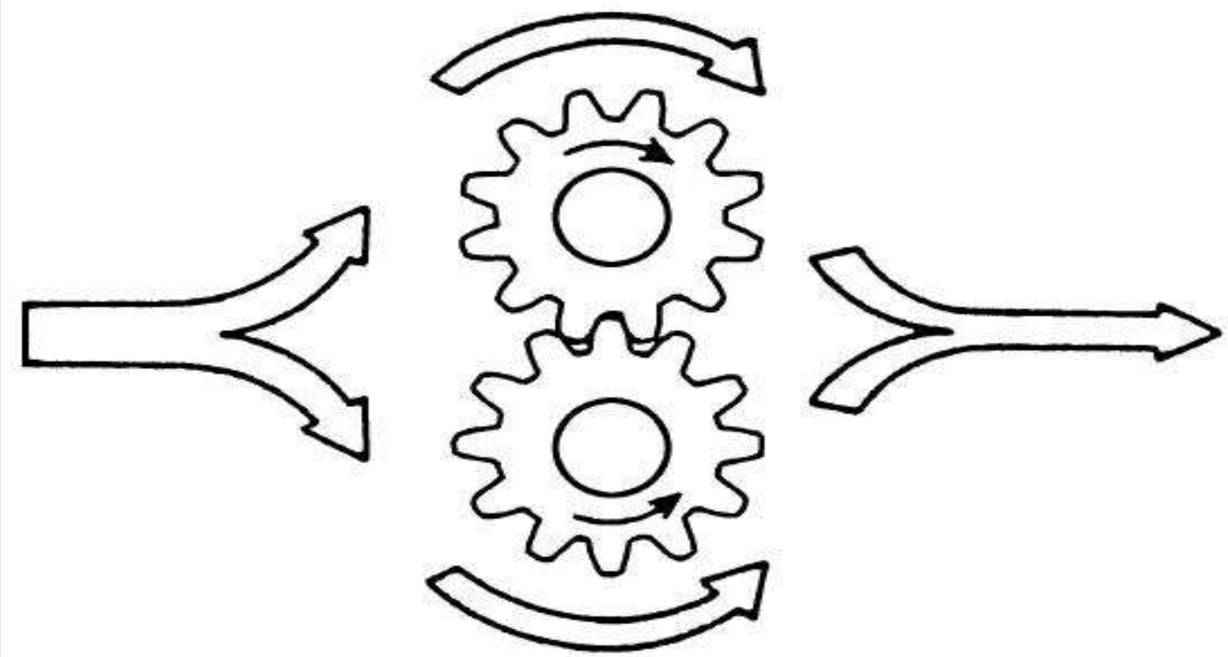


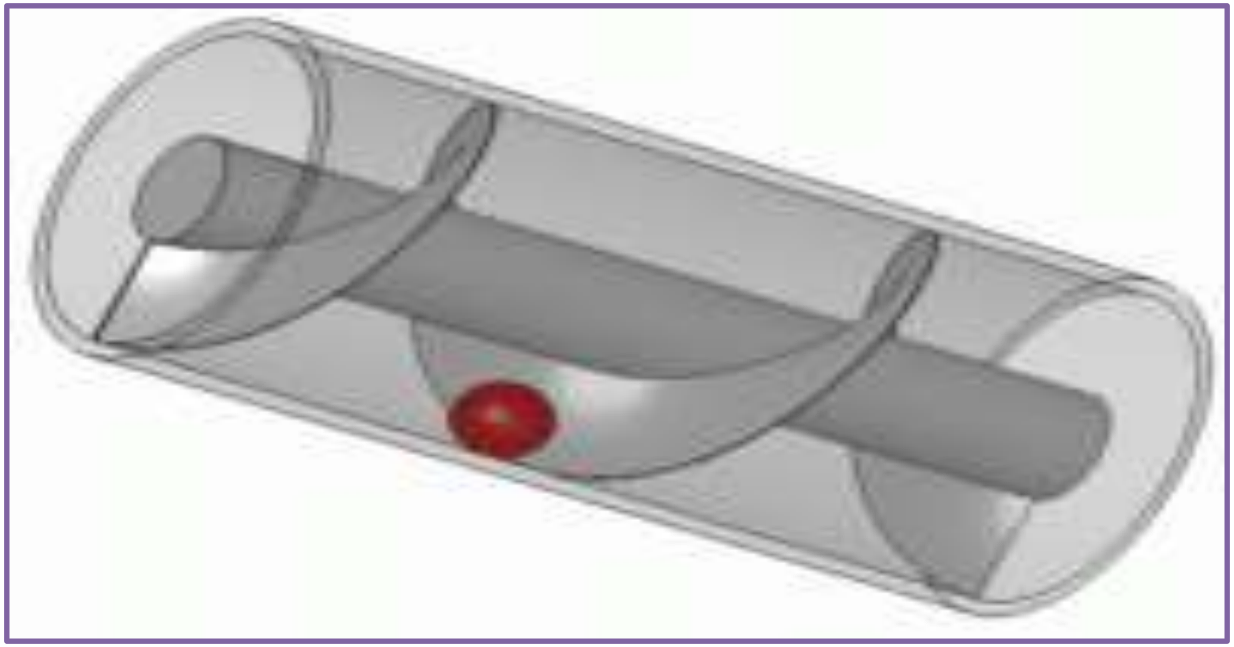
Fig. 3.2-7B Gear Pump — Circumferential Flow

TYPES OF SCREW PUMPS

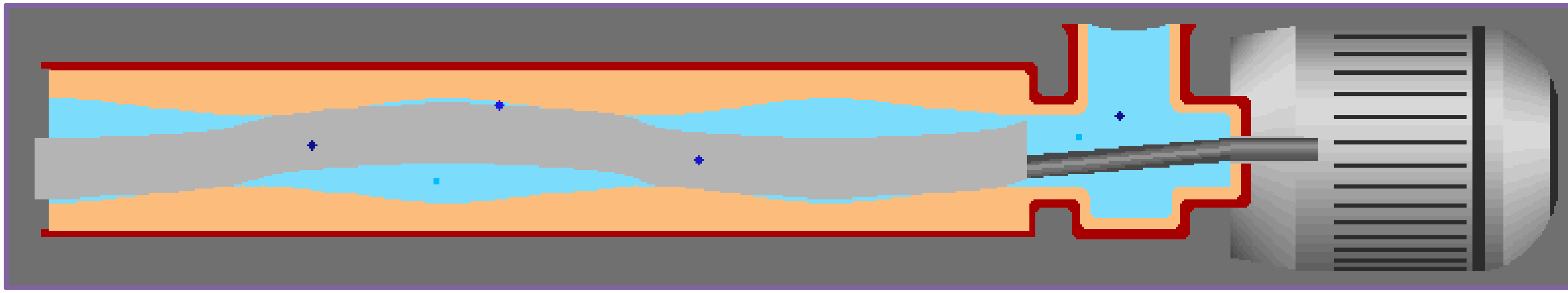
Screw pumps can have one , two or three screws

The types of screw pumps are the:

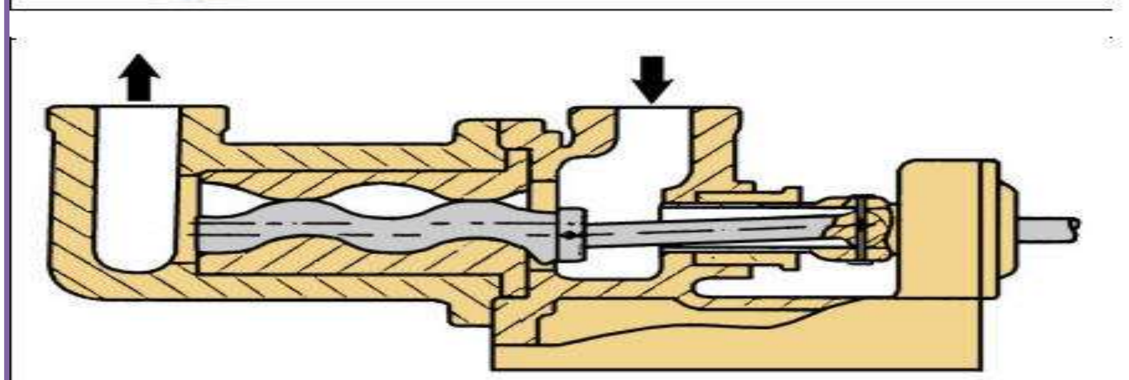
Single Screw Pump | Multiple Screw Pump



Single Screw Pumps



It consists of a spiral-shaped rotor that turns in an internal-helix liner. The rotor is usually metal. The liner is rubber.



Multiple Screw Pumps

Multiple screw pump increases the pumping capacity of a single screw type by providing additional rotors to move fluid.

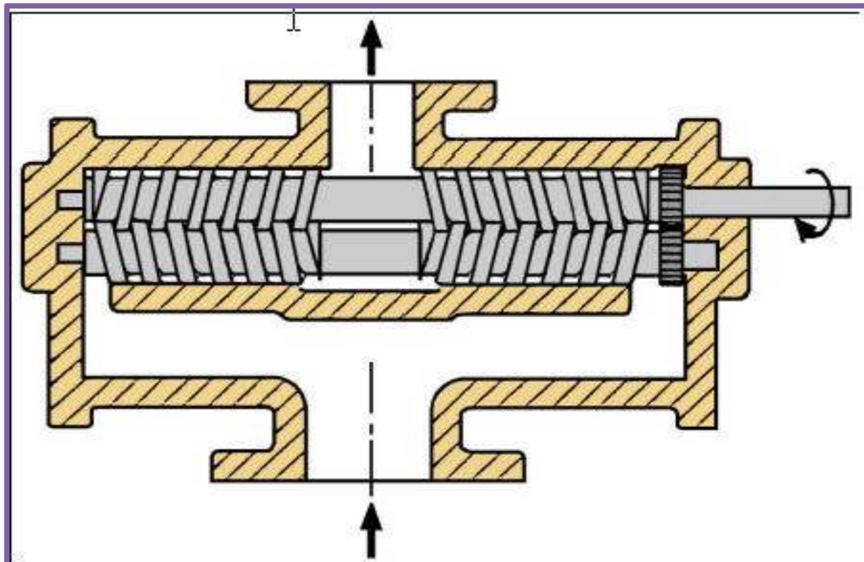
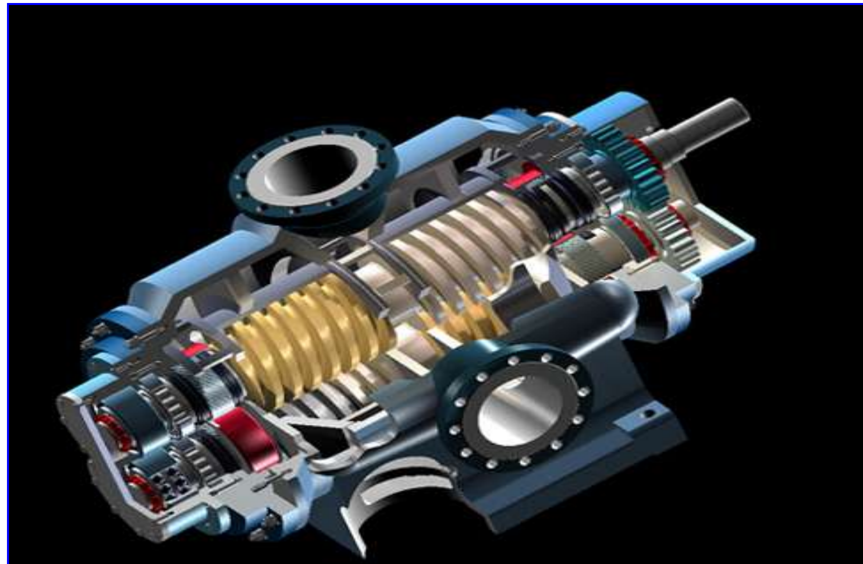


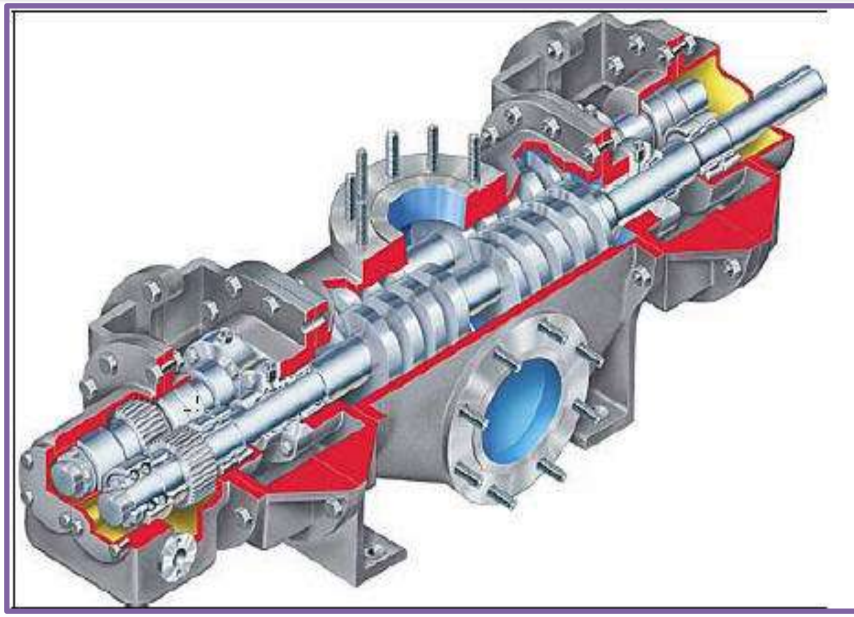
Fig. 3.2-9A Pump with Internal Timing Gears

Multiple screw pumps are driven by a single rotor called the **power rotor.**



Two screw pumps are often called timed screw pumps

Multiple Screw Pumps



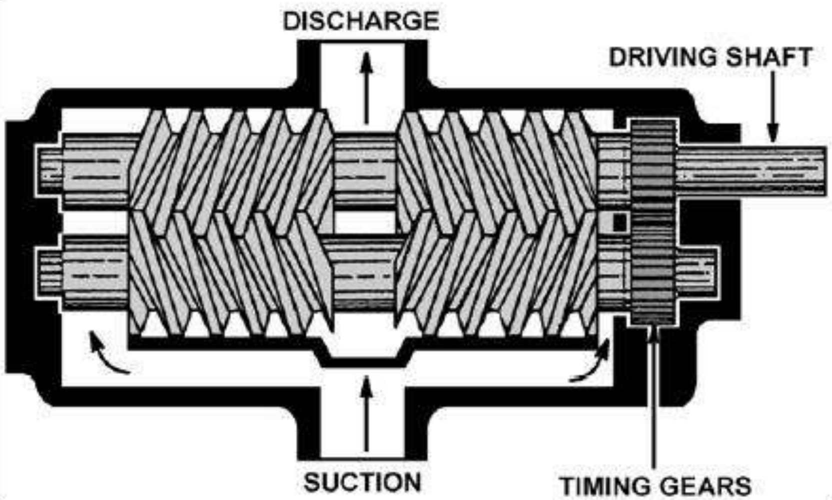


Fig. 3.2-9B Pump with External Timing Gears

Multiple Screw Pumps

Three~screw pumps have two idler screws. The idlers are threaded to mesh with the power rotor. (**<u>untimed screw pumps</u>**)

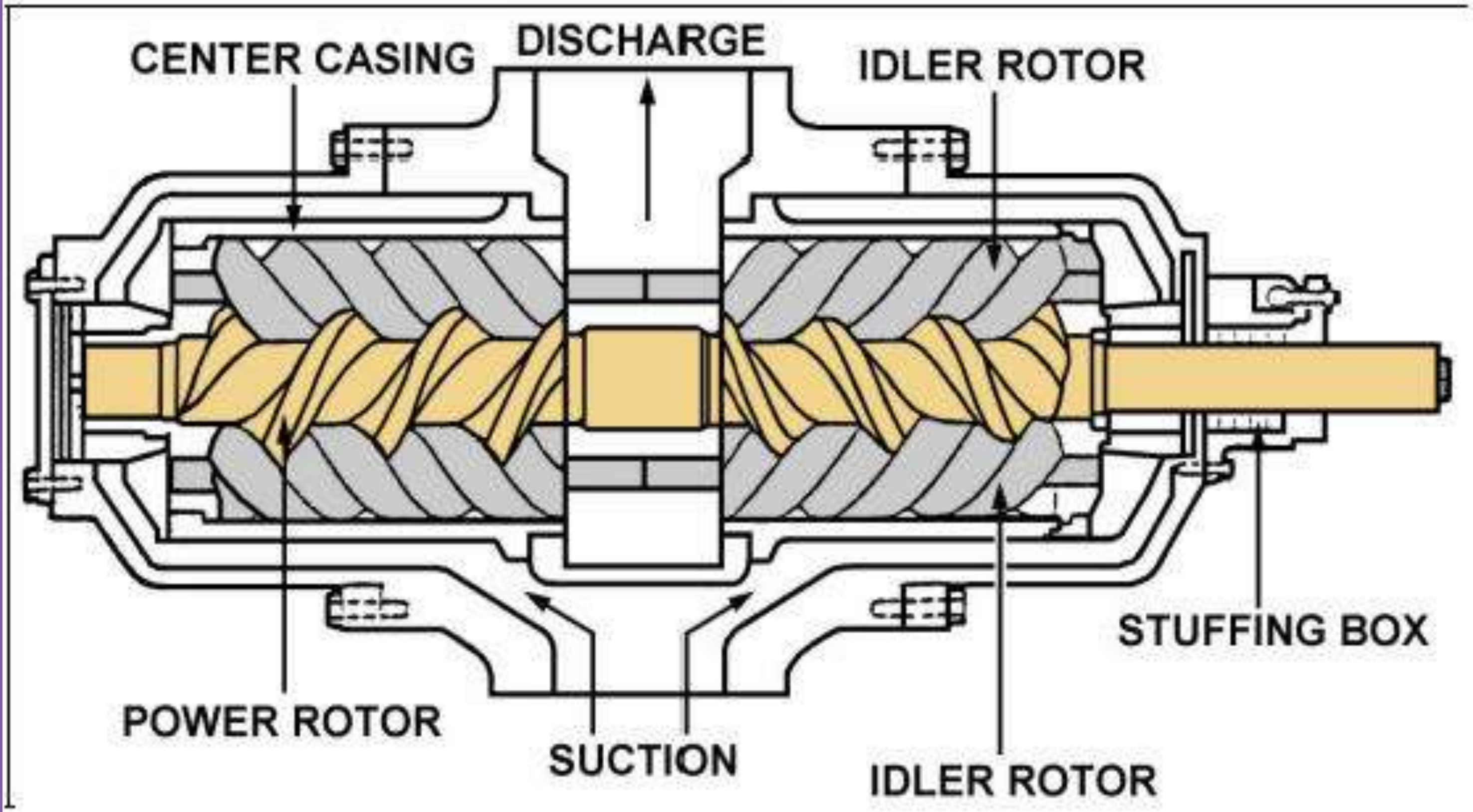


Fig. 3.2-10 Three-Screw Pump

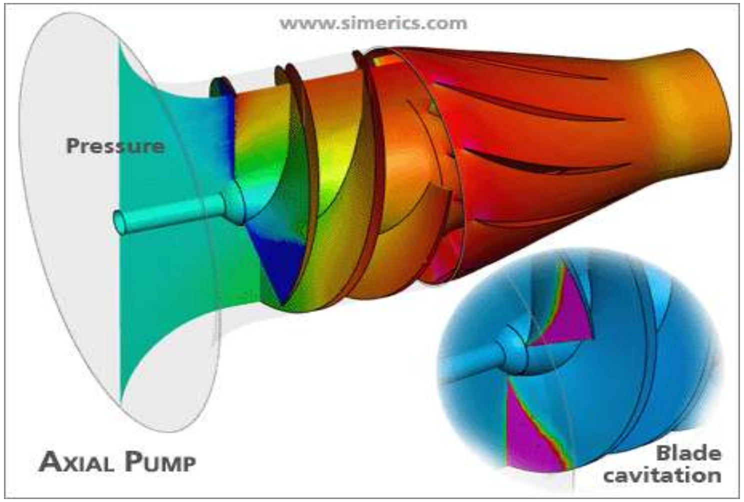
Centrifugal and axial pumps

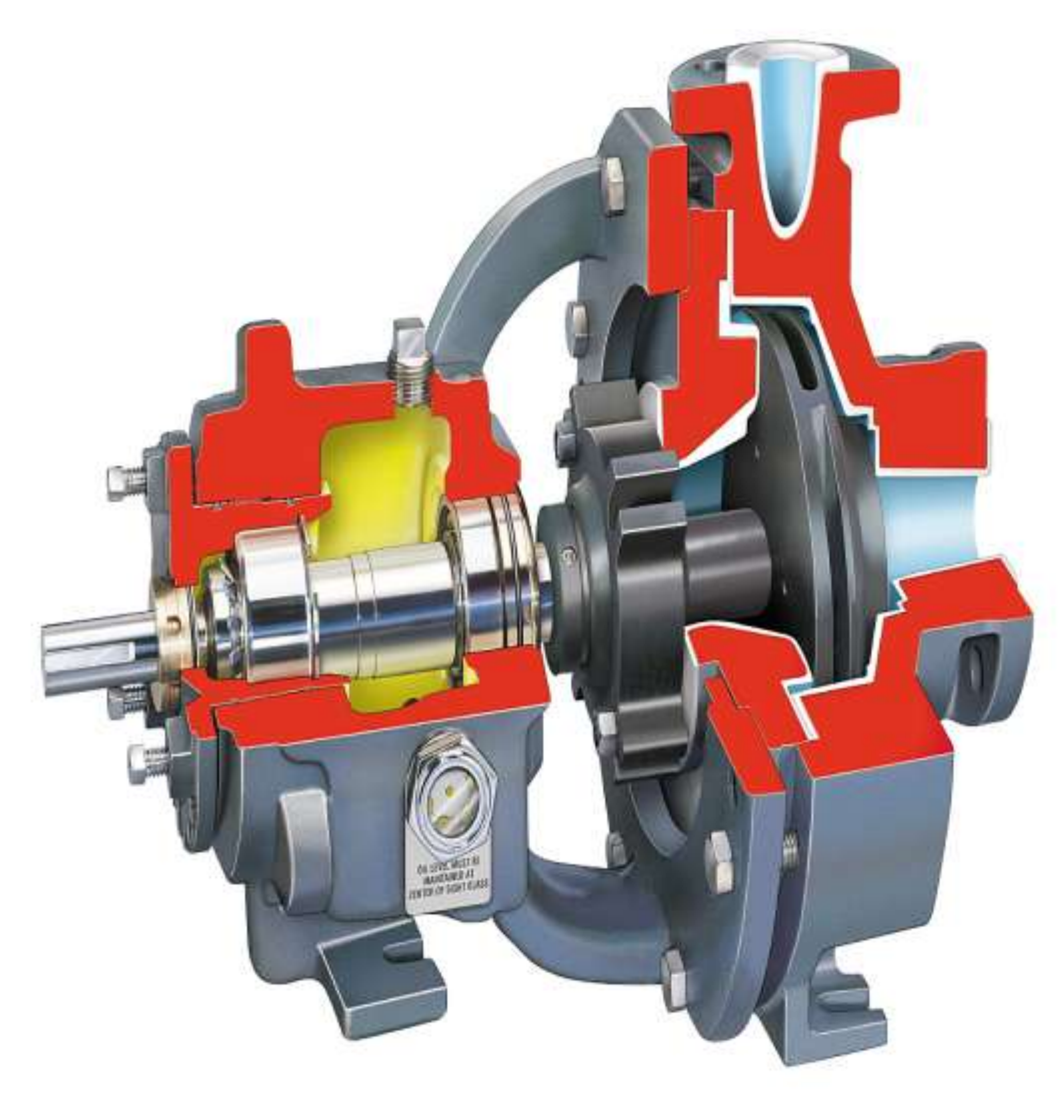
Initial Pump Selection

Centrifugal and axial pumps

Centrifugal and axial pumps impart kinetic energy to a fluid and rely on the conversion of this kinetic energy to potential energy to increase fluid pressure

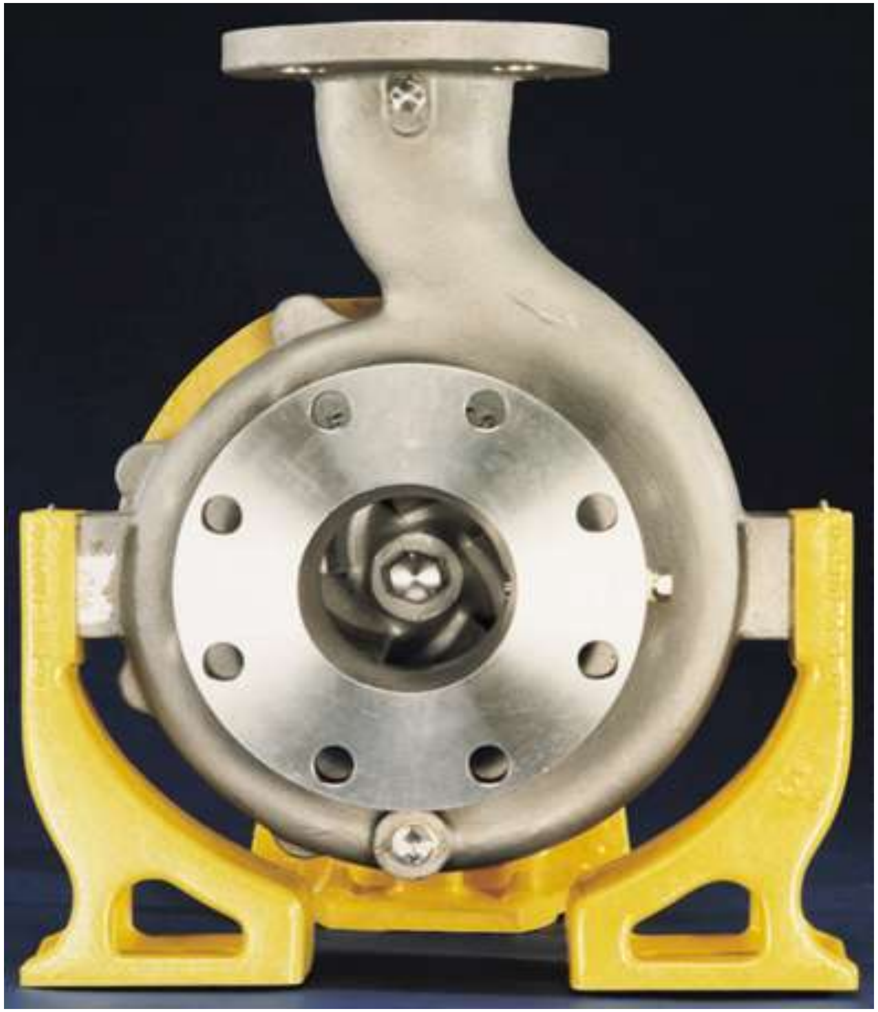
centrifugal pumps are used typically in high-flow, low-head applications in which fluid viscosity is not prohibitively high

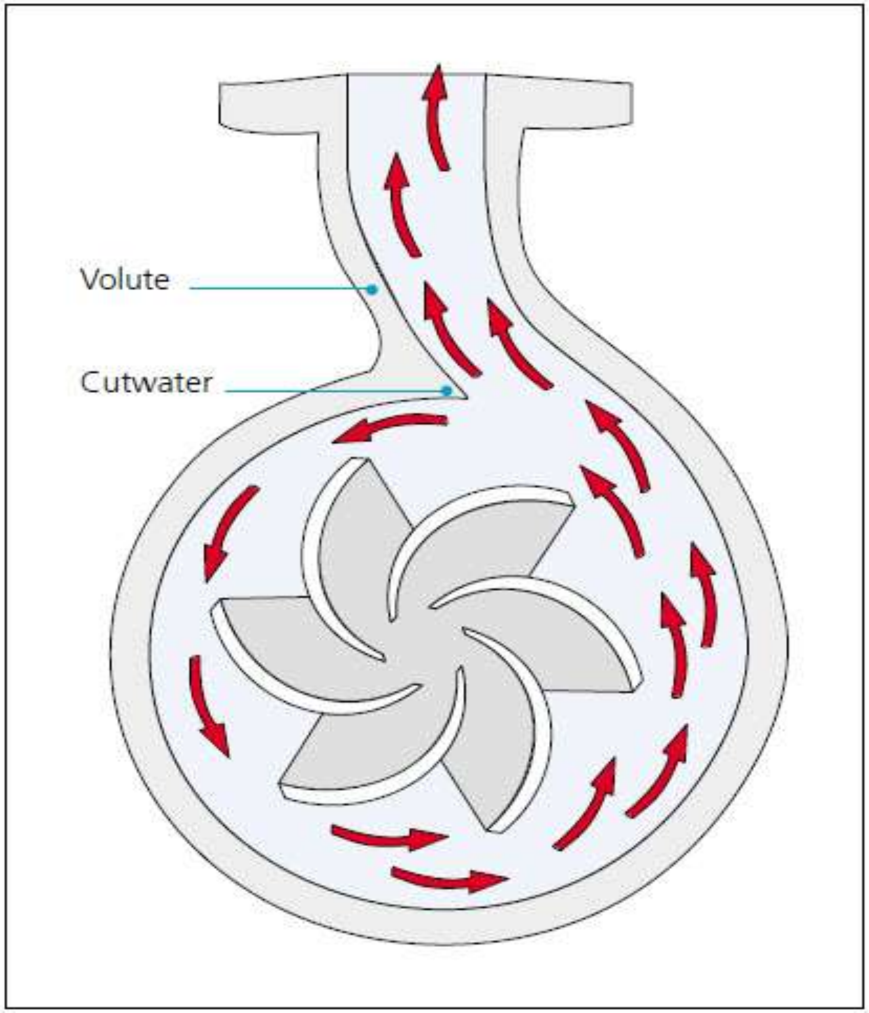




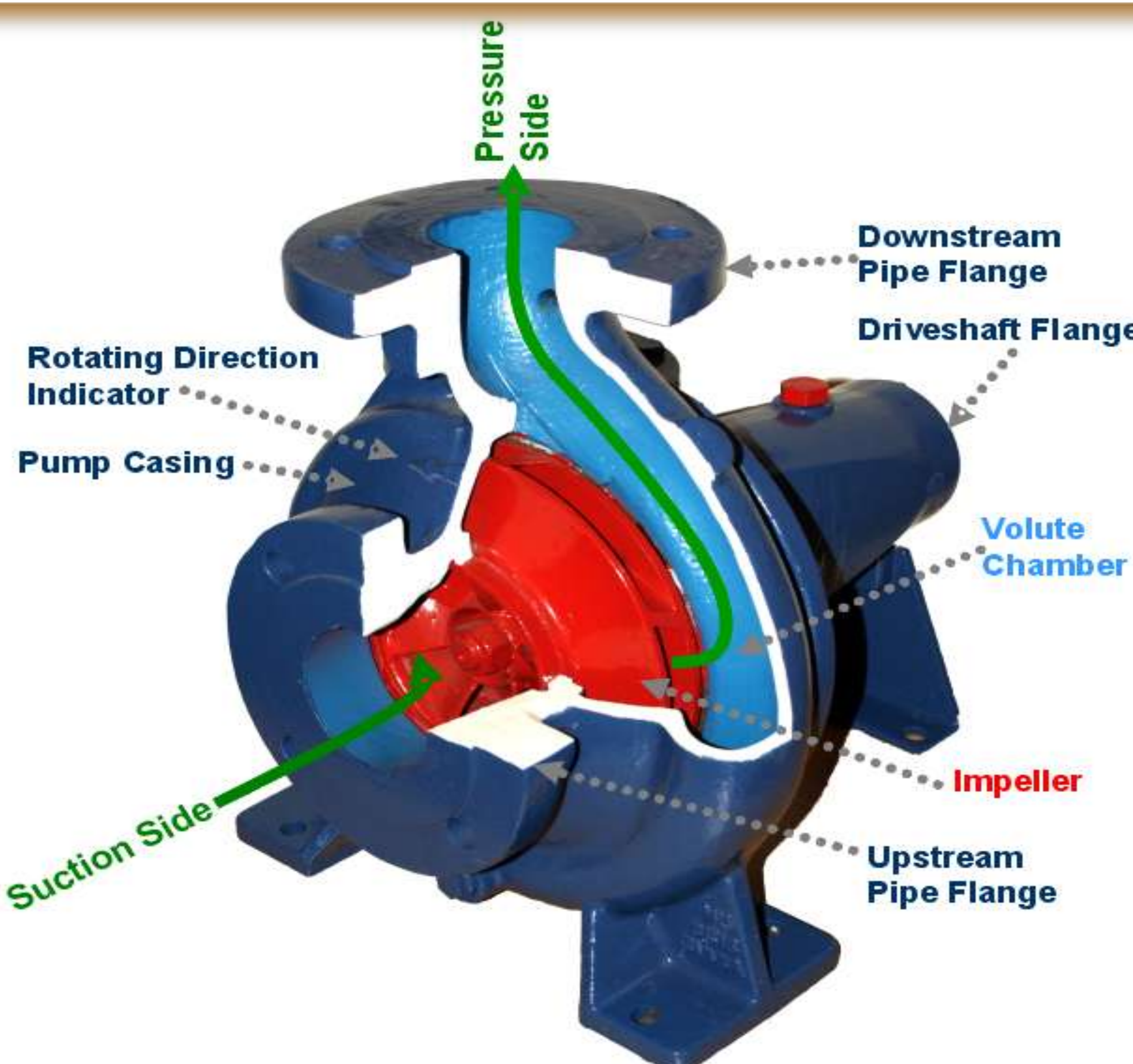
Initial Pump Selection

Centrifugal pumps



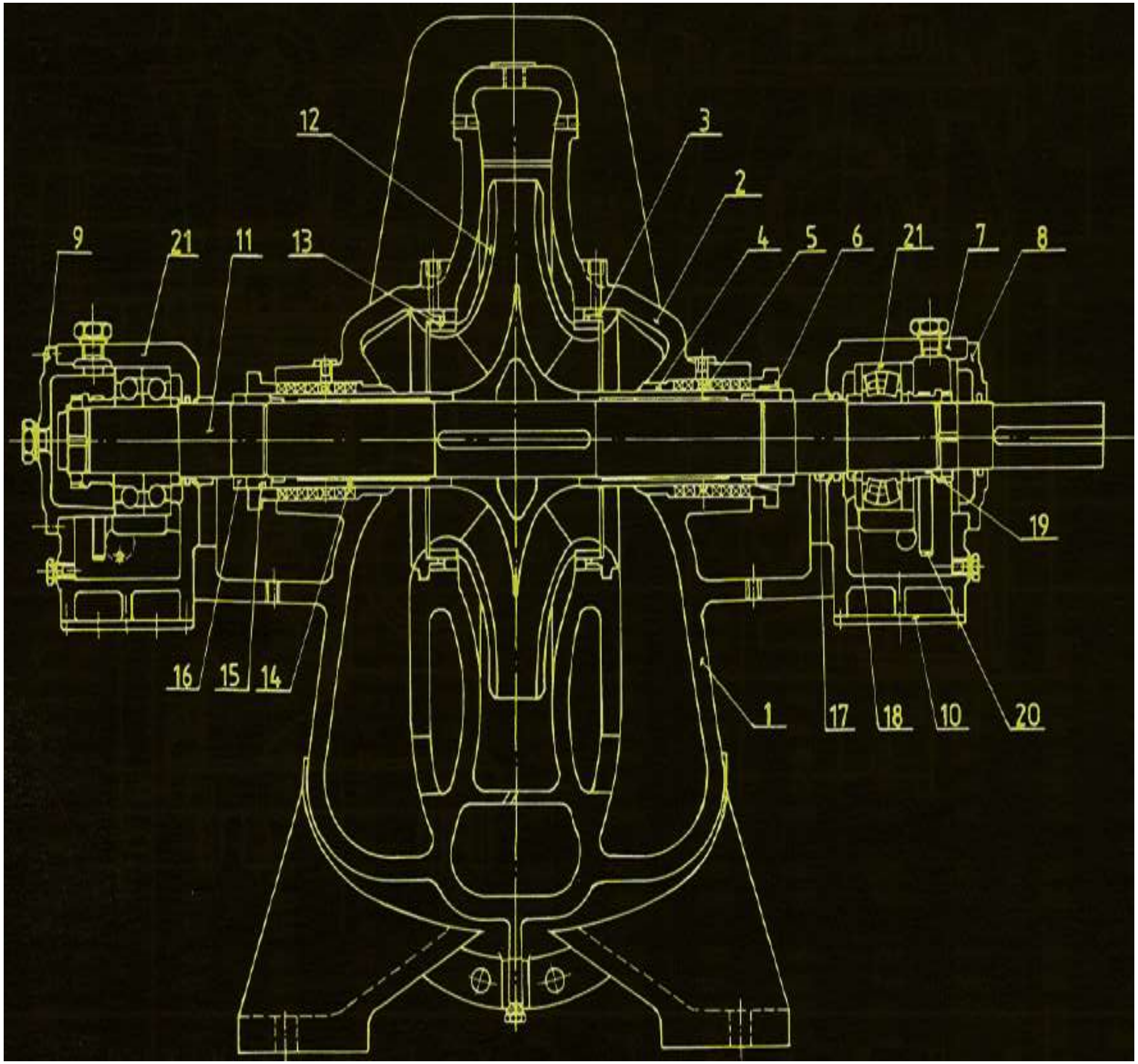


Pumps sectional drawing



pumps, typical sectional drawing

1. Casing half, lower
2. Casing half, upper
3. Casing wear ring
4. Neck bush
5. Lantern ring
6. Stuffing gland
7. Bearing housing
8. Bearing cower I.
9. Bearing cover II.
10. Cooling cover
11. Shaft
12. Impeller
13. Impeller ring
14. Shaft protecting sleeve
15. Shaft nut
16. Lock nut
17. Labyrinth ring
18. Shoulder ring
19. Distance sleeve
20. Lubrication ring
21. Bearing



Pumps, typical sectional drawing

Initial Pump Selection

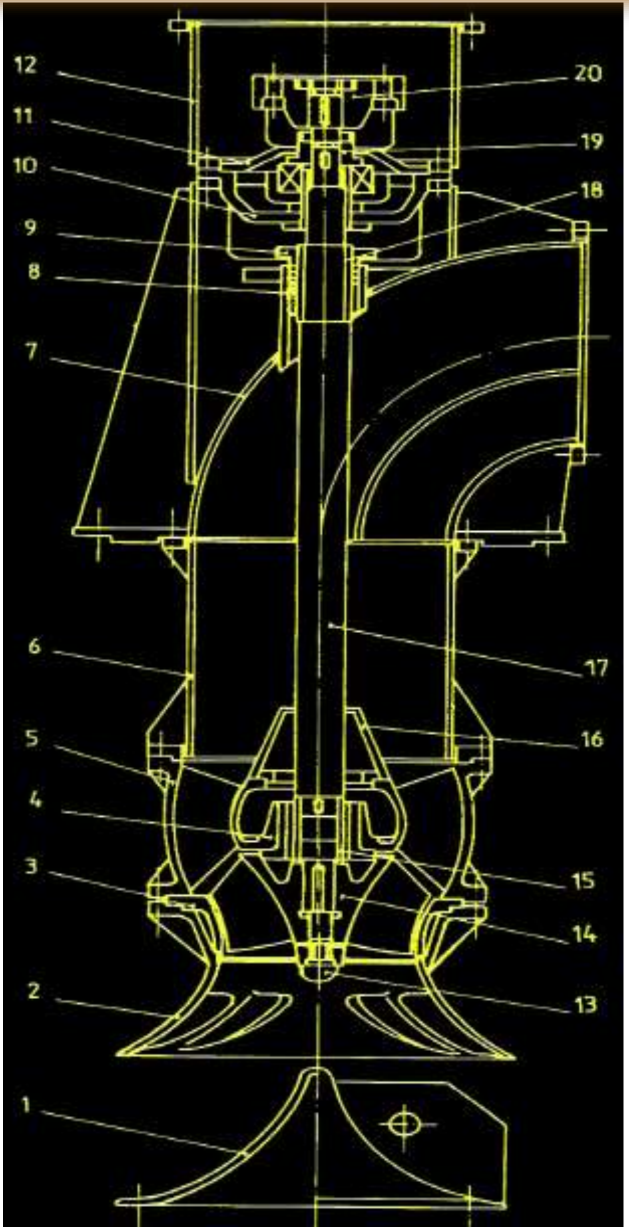
Axial pumps

Axial-flow pumps with pull-out rotor and with blading adjustable during operation

Initial Pump Selection

Mixed-flow pumps

Vertical shaft

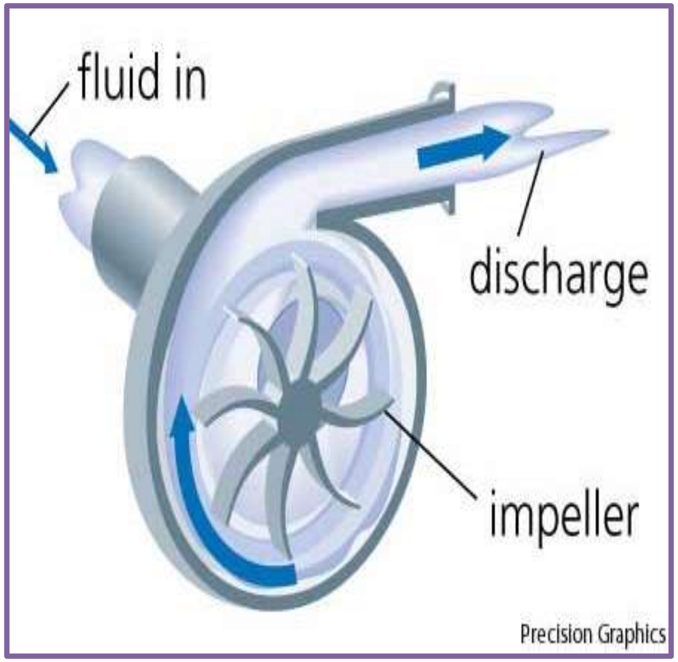


1. Suction cone
2. Suction bell
3. Wearing ring
4. Guide bearing casing
5. Guide vanes casing
6. Tube
7. Delivery elbow
8. Neck bush
9. Stuffing box
10. Thrust bearing casing
11. Thrust bearing cover
12. Motor stool
13. Cover
14. Shaft nut
15. Blade
16. Fixing plate
17. Impeller hub
18. Shaft sleeve
19. Shaft
20. Packing
21. Shaft sleeve
22. Oil retaining tube
23. Bearing bell
24. Coupling

ADVANTAGES OF CENTRIGUGAL PUMPS

Advantages

- Simple in construction and cheap
- Handle liquid with large amounts of solids
- No metal to metal fits
- No valves involved in pump operation
- Maintenance costs are lower

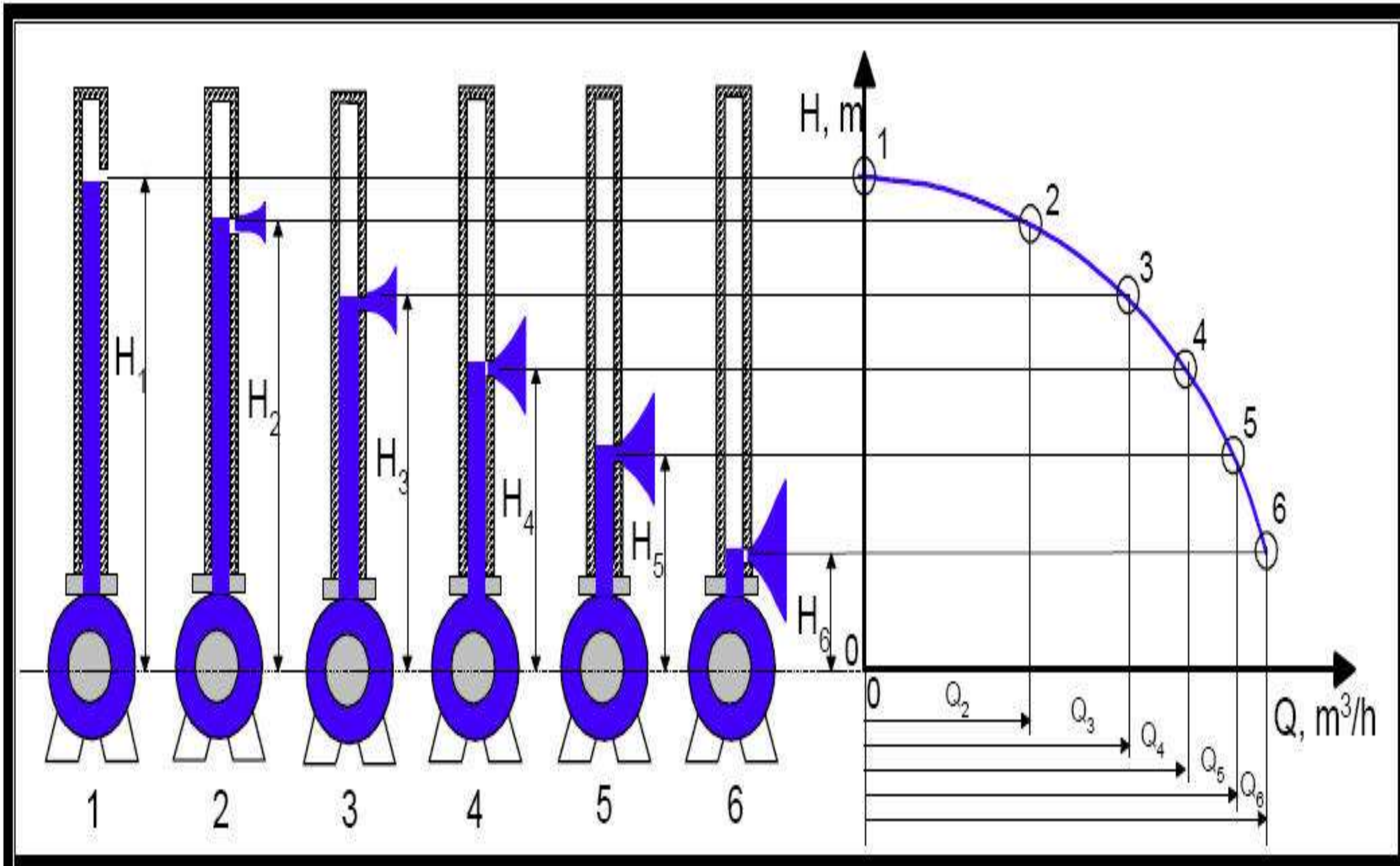


Disadvantages

Cannot handle highly viscous fluids efficiently
Cannot be operated at high heads
Maximum efficiency holds over a narrow range of conditions

Initial Pump Selection

HQ Curve



Initial Pump Selection

The amount of fluid power that a system consumes is a product of head and flow, according to this equation:

$$\text{Fluid power} = \frac{HQ\,(s.g.)}{3{,}960}$$

where

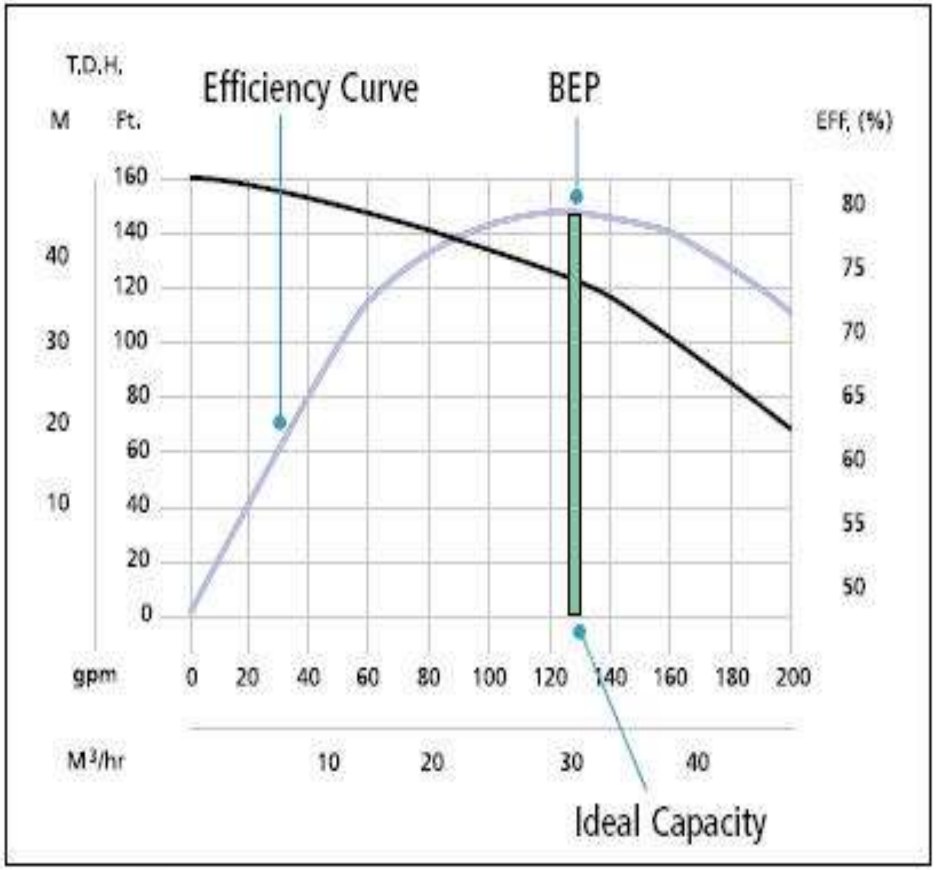
H = head (ft)

Q = flow rate (gallons per minute [gpm])

s.g. = **specific gravity of the fluid**

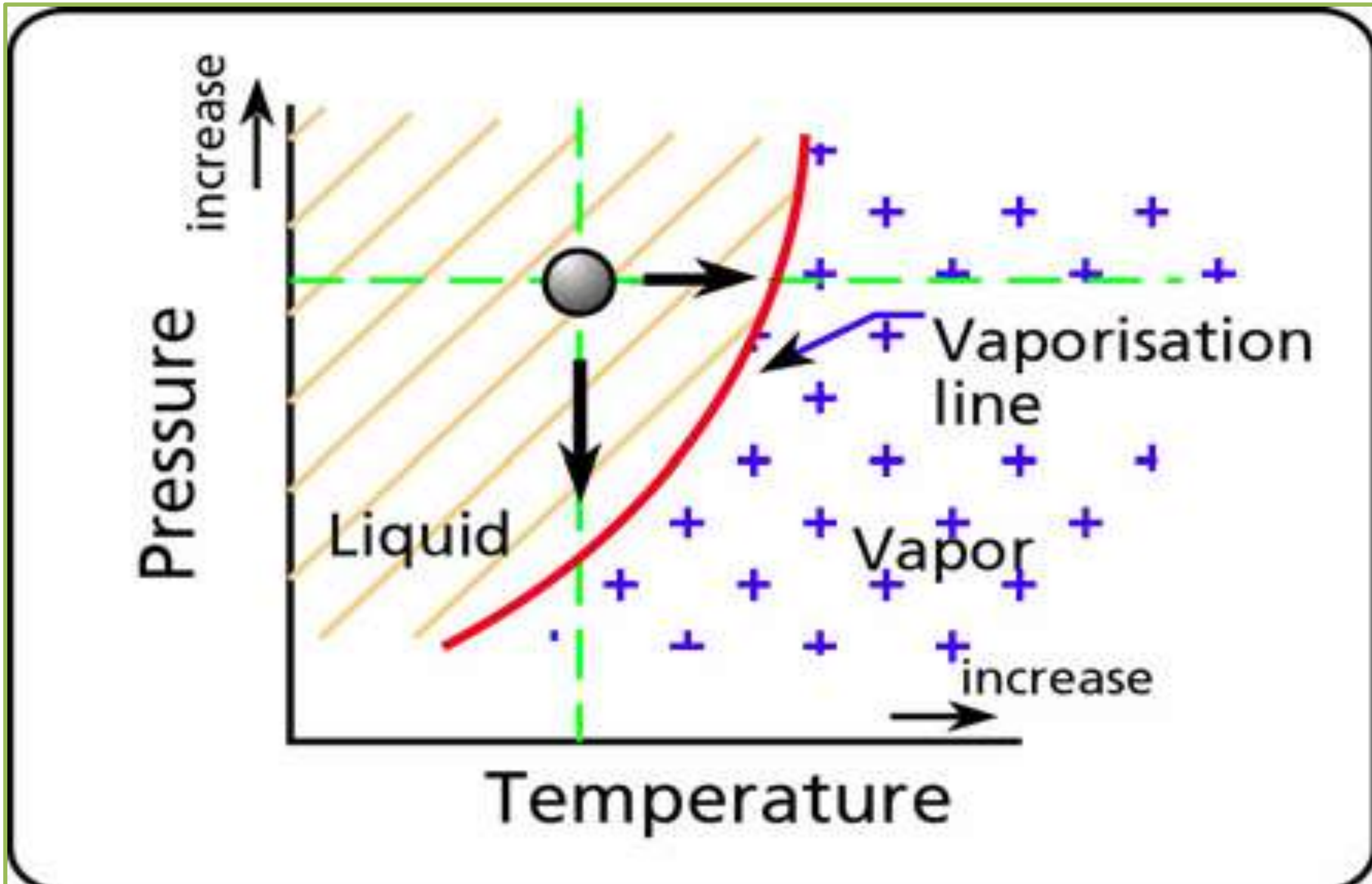
3,960 is a units conversion to state fluid power in terms of horsepower

The operating point of centrifugal pumps at which their efficiency is highest is known as the best efficiency point (BEP). Efficiencies range widely, from 35% to more than 90%, and they are a function of many design characteristics

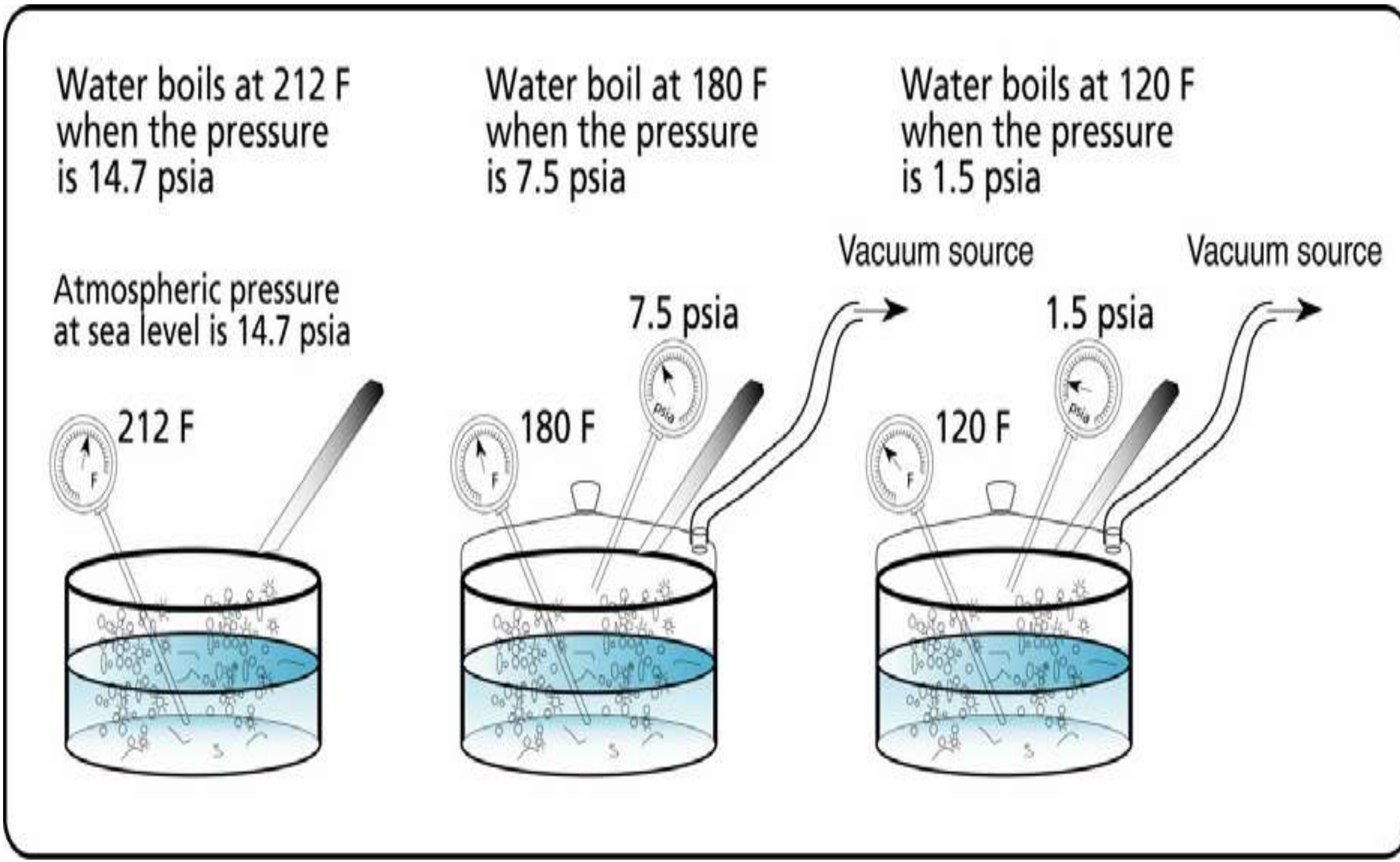


Efficiency curve illustrating decreasing efficiencies as the capacity moves away from the ideal capacity and BEP

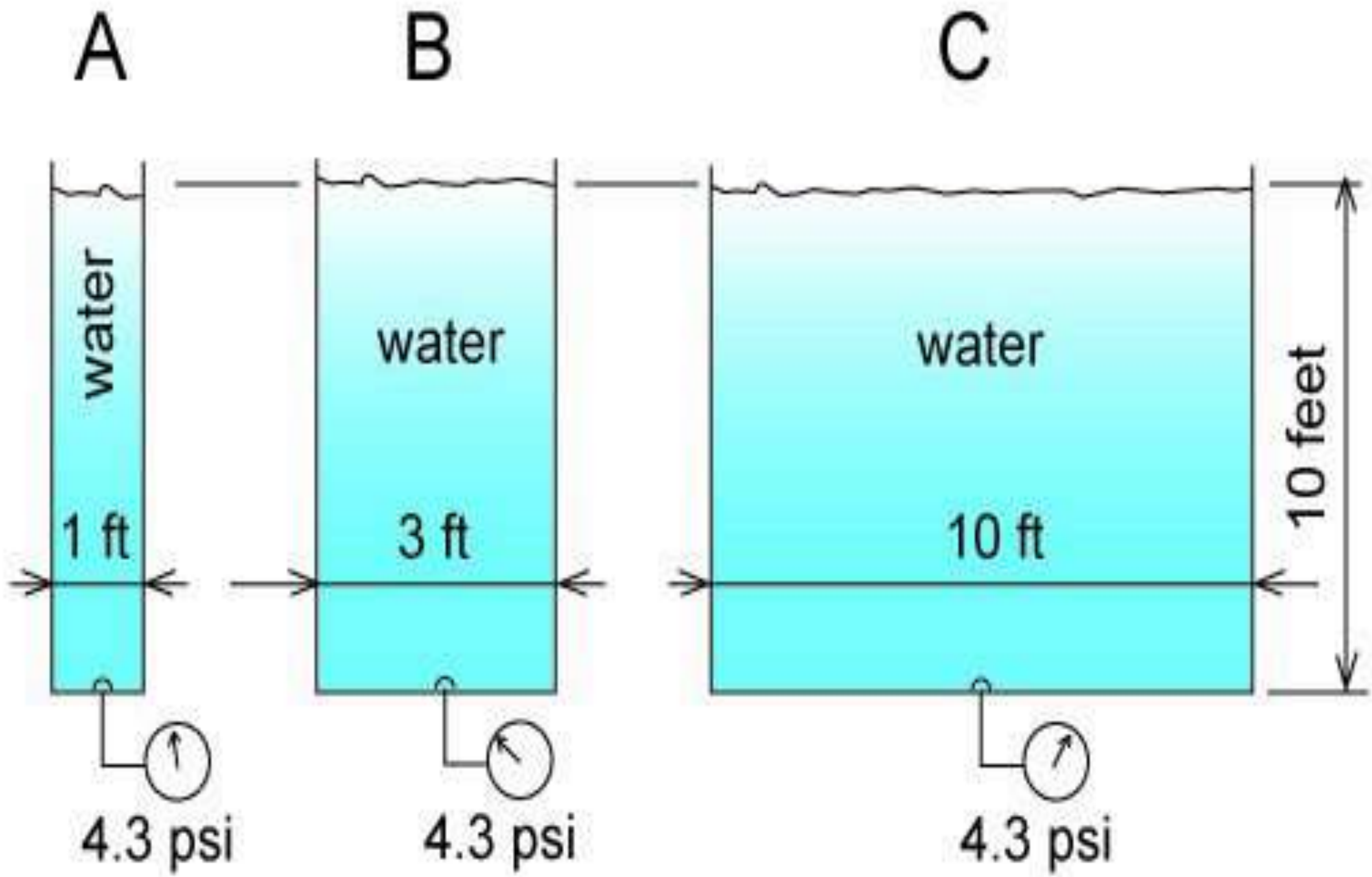
Vapor pressure vs. temperature



Boiling water with low pressure



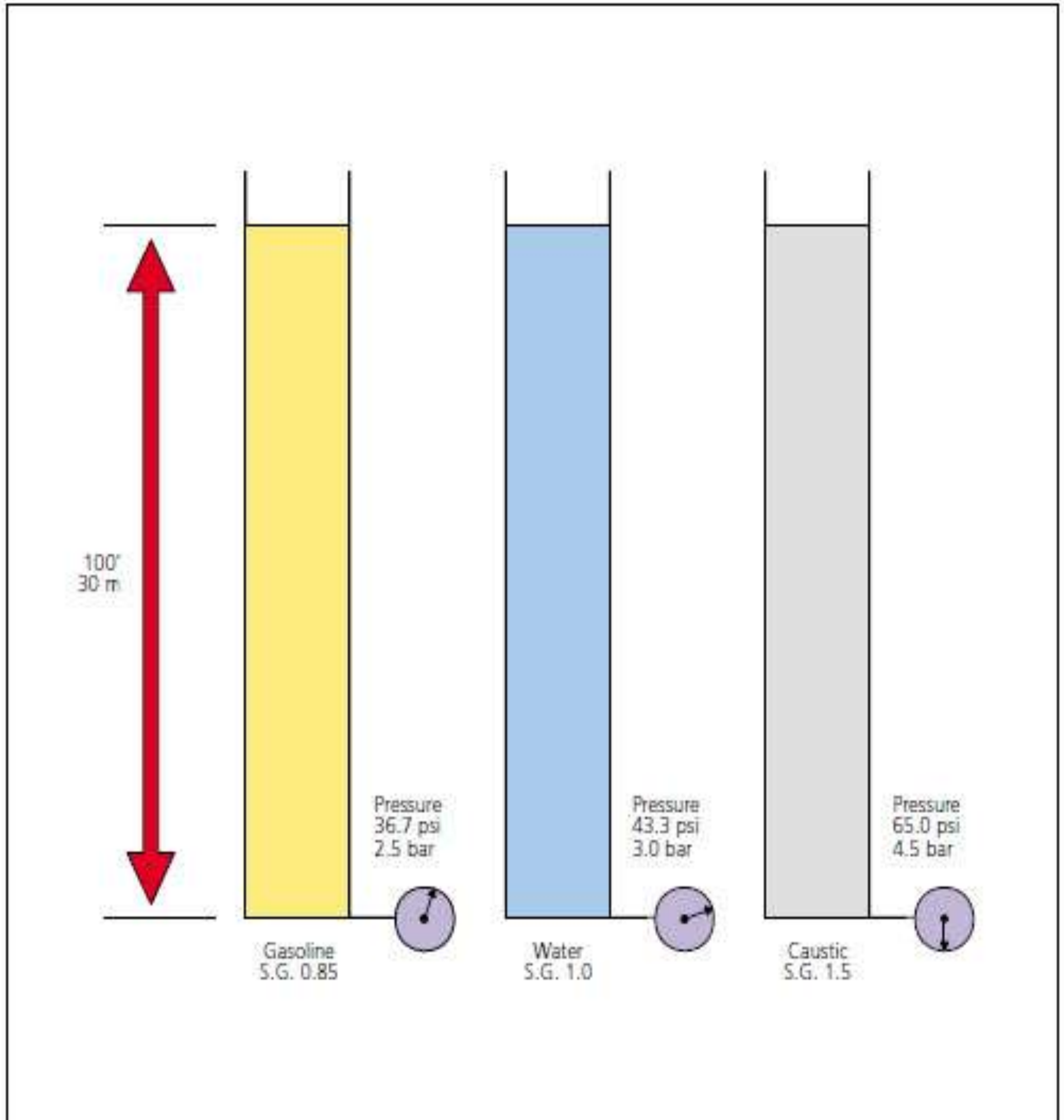
Pressure



Specific Gravity

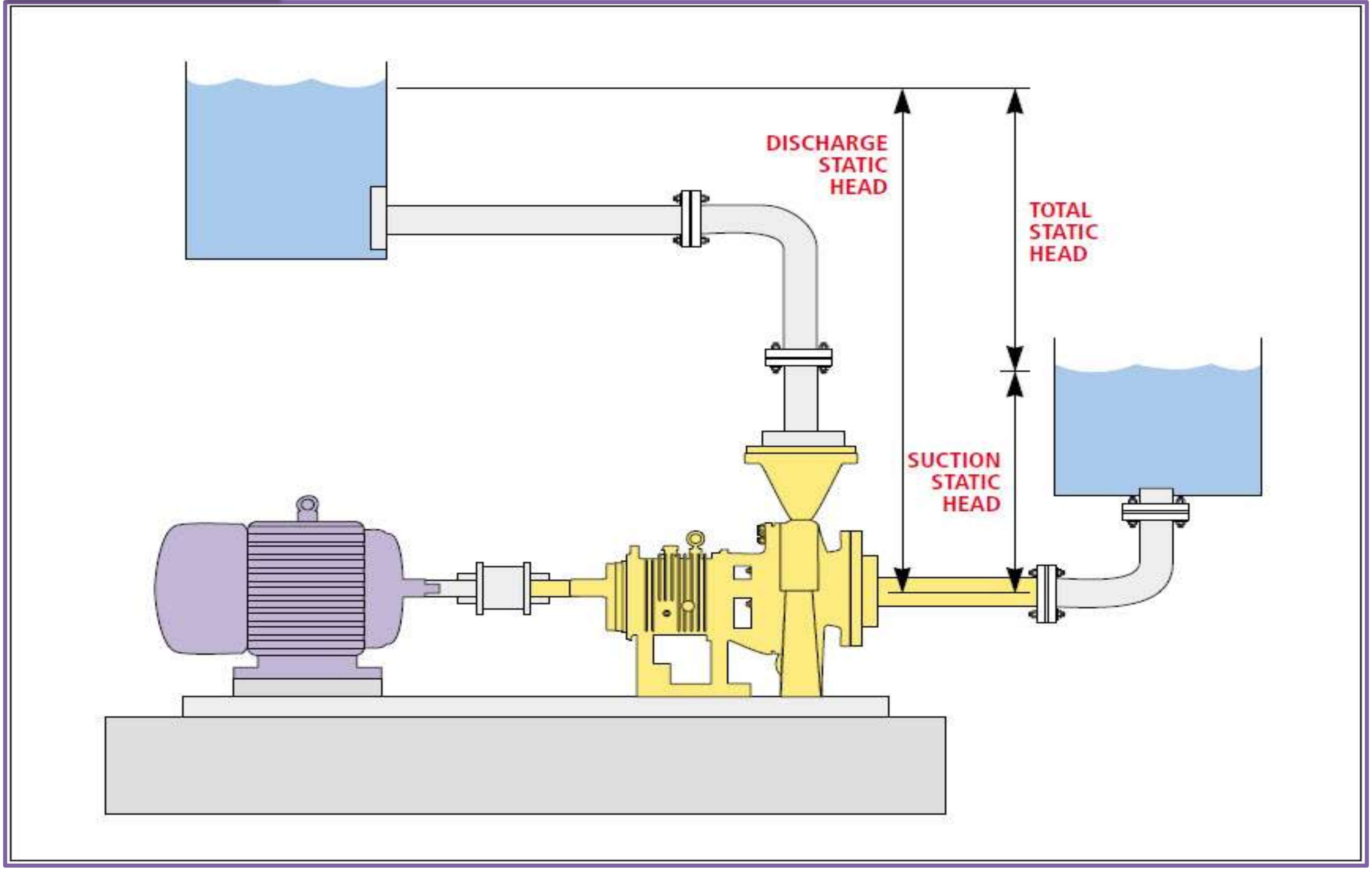
Specific gravity is the density ratio of a liquid as compared to water at a given temperature. Water is used as the standard at 14.69 psia (1.013 bar abs) and at 60°F (15.5°C).

Its specific gravity is 1.0 at this standard temperature and pressure.



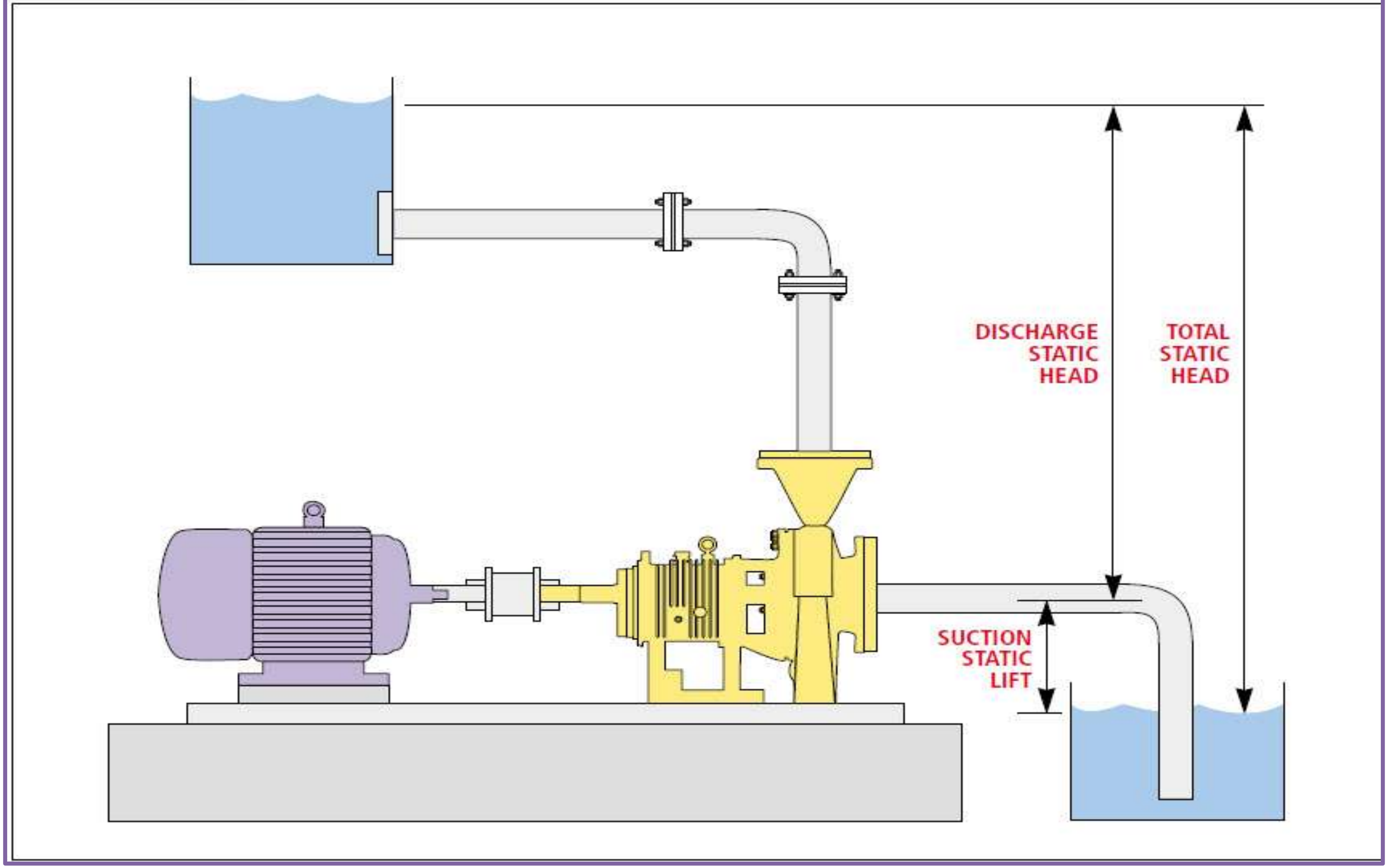
Initial Pump Selection

Static Head



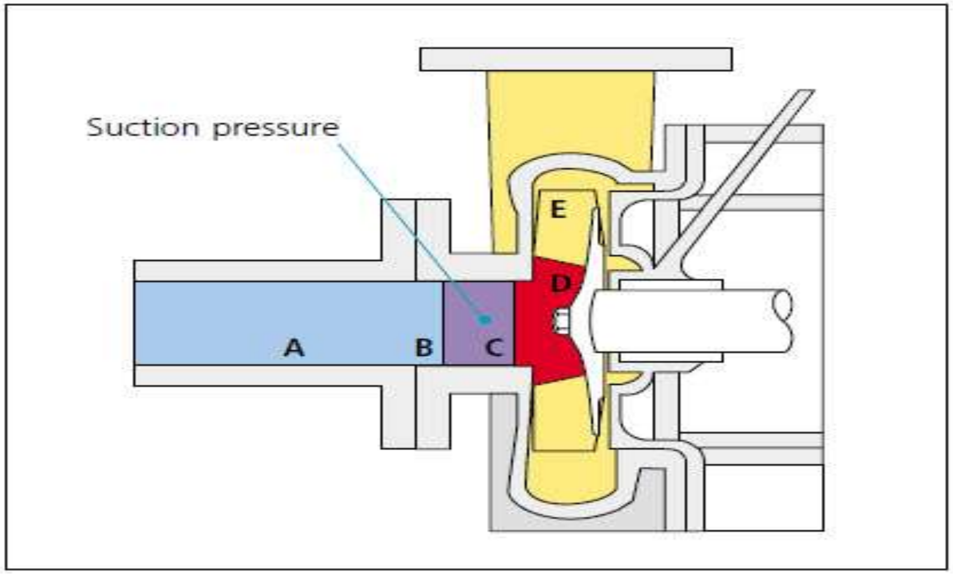
Initial Pump Selection

Static Lift

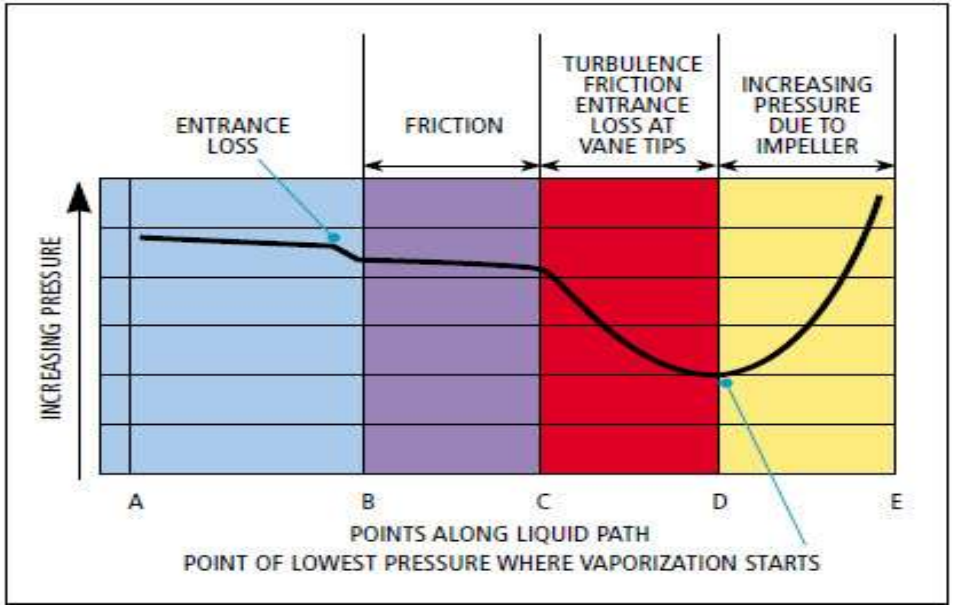


Net Positive Suction Head (NPSH)

is defined as the minimum hydraulic head condition in which a pump can meet its head and capacity requirements without the liquid vaporizing inside the pump.



Vaporization of the liquid causes cavitations. This cavitations reduces a pump's performance
and may damage the pump.



Cavitations

Initial Pump Selection

$$\text{NPSHA} = \frac{2.31\,(P_a - P_v)}{spgr} + (H_e - H_f)$$

where

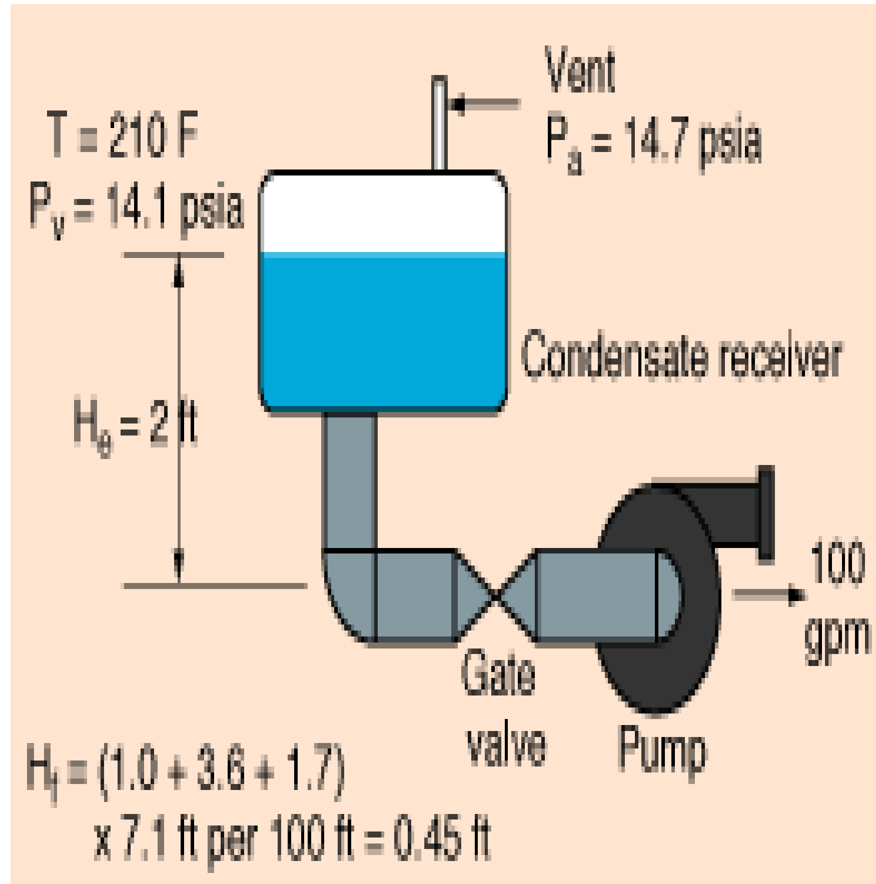
P_a = Pressure in the receiver, psia

P_v = Vapor pressure of the liquid at its maximum temperature, psia

H_e = Elevation head, ft.

H_f = Friction losses in the suction piping at the required flow rate, ft

$spgr$ = Specific gravity

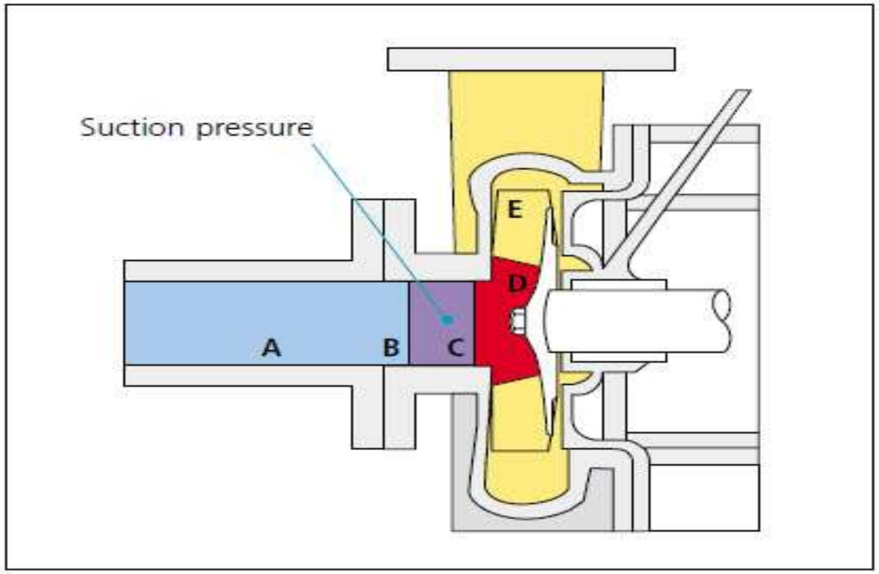


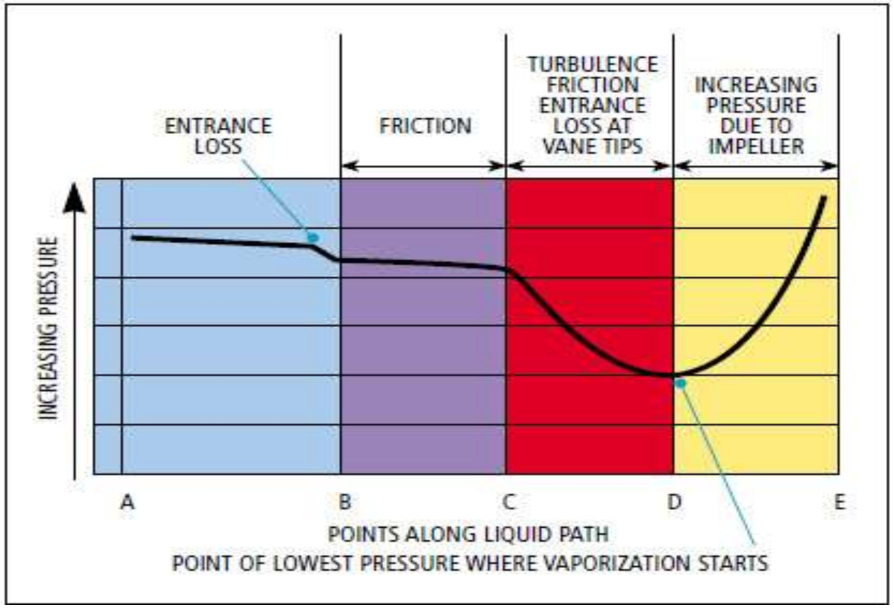
NPSH Available and NPSH Required

The standard tests for NPSHR tell us that even if NPSHA equals NPSHR there still is still a mild incipient cavitation occurring. Therefore, we need a little safety margin. A good margin to use is:

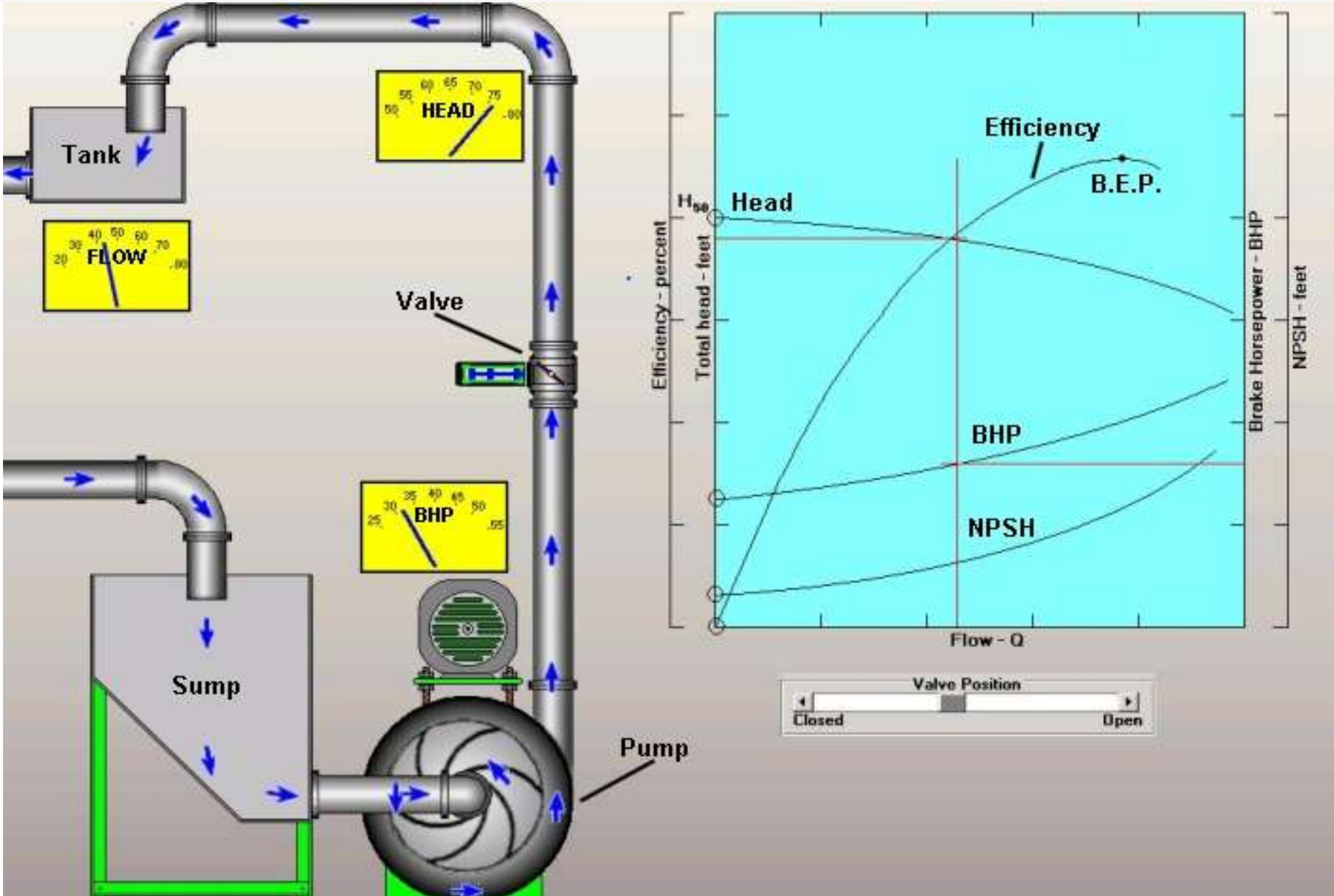
NPSHA › NPSHR +3 ft. (1m)

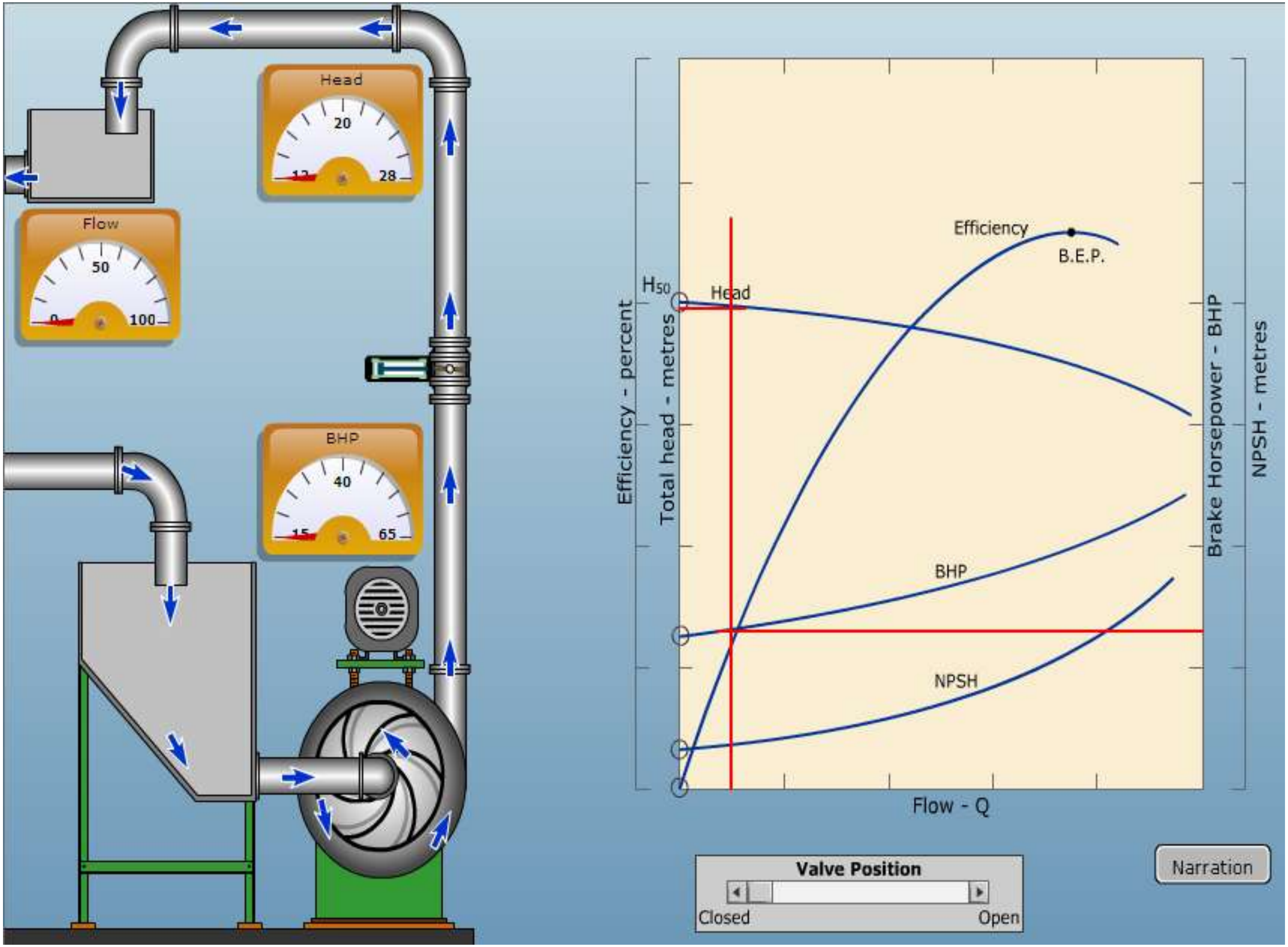
This margin can vary with pump type, impeller type, and fluid being pumped. However for most Overhung Impeller Centrifugal Pumps the 3 ft (1m) safety margin is usually satisfactory.





Initial Pump Selection

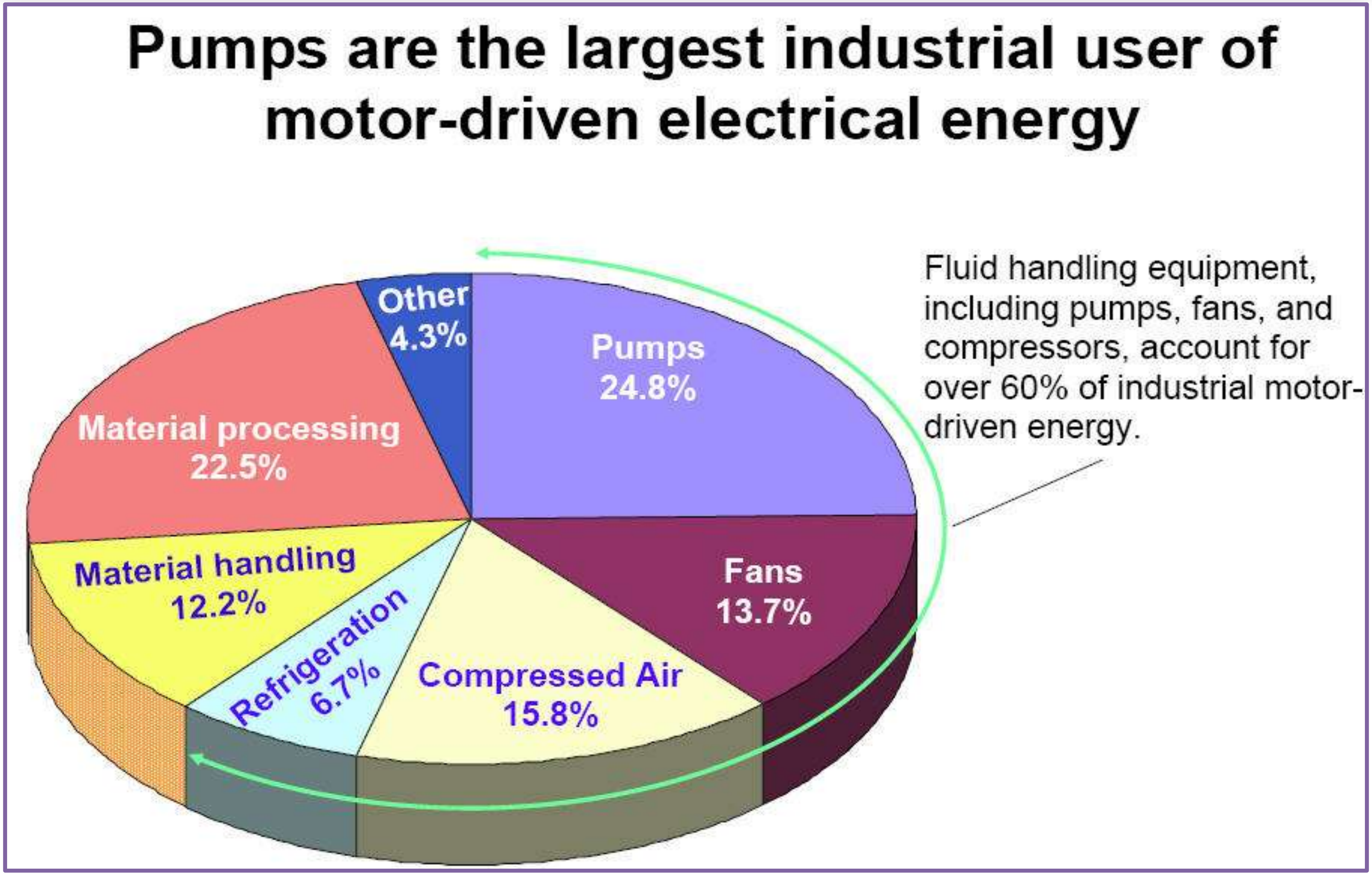



Head
20
12
28
Flow
50
0
100
BHP
40
15
65
Efficiency - percent
Total head - metres
H50
Head
Efficiency
B.E.P.
BHP
NPSH
Brake Horsepower - BHP
NPSH - metres
Flow - Q
Valve Position
Closed
Open
Narration

Prime Movers

Most pumps are driven by electric motors. Although some pumps are driven by direct current (dc) motors, the low cost and high reliability of alternating current (ac) motors make them the most common type of pump prime mover.

Prime Movers



Piping

Piping is used to contain the fluid and carry it from the pump to the point of use.

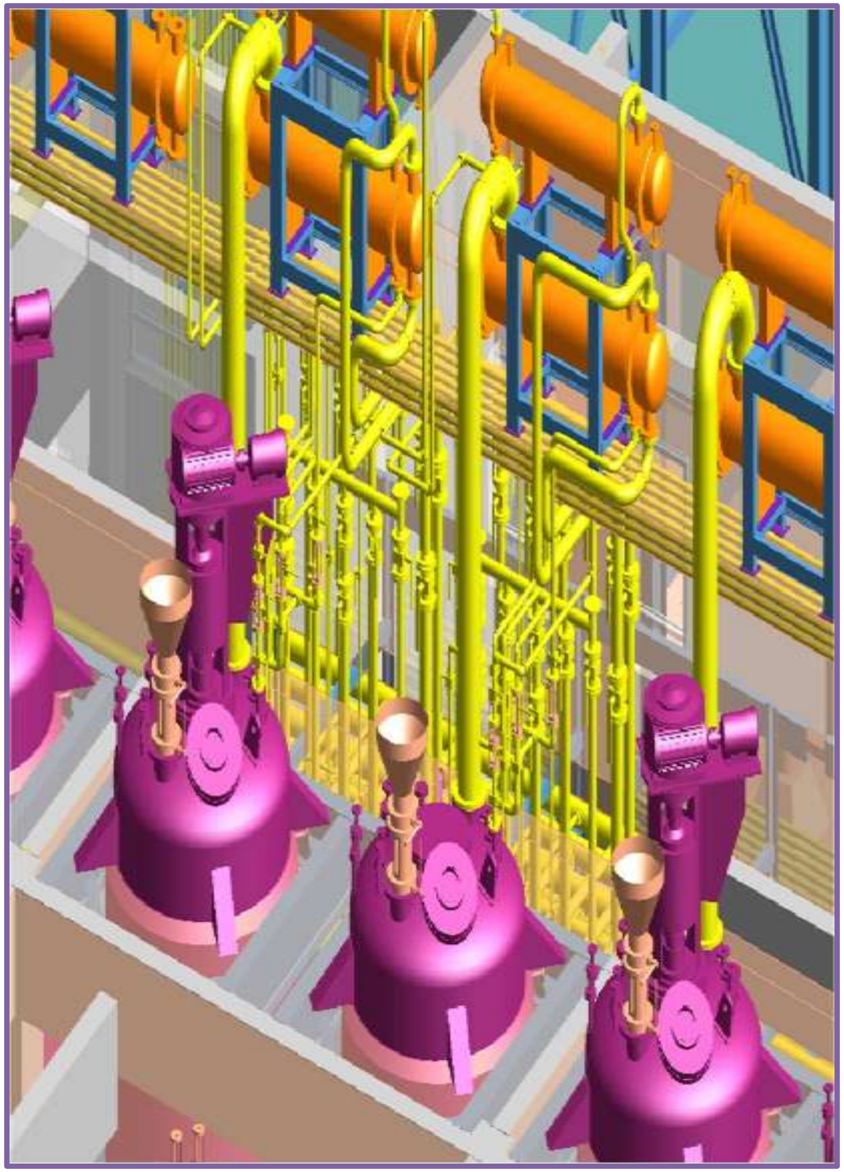
aspects of piping are its dimensions, material type, and cost.

The flow resistance at a specified flow rate of a pipe decreases as the pipe diameter gets larger; however, larger pipes are heavier, take up more floor space, and cost more than smaller pipe.

Piping

In systems that operate at high pressures small-diameter pipes can have thinner walls than large-diameter pipes and are easier to route and install.

Small-diameter pipes restrict flow, can be especially problematic in systems with surging flow characteristics. Smaller pipes also operate at higher liquid velocity, increasing erosion effects, wear, and friction head. Increased friction head affects the energy required for pumping



Valves

The flow in a pumping system may be controlled by valves.

Some valves have:

- distinct positions.
- shut or open.
- throttle flow.

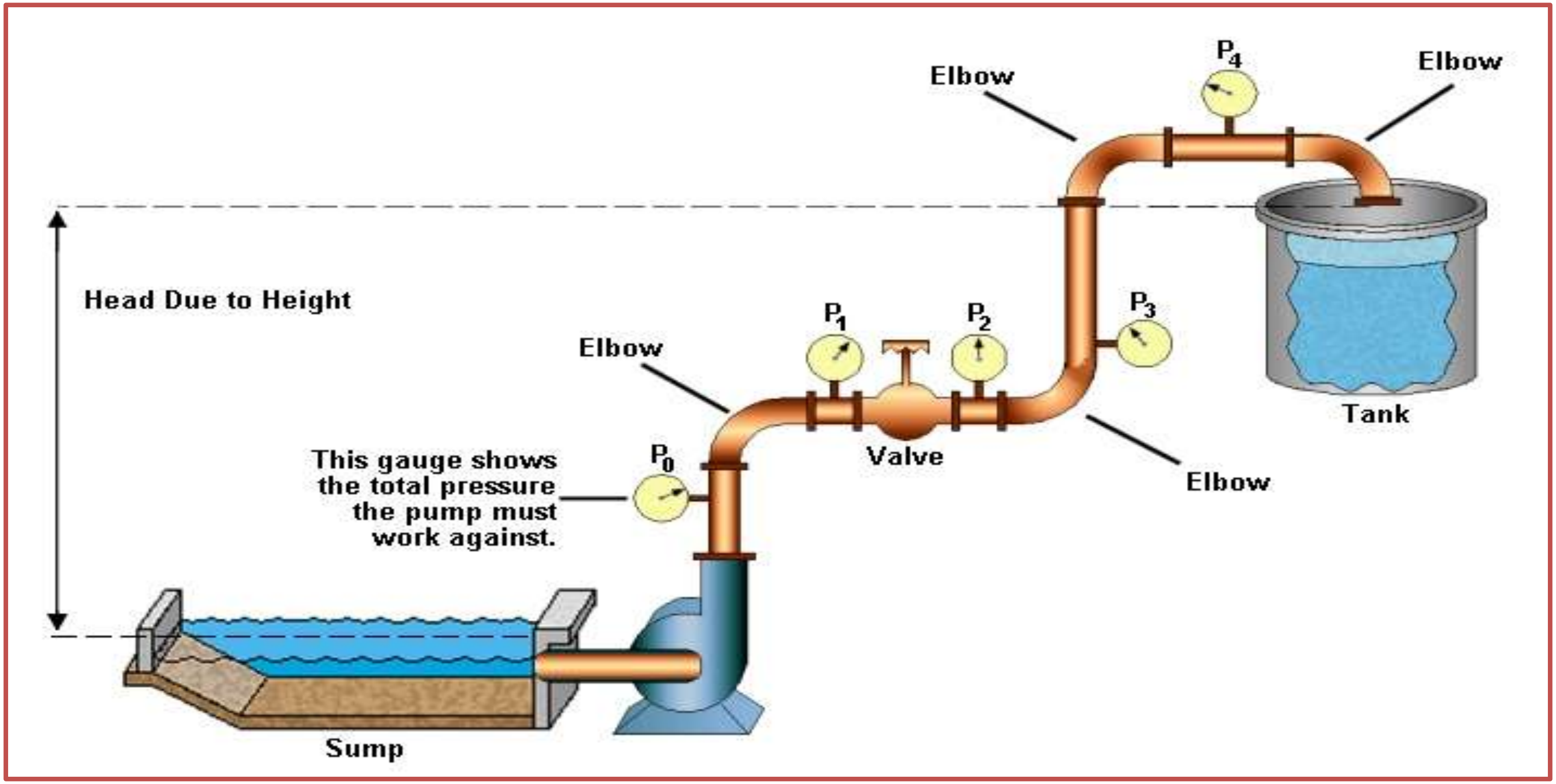
selecting the correct valve for an application depends on:

- ease of maintenance.
- Reliability.
- leakage tendencies.
- Cost.
- frequency with which the valve will be open and shut.

Valves

End-Use Equipment

The essential purpose of a pumping system may be to provide cooling, to supply or drain a tank or reservoir, or to provide hydraulic power to a machine.



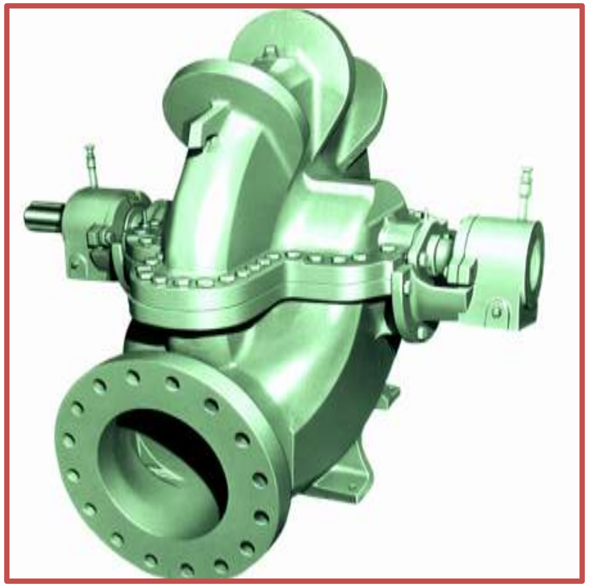
Pumping System Basics

Design Practices

Fluid system designs are usually developed to support the needs of other systems.

In cooling system applications, the requirements flow is determine. Pump capabilities are then calculated based on the system layout and equipment characteristics

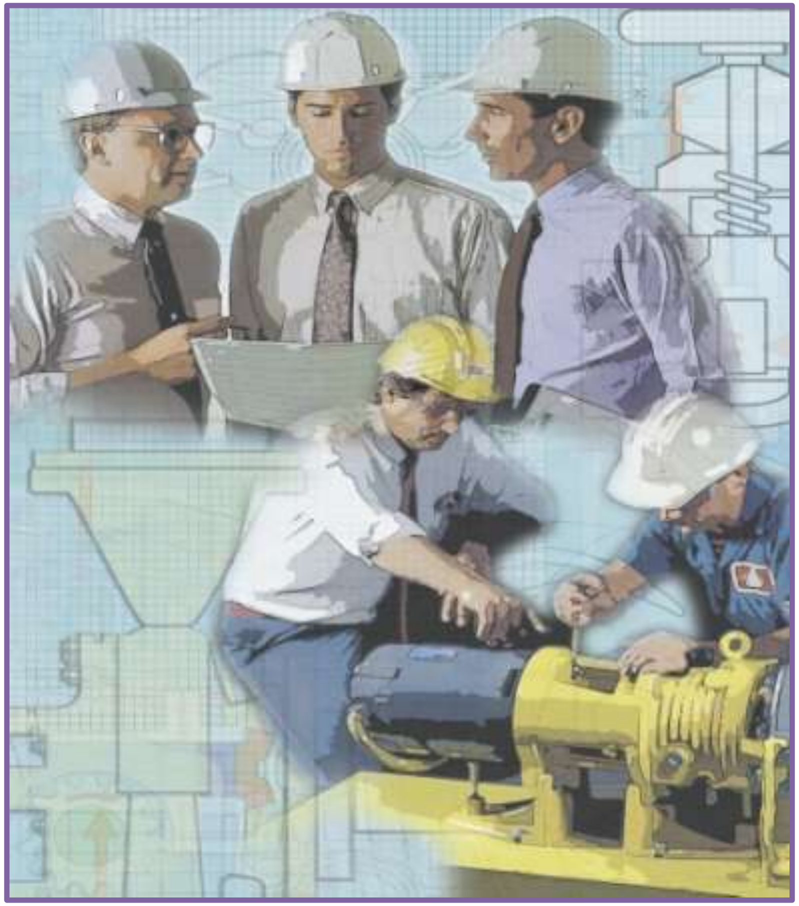
The most challenging aspect of the design process is cost-effectively matching the pump and motor characteristics to the needs of the system



Analyzing System Requirements

fully understand system requirements
(peak demand, average demand, and the variability of demand)
with respect to time of day and time of year

Problems with oversized pumps often develop because the system is designed for peak loads, while normal operating loads are much smaller. Excess flow energy is then forced into the system. In addition to increasing operating costs, this excess flow energy creates unnecessary wear on components such as valves, piping, and piping supports.



Initial Pump Selection

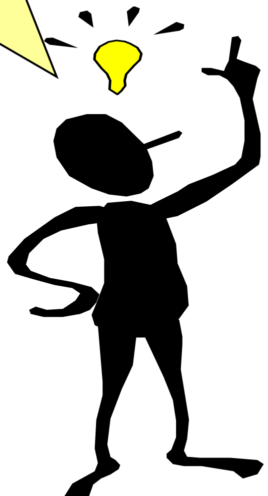
Pump selection starts with a basic knowledge of:

System operating conditions.
Fluid properties.
Pressures.
Temperatures.
System layout.
System Operating Costs.

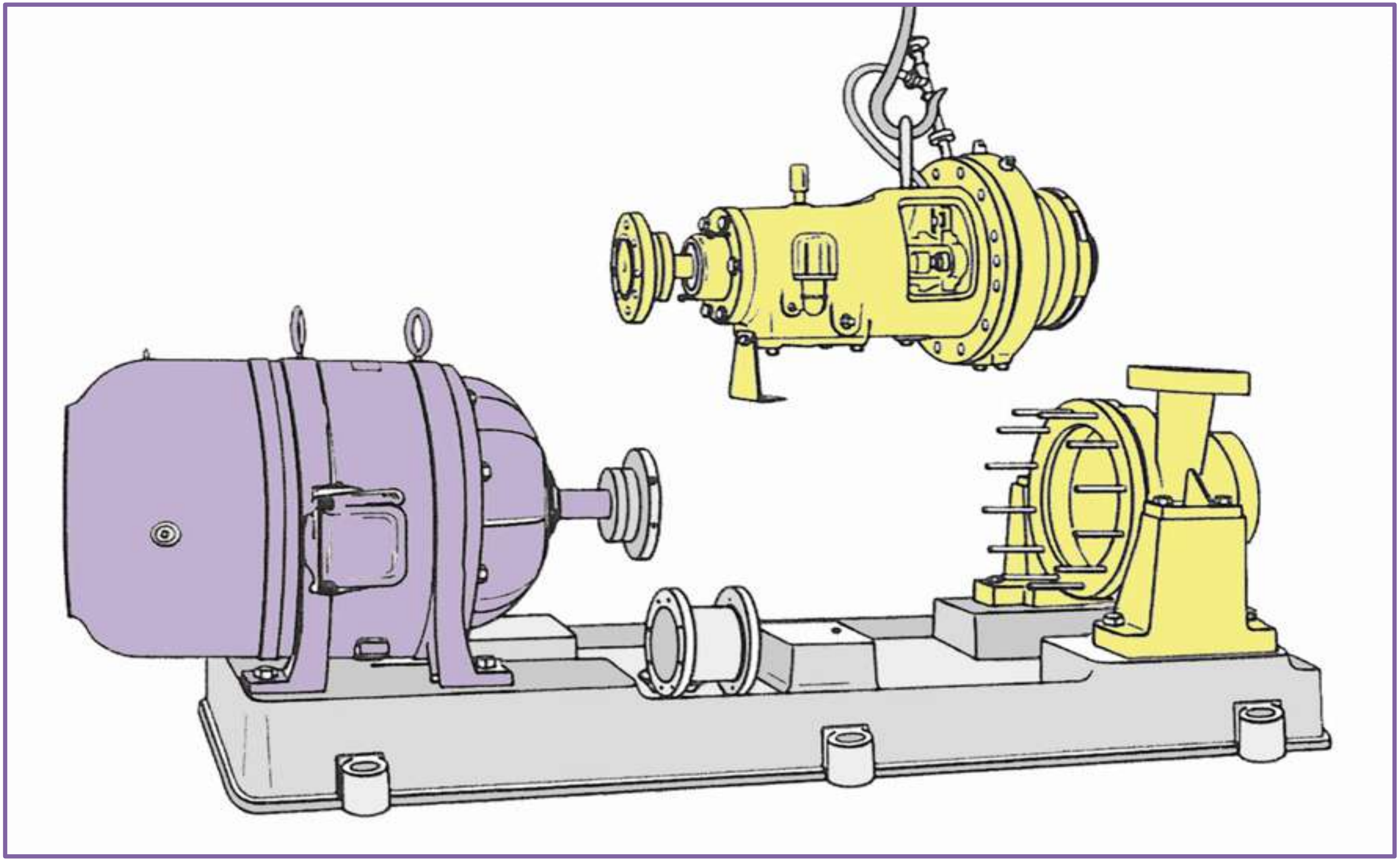
These conditions determine the type of pump that is required to meet certain service needs.

positive displacement
centrifugal.
Axial flow pumps

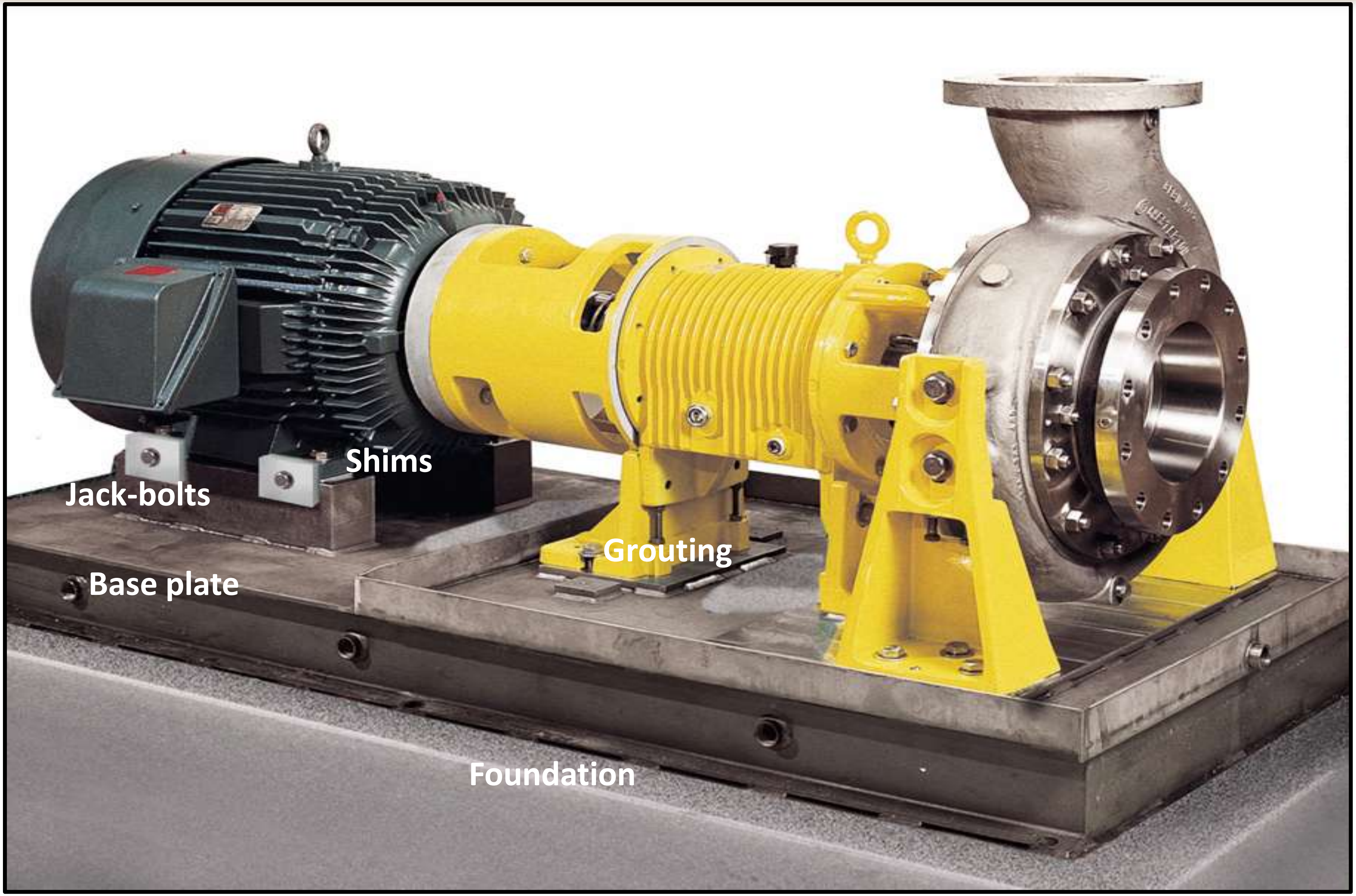
flow rate and head!
efficiency
suction inlet conditions
operating life
maintenance.
Costs



Pumps Installation

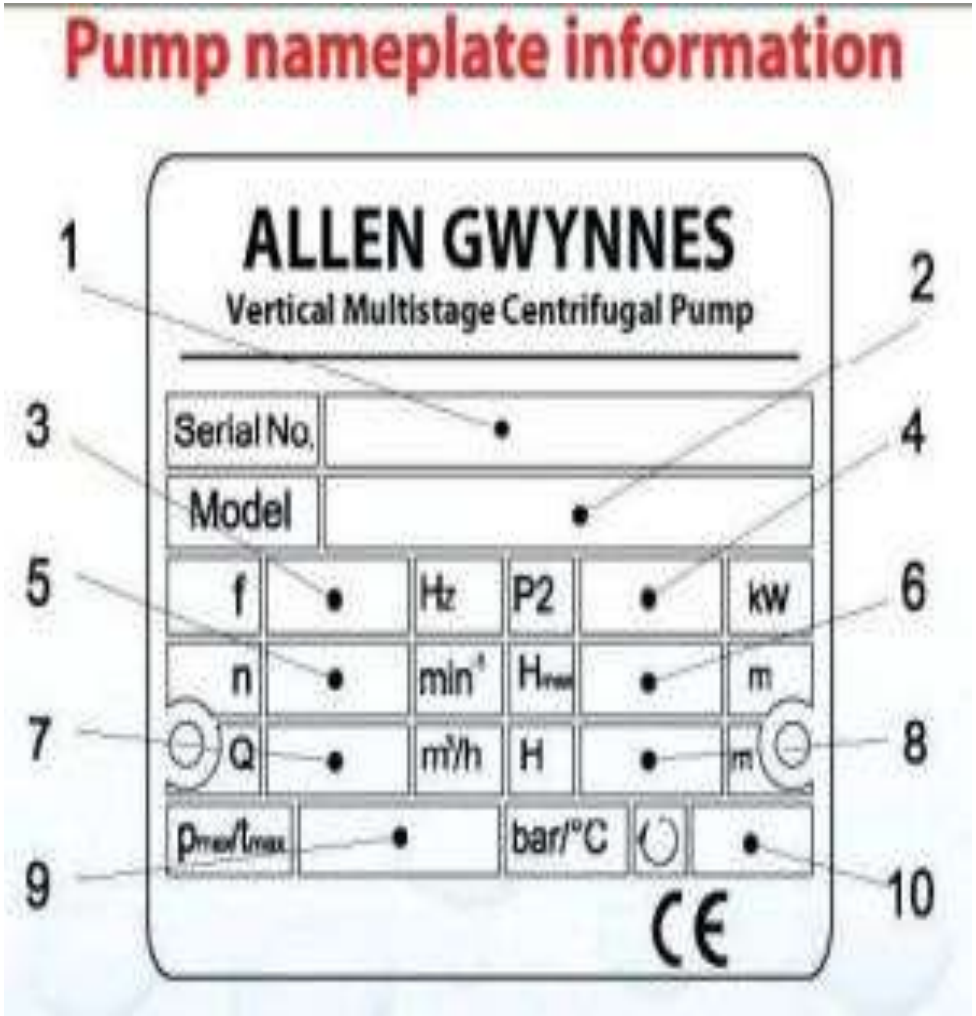


Pumps Installation



Pump nameplate information

1. Serial number
2. Pump Model
3. Frequency
4. Rated Power
5. Speed
6. Maximum Head
7. Capacity
8. Head Range
9. Maximum Operating Pressure
10. Rotating Direction



Transport, Handling

1-Check the pump/pump unit immediately upon delivery/receipt of dispatch for damage or missing parts.

2-The pump/pump unit must be transported carefully and by competent personnel. Avoid serious impacts.

3-Keep the pump/pump unit in the same position in which it was supplied from the factory.

4-Take note of the instructions on the packaging.

5-The intake and discharge side of the pump must be closed with plugs during transport and storage

Transport, Handling

Dispose of all packing materials in accordance with local regulations.

6-Lifting devices (e.g. fork-lift truck, crane, crane device, pulleys, sling ropes, etc.) must be sufficiently strong and must only be used by authorized persons.

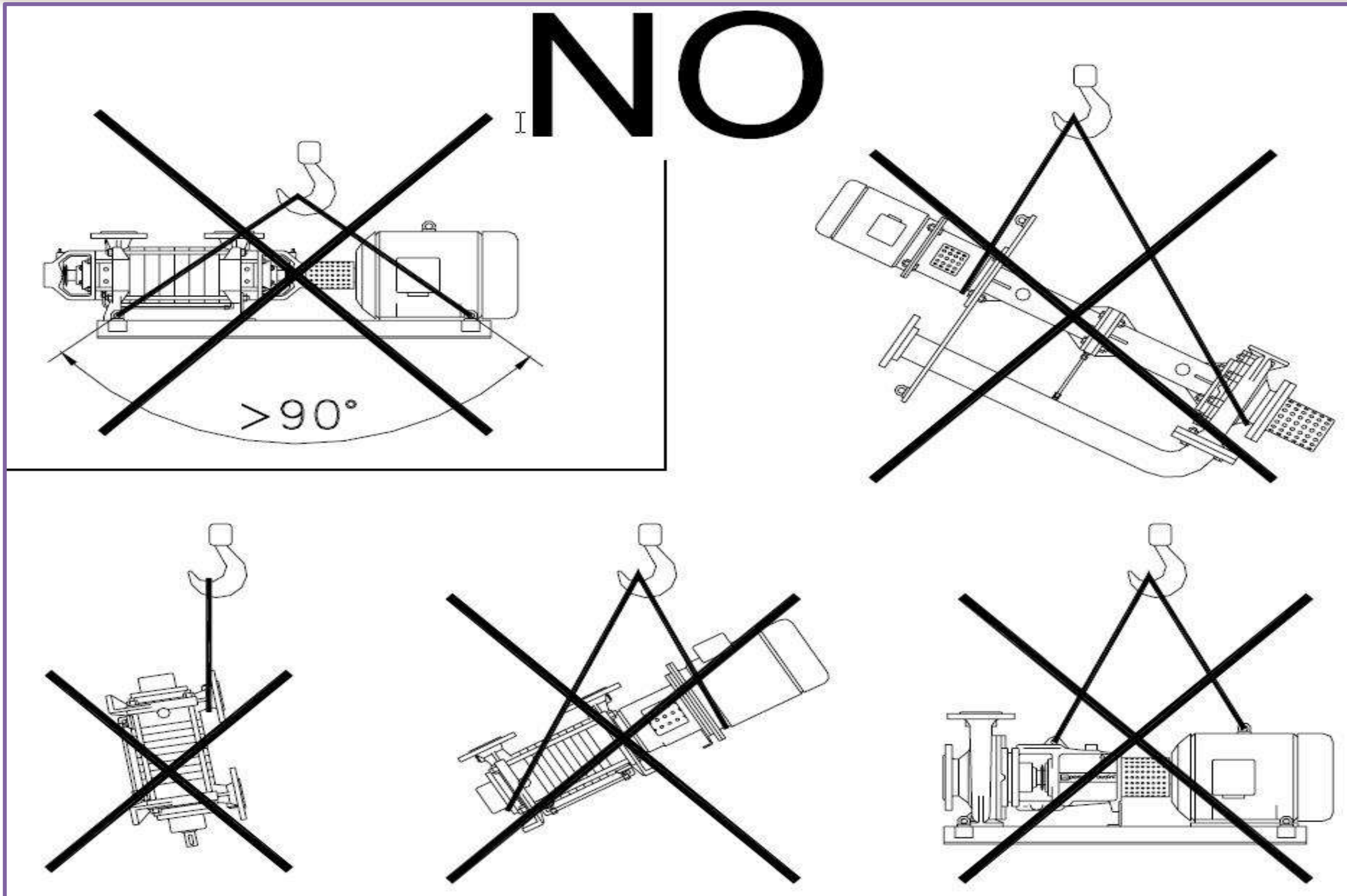
7-The weight of the pump/pump unit is given in the Data Sheet.

.

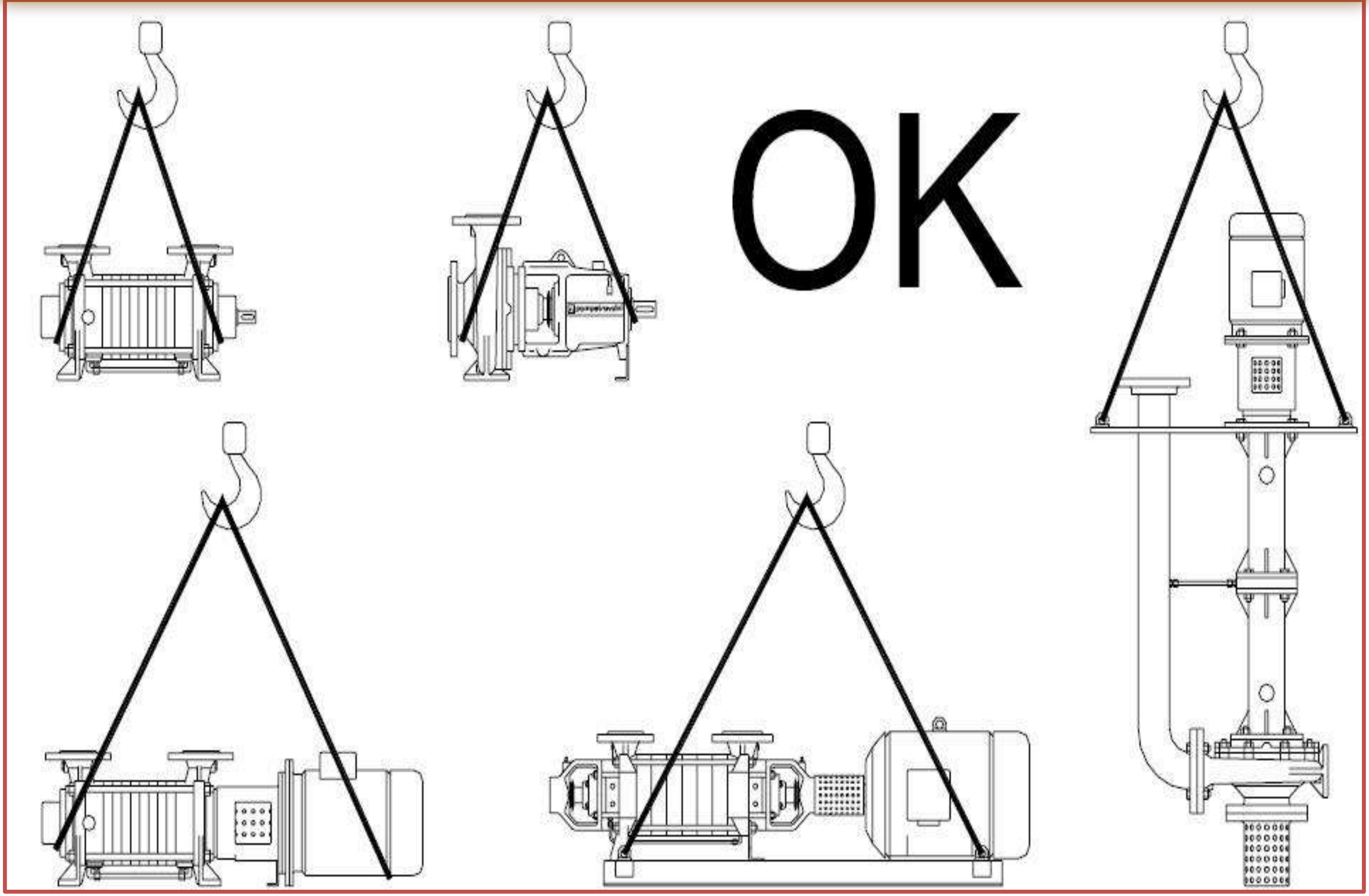
8-The pump/pump unit may only be lifted by solid points such as the casing, flanges or frame.

9-The following illustration shows the correct method of carrying by crane.

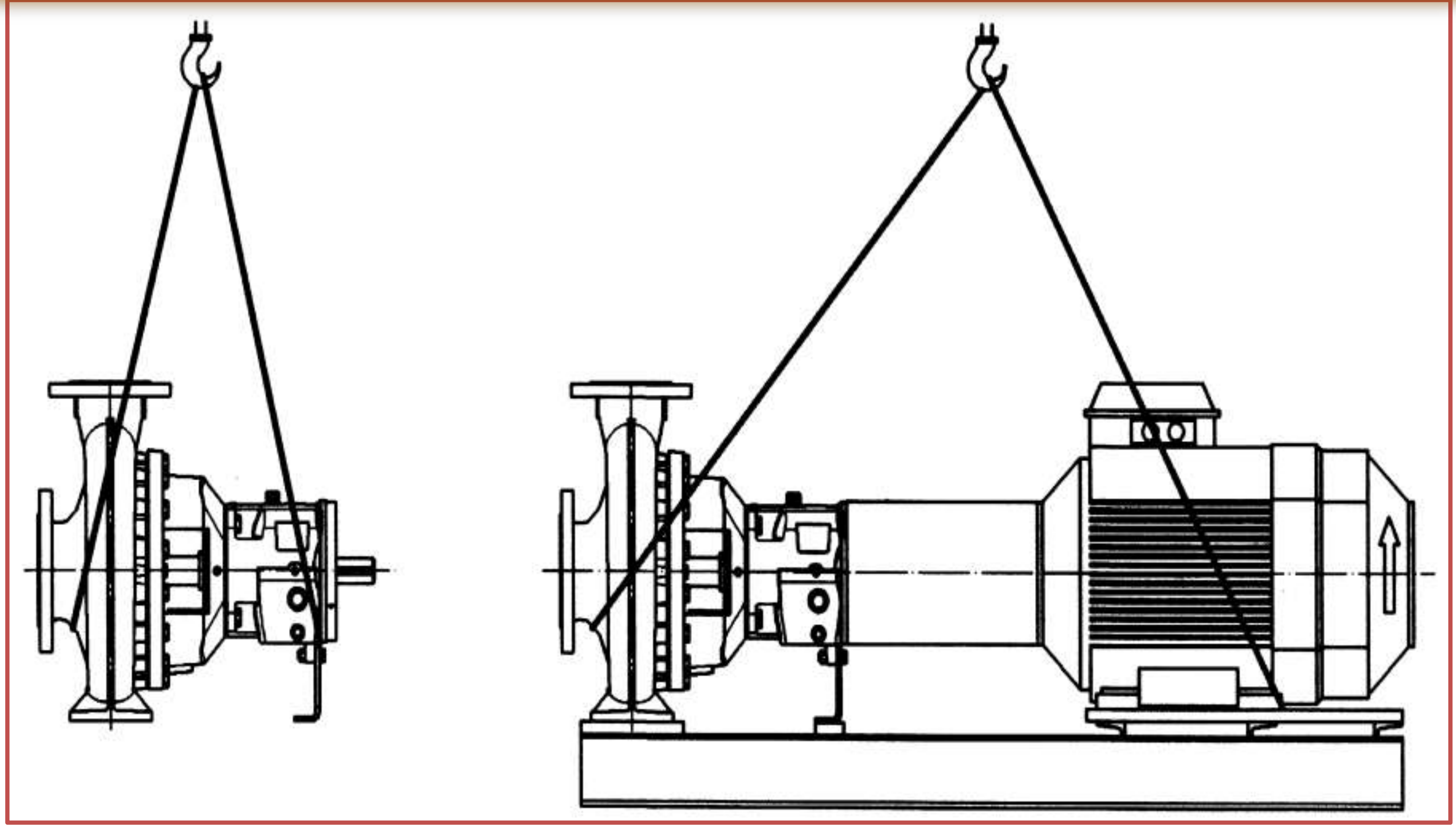
Transport, Handling



Transport, Handling



Transport, Handling



Do not stand underneath suspended loads.

Pumps Storage

Pumps or pump units that are stored for a long time (6 months max) before use must be protected against moisture, vibrations and dirt (e.g. by wrapping in oil paper or plastic sheeting).
Pumps must basically be stored in a place where they are protected from the weather, e.g. under cover. During
this time, all suction and discharge branches and all other intakes and outlets must be closed with dummy flanges or plugs.
Please contact factory for storage instructions for storage periods longer than 6 months

Cover the equipment with industrial strength plastic, preferably transparent to allow its visual inspection, including its nameplate, without uncovering the unit.

Pumps Storage

Drain the casing completely and dry it including :
bearing housing .
stuffing box.
seal chamber.
Apply a coat of soluble rust preventive solution both internally and externally

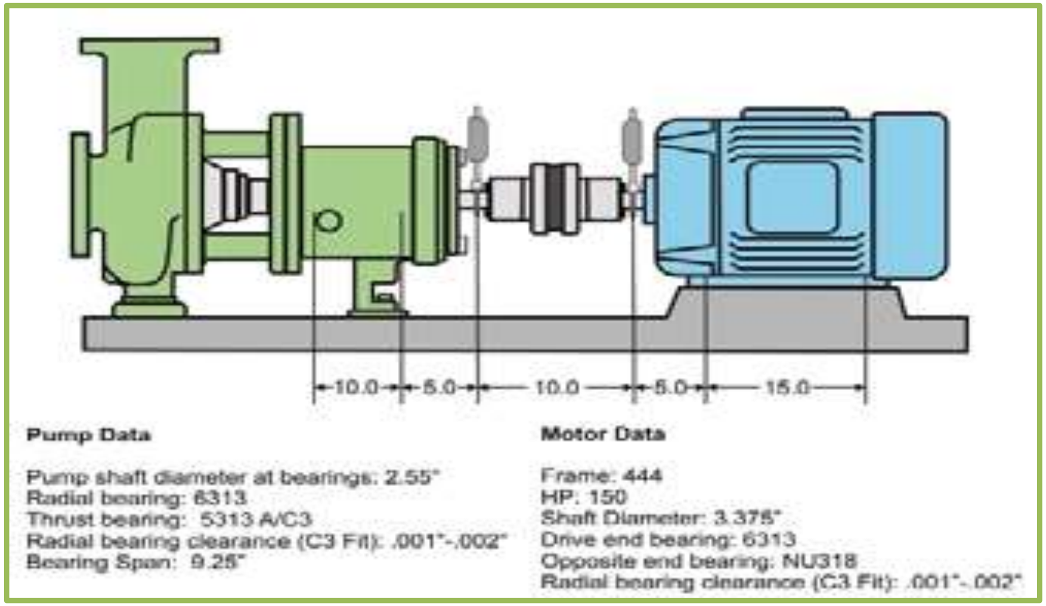
Remove the shaft coupling; it may cause the shaft to develop a permanent sag during prolonged storage.

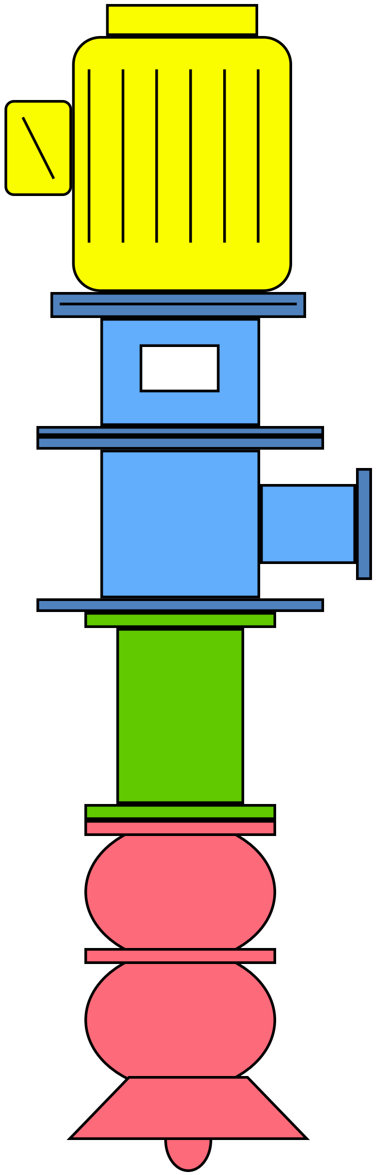
Protect the bearing housing from moisture by placing bags of vapor phase inhibitor crystals around the housing

Store the unit in its normal position in a dry place.

Pumps Storage

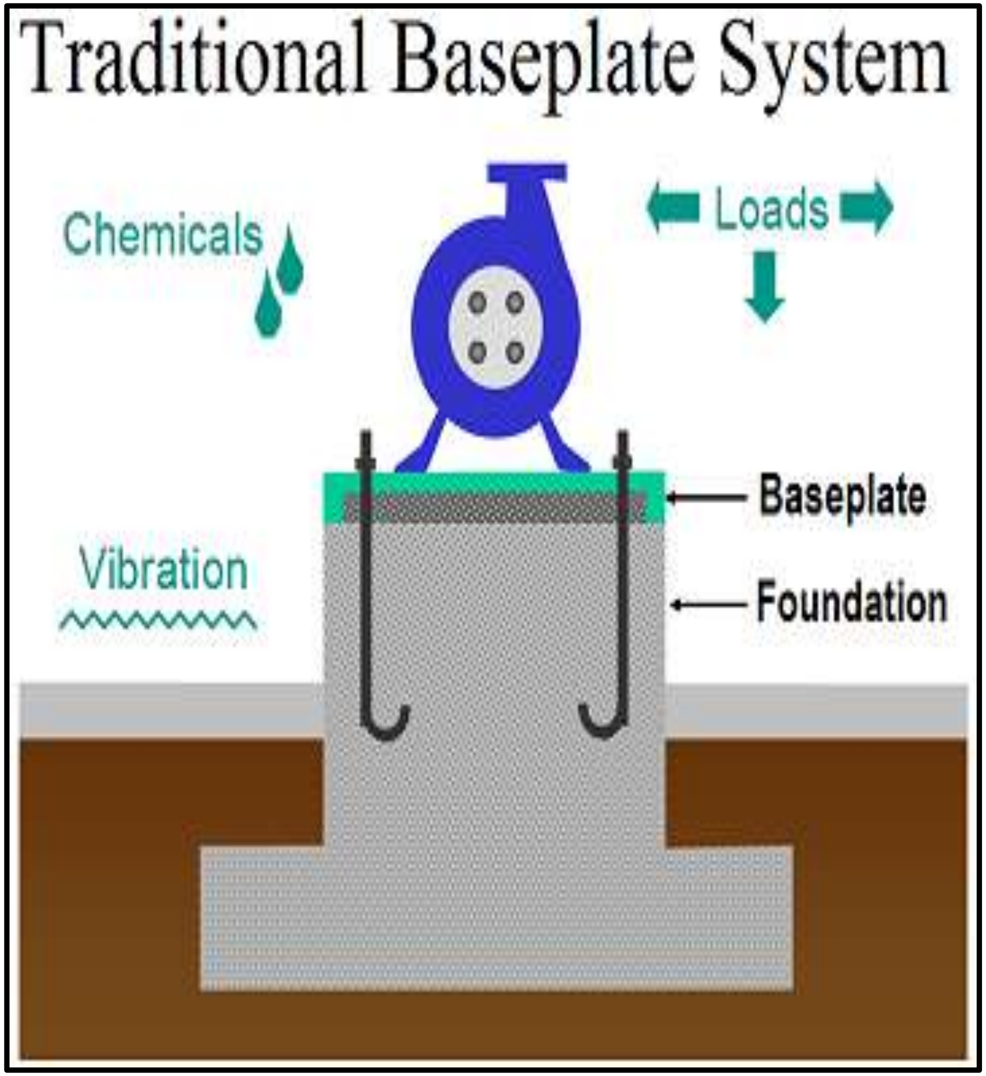
Inspect the unit periodically and turn the shaft a few times plus 1/4 turn. Turning the shaft prevents pitting of finished surfaces. The extra 1/4 turn is to displace the sag and prevent the shaft from developing a permanent bow.





Pumps Installation

- Mounting of pump onto a base frame
- Installation and Alignment of Coupling
- Connecting the pipes to the pump
- Electrical connection
- Starting up
- Operation and Monitoring
- Shutting down



Pumps Installation

Mounting of pump onto a base frame

The pump unit must be provided with a shared base frame made of steel or cast iron or a welded steel profile frame. This base frame must be placed on a foundation which can withstand all loads that arise during operation.

following is to be noticed

The base must withstand all loads occurring during operation.
The mounting surfaces of the pump feet and motor on the base frame must be flat
safe fastening
Space between pump and motor depending on the used coupling

Pumps Installation

Installation and Alignment of Coupling

Make sure that nobody can start the motor during work on the coupling.

Before starting installation **coupling**

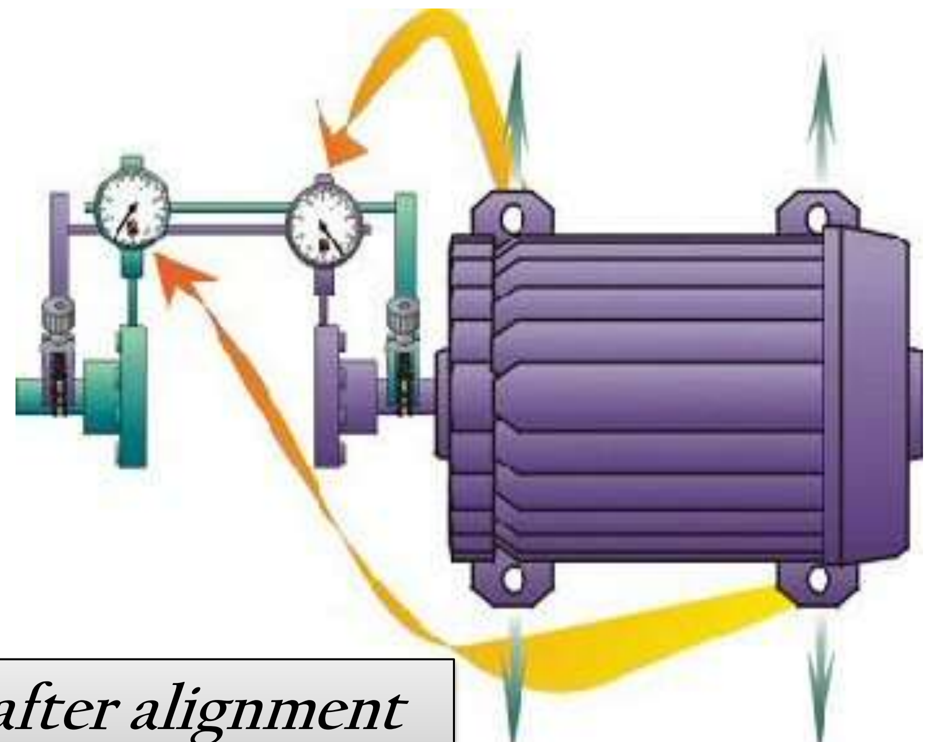
carefully clean shaft ends
do not hit the coupling
coupling may be heated before
hand in an oil bath approx. 100°C
Secure coupling hubs against
axial sliding

Pumps Installation

Installation and Alignment of Coupling

The installation and alignment of the coupling must be carried out with the utmost care and attention.

Badly aligned couplings cause
noise.
vibration .
increased wear on bearings,
couplings and shaft seals



Mount coupling guard after alignment and before starting the unit.

Pumps Installation

Connecting the pipes to the pump

The pipes must be of a size and design that liquid can flow freely

it is recommended that a check valve is installed in the discharge pipe shortly after the pump.

Particular attention is to be paid to ensuring that suction pipes are air tight and that the NPSH values are observed.

Do not install fittings or bends right before the suction nozzle.

When laying the pipes, make sure that the pump is accessible for maintenance, installation and disassembly.

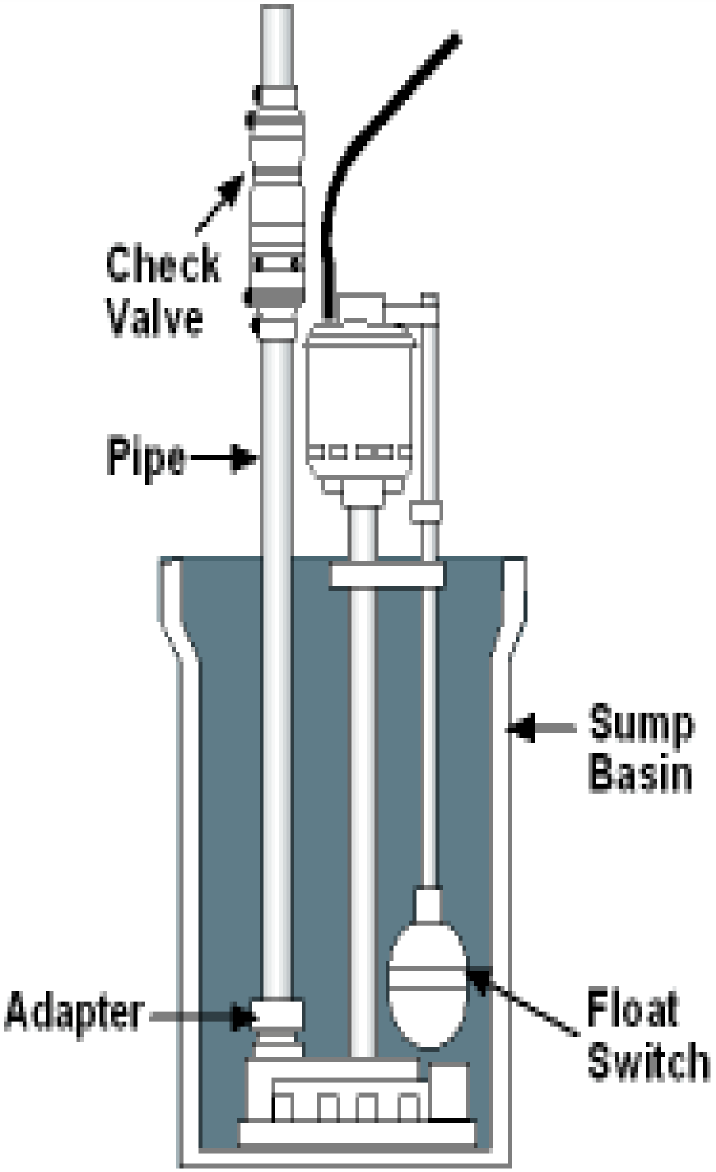
Pumps Installation

Connecting the pipes to the pump

If the pipe system is tested with the pump installed, do not exceed the maximum permitted casing pressure of the pump and/or shaft sealing.

In the case of pumps with stuffing boxes, replace packing after pressure test

Any sealing, flushing or cooling pipe connections must be installed

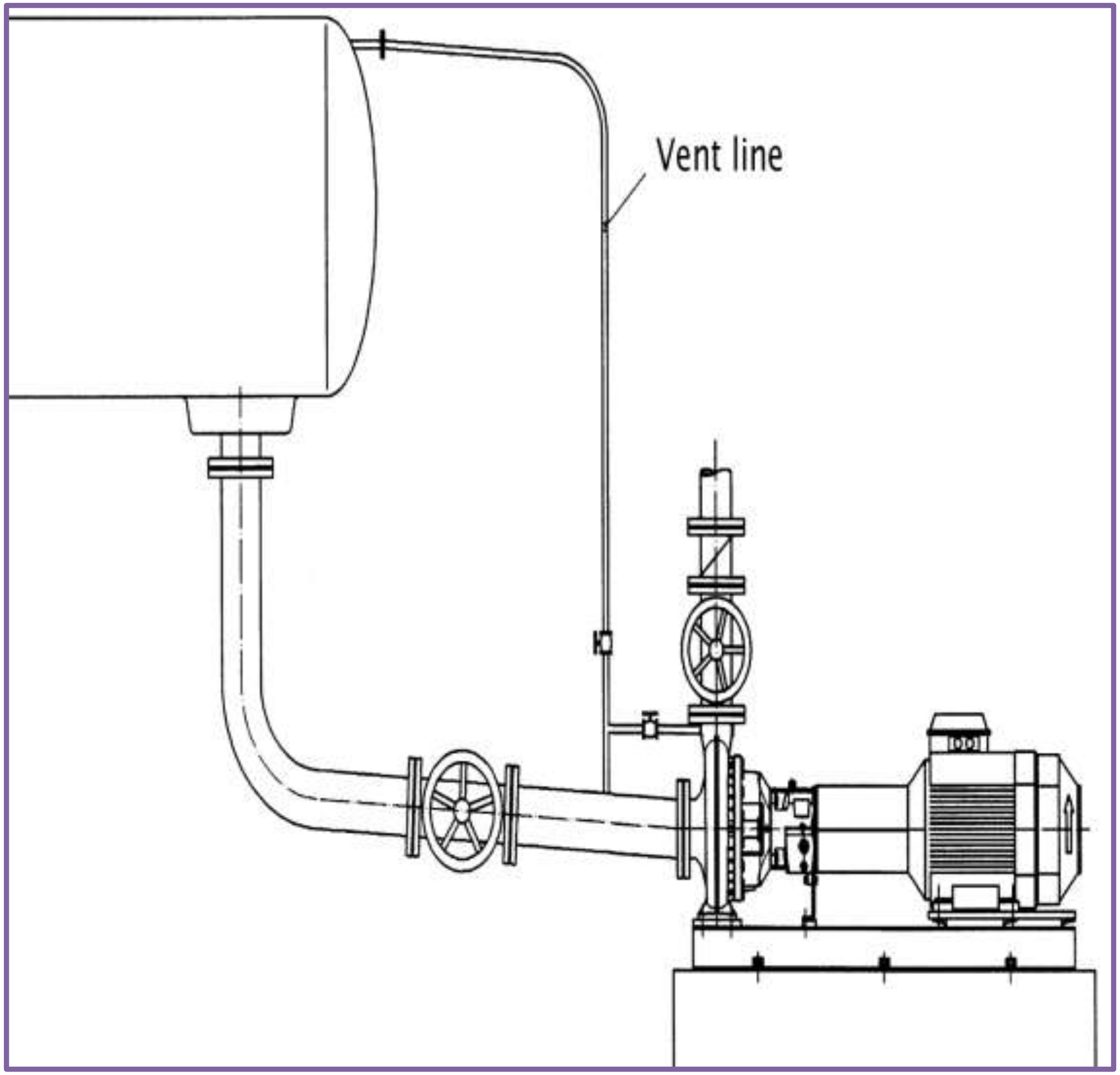


Pumps Installation

Connecting the pipes to the pump

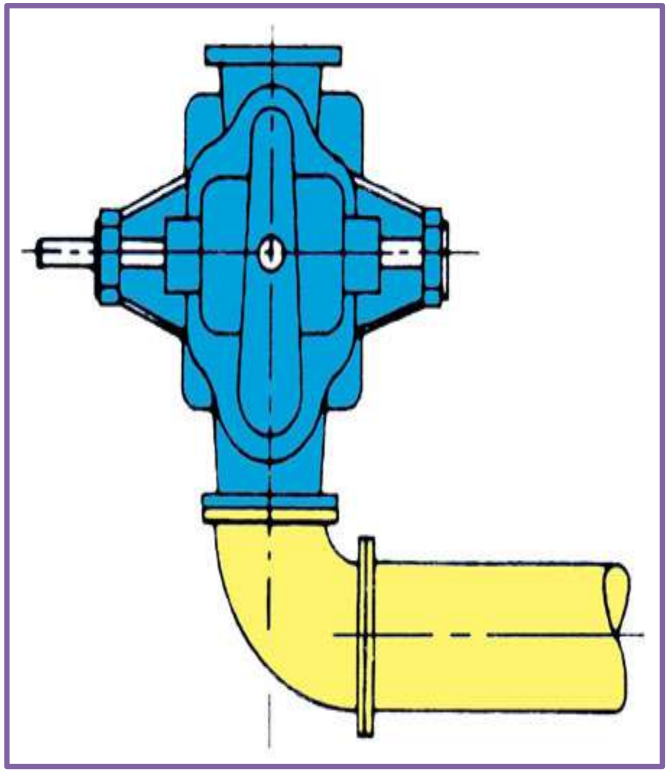
This vent will prevent air binding problem during operation and facilitate proper filling and vent of the pump during startup.

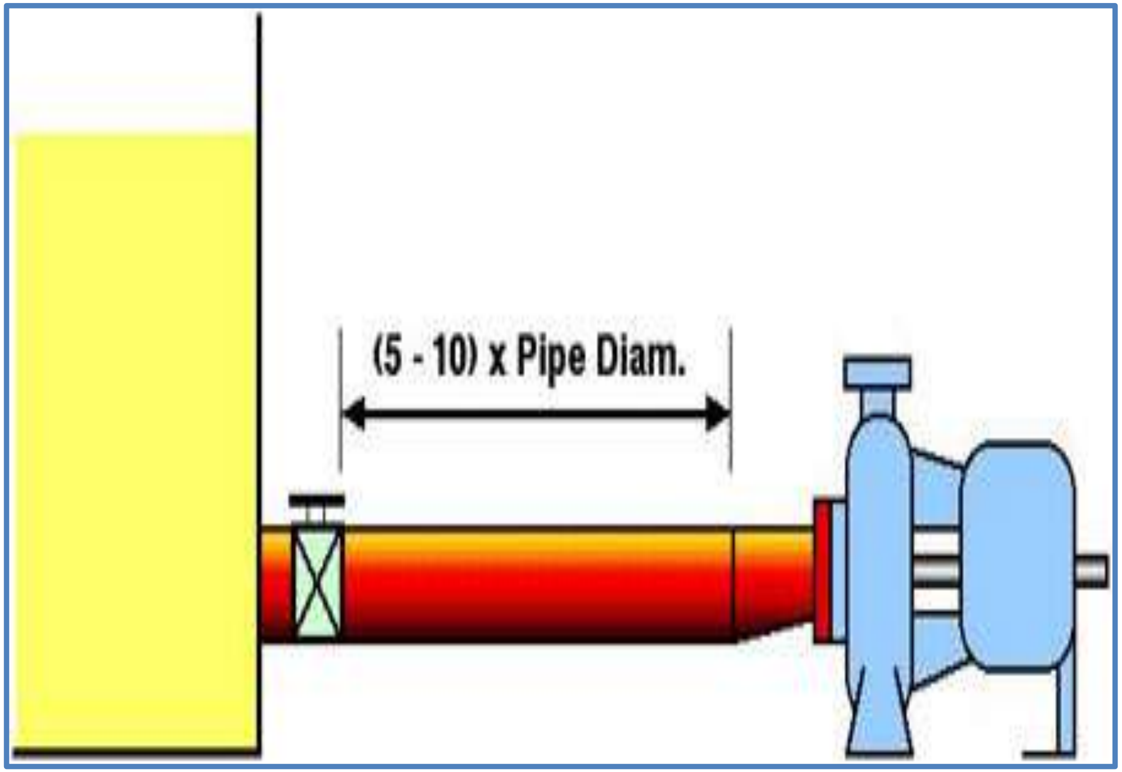
An additional flushed piping -– discharge branch-vent line – makes it easier to de-aerate the pump before start-up.



Pumps Installation

Connecting the pipes to the pump





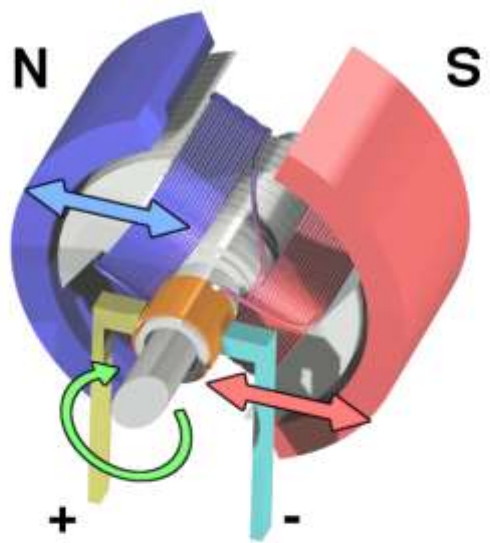
Pumps Installation

Electrical connection

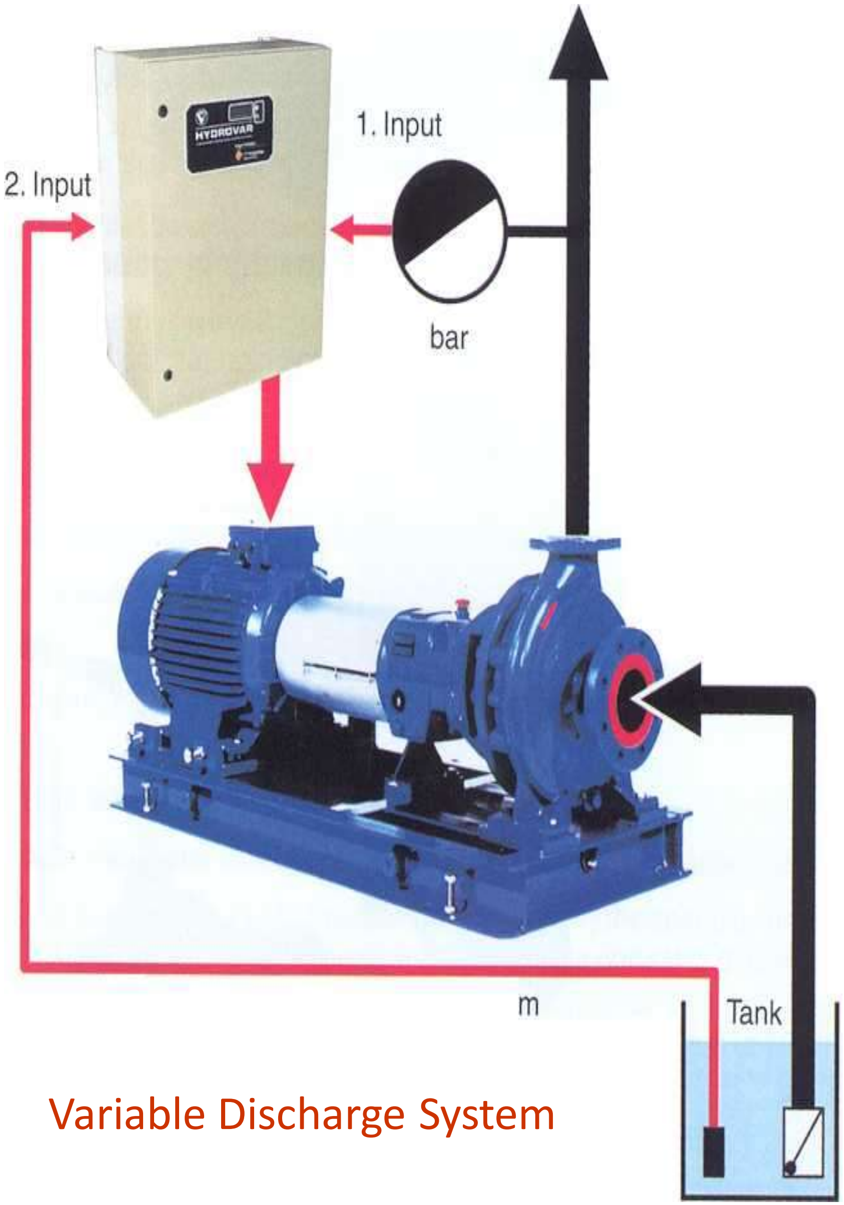
Electrical connection work may only be carried out by an authorized professional

Before starting work, check that the information on the motor rating.
The power supply cable accordance with the wiring diagram.
A protective motor switch is to be provided.

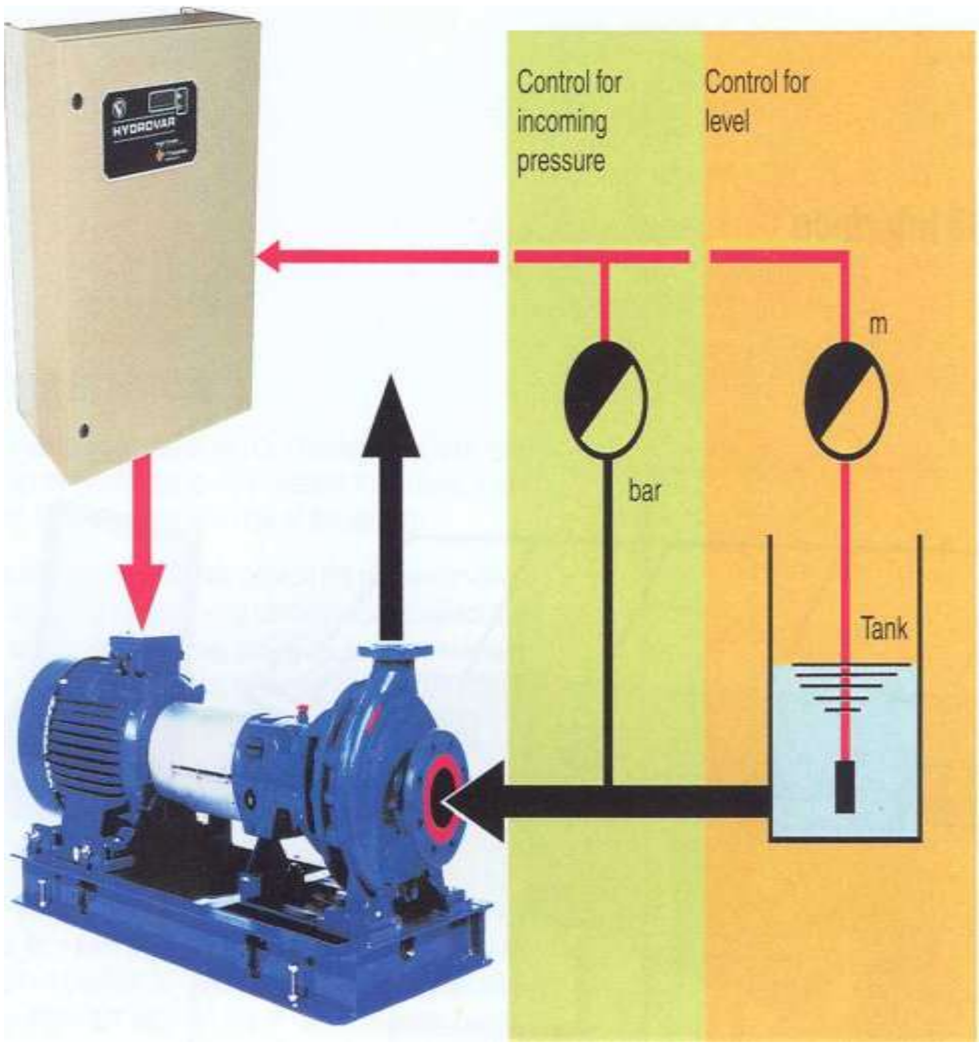
The direction of rotation should only be checked when the pump is full. Dry running will cause damage to the pump.



Tank Transfer\Unloading



Variable Discharge System



Fixed Discharge System

Pumps Installation

Starting up

The plant may only be started up by people who are familiar with the local safety regulations and with these Operating Instructions

Starting up for the first time

If pump is oil lubricated, first open oil drain and drain off any liquid that may have collected.

Fill until the fluid level is at the mid of the oil level sight glass.

For pumps with grease lubrication, no further lubrication is needed before initial start-up.

Pumps Installation

Starting up

·Pump and suction pipe must be filled completely with liquid when starting up.
·Turn pump unit once again by hand and check that it moves smoothly and evenly.
·Check that coupling guard is installed and that all safety devices are operational.
·Switch on any sealing, flushing or cooling devices that are provided.
·Open isolation valve in suction /intake pipe.
·Set discharge side isolation valve to approx. 25% of rated flow quantity. With pumps with a discharge
branch rated width less than 200, the isolation valve can remain closed when starting up
·Check direction of rotation by switching on and off briefly. It must be the same as the directional arrow on the bearing frame.
·Start drive device.
·As soon as it reaches normal operating speed, open discharge valve immediately and adjust the required operating point.

Pumps Installation

Starting up /Packing

During the first few hours of operation, slowly reduce the leakage rate as the pump is running by gradually tightening the packing gland. The guideline value is around 30 - 100 drops/minute

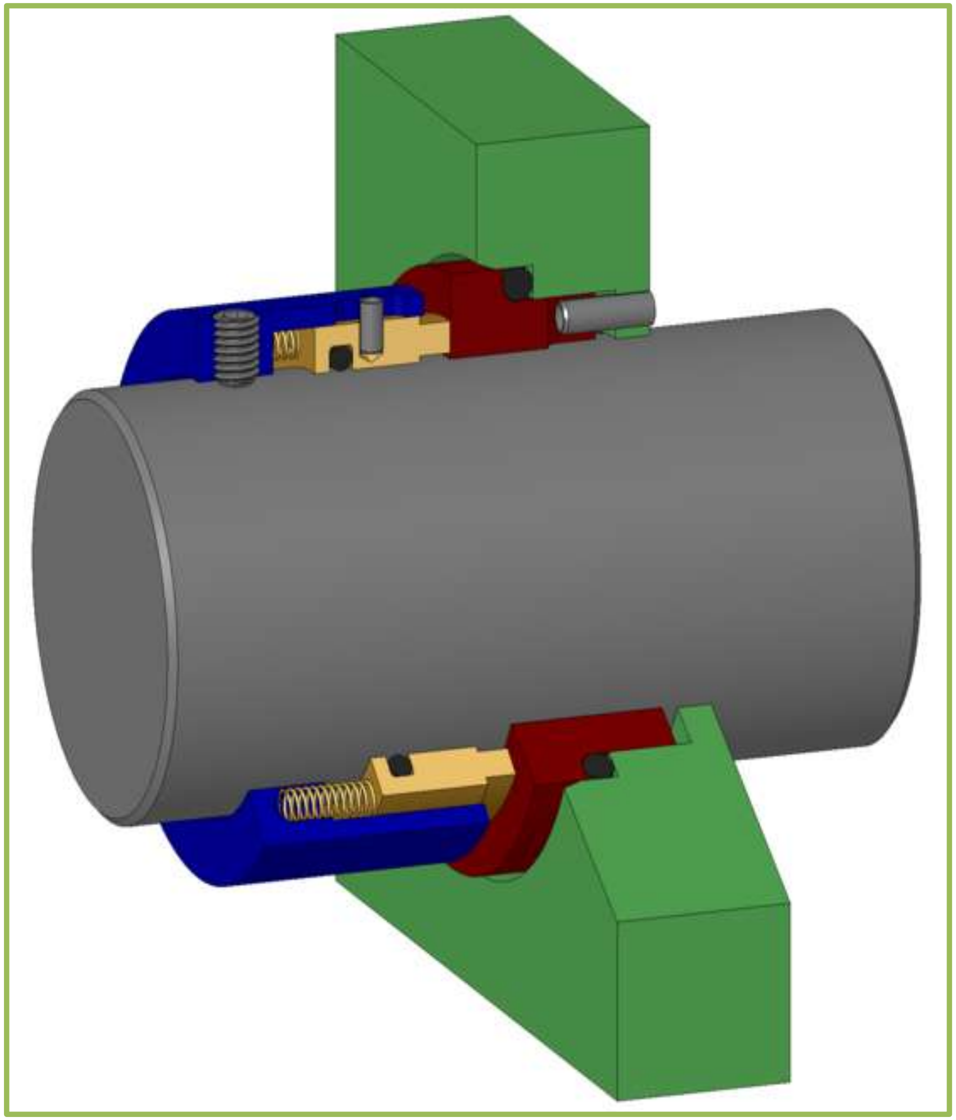
Packing that run dry will harden and then destroy the shaft sleeve and/or the shaft.

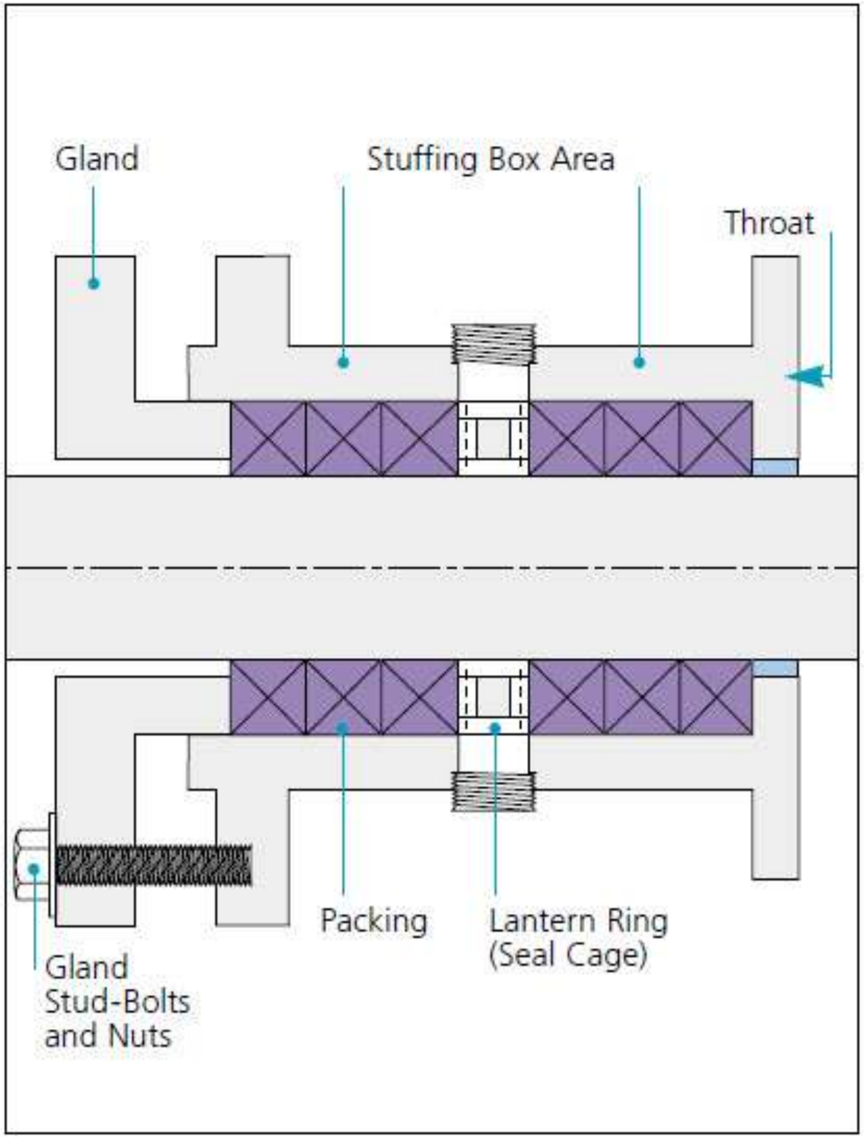
If pump does not reach attended head or if atypical sounds or vibrations do occur:
Switch off pump and seek for causes

Pumps Installation

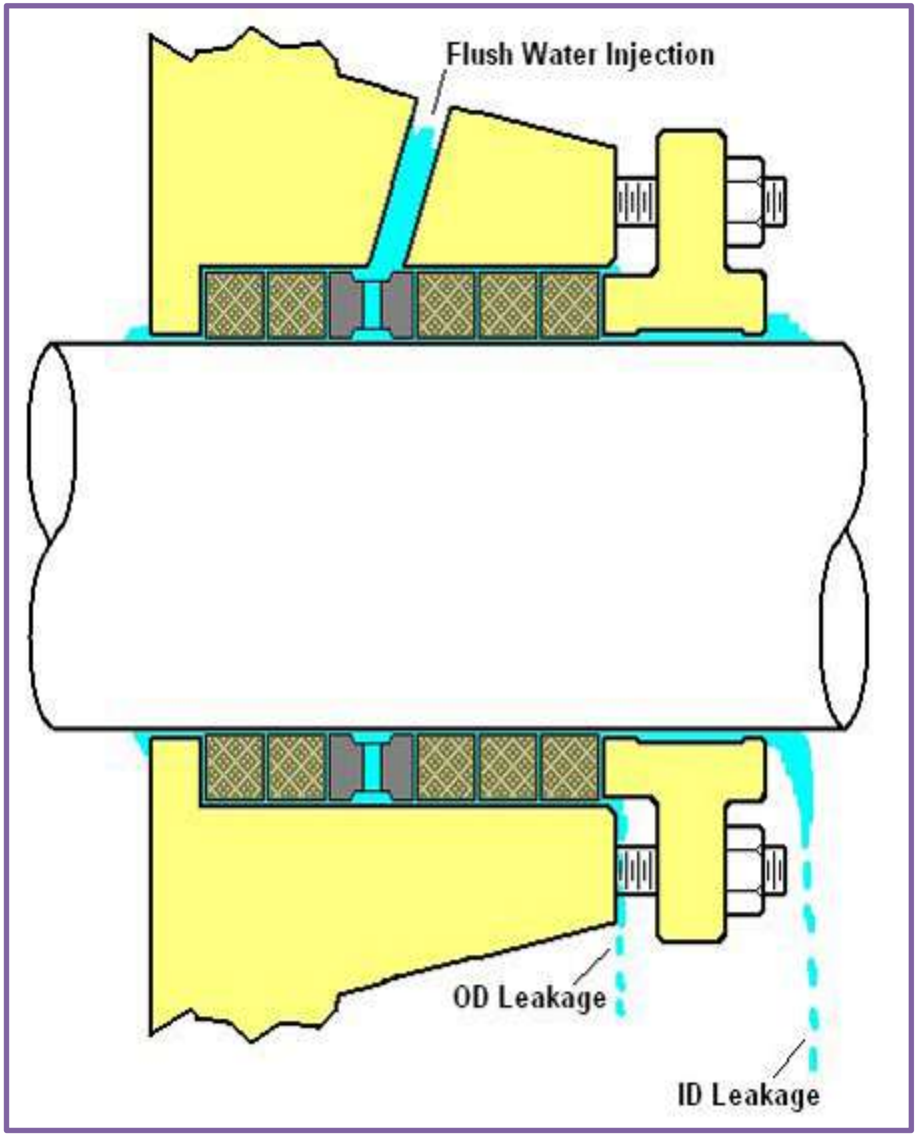
Starting up /Packing

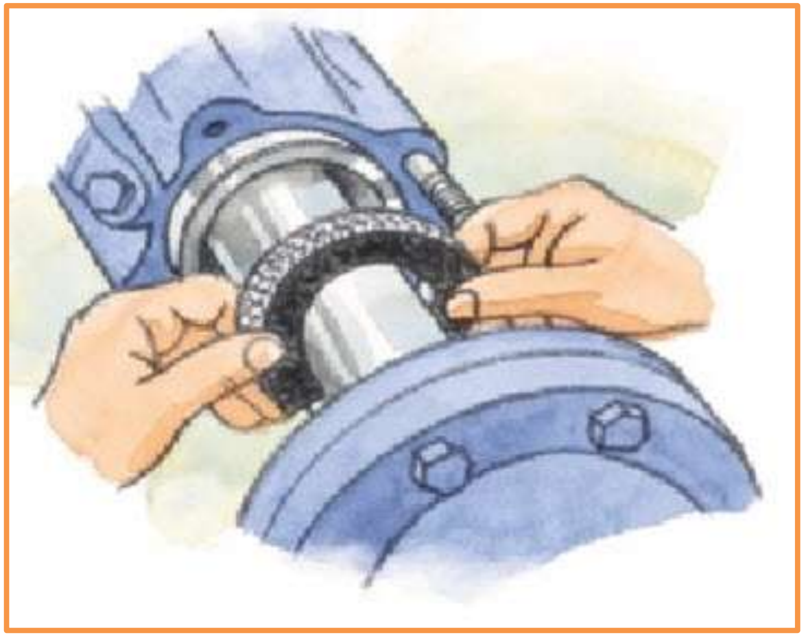
Packing & Mechanical Seal



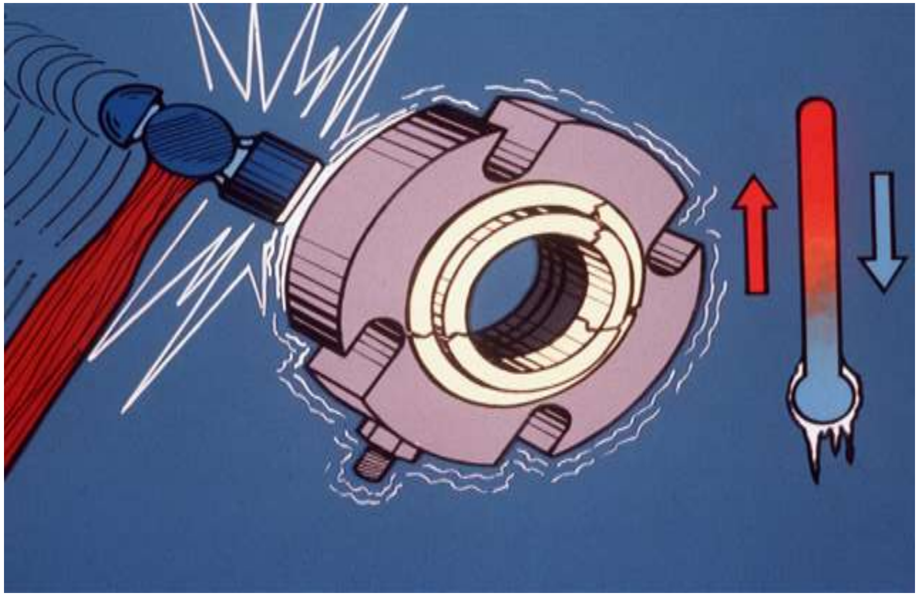


The Basic Sealing Problem:

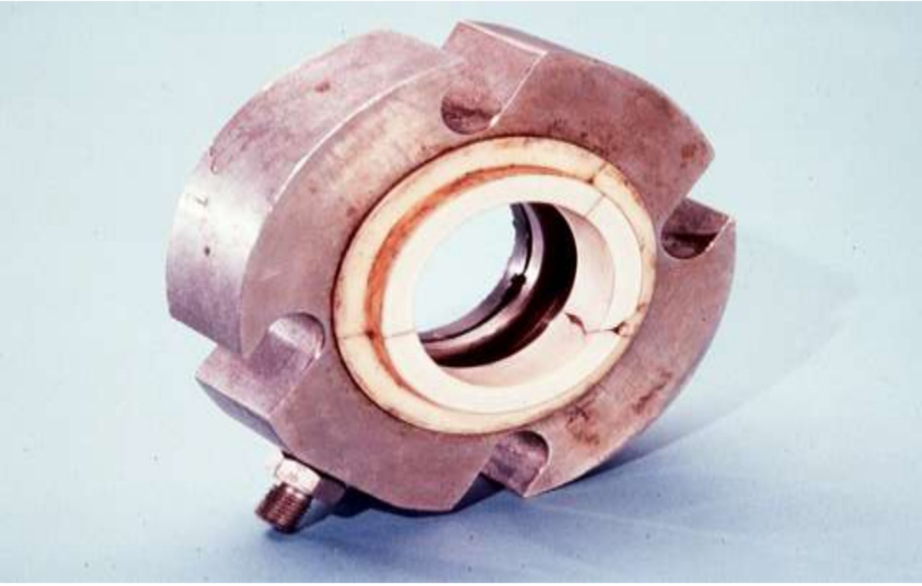




MECHANICAL SEAL COMMON FAILURES



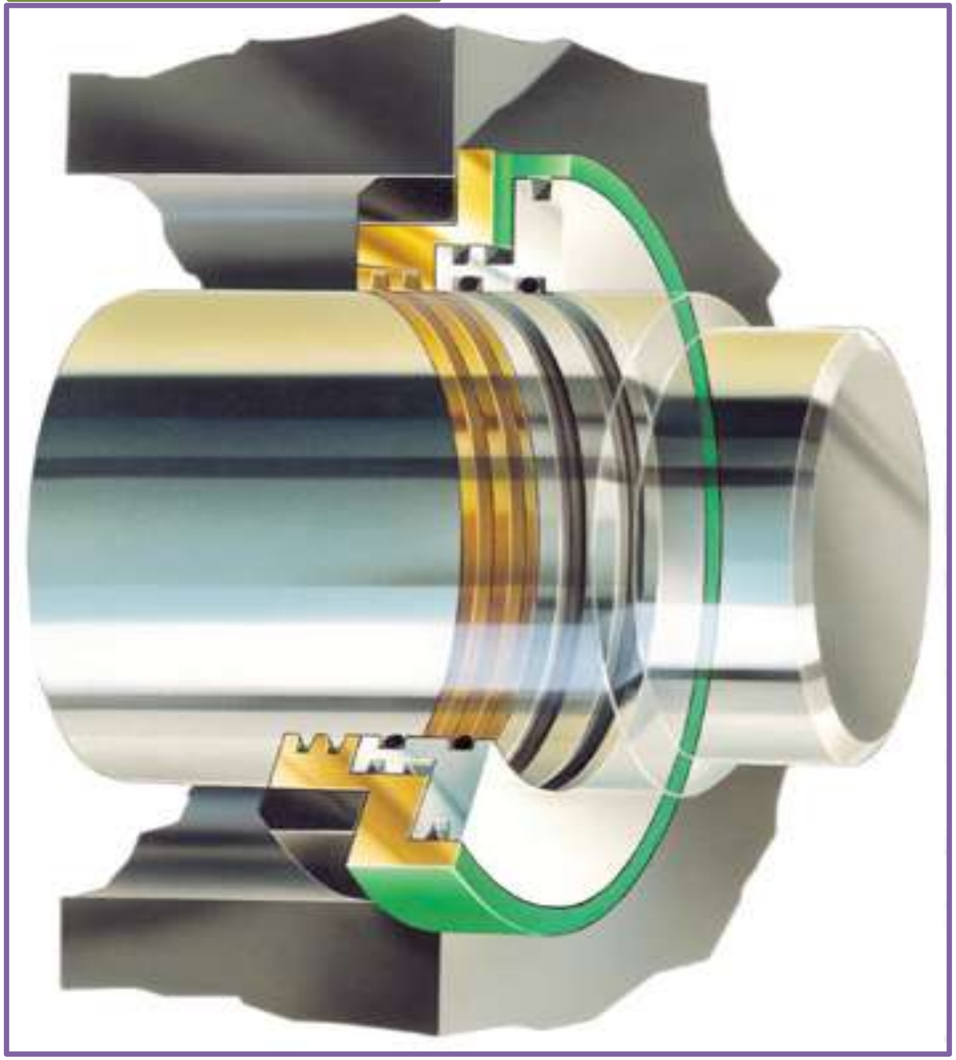
- RUN-DRY
- DEAD HEADING
- TEMPERATURE
- ALIGNMENT
- VIBRATION
- PARTICULATE / ABRASIVES
- CHEMICAL INCOMPATIBILITY




Stock number !?!!

Pumps Installation

Labyrinth seals

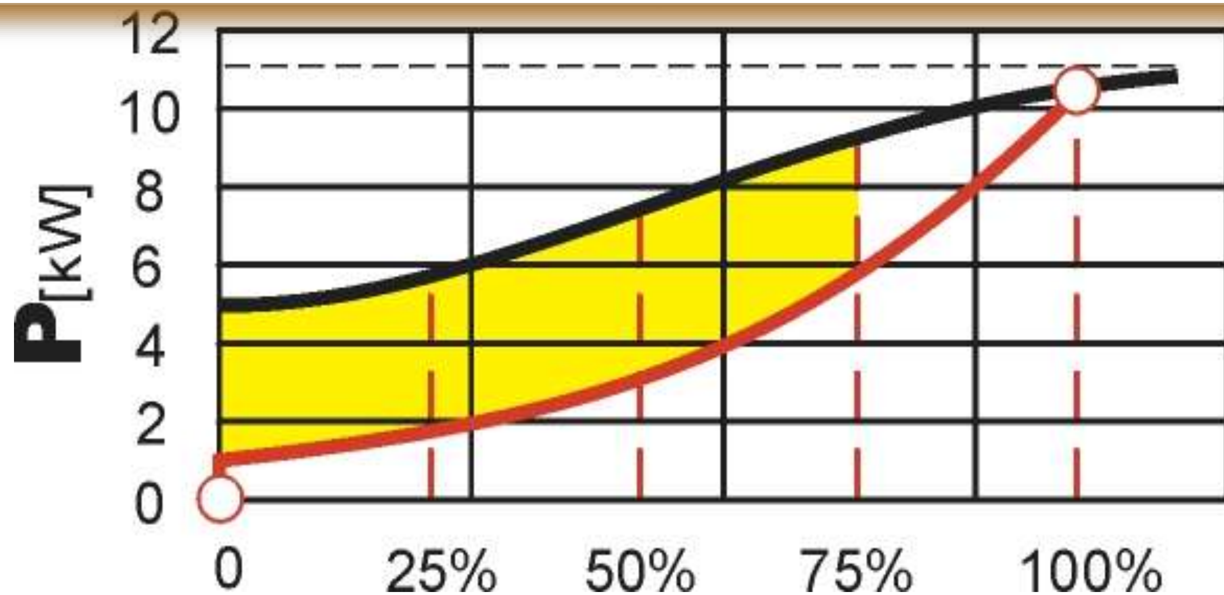


Pumps Installation

Operation and Monitoring

suction pressure:
Suction pressure is the actual pressure, positive or negative, at the pump suction connection as measured on
a gauge. Pumps do not "suck" fluid as the pump suction

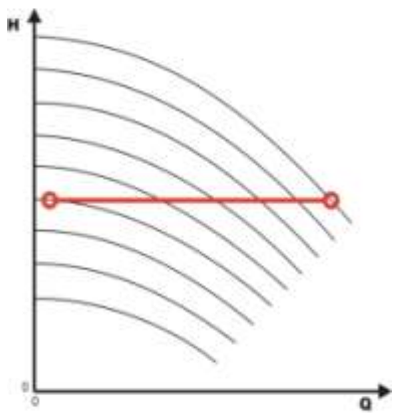
Reduces Operating Cost



capacity in %	power consumption as per curve: pump at constant speed	pump at variable speed	saving in kW	saving per 1/3 year (2920 hours)
25 %	5,8 kW	1,8 kW	4,0 kW	11.680 kWh
50 %	7,6 kW	3,2 kW	4,4 kW	12.848 kWh
75%	9,2 kW	5,7 kW	3,5 kW	10.220 kWh
				34.748 kWh

Energy saving within 1 year (8.760 hours)

Process Application

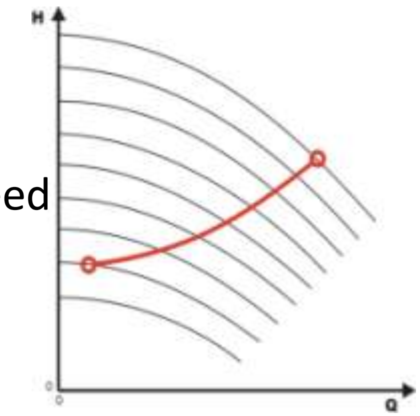


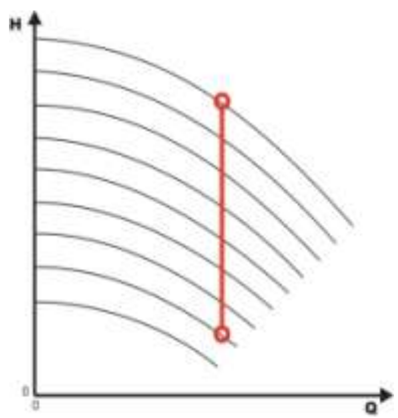
Constant Pressure

- Spray Nozzles
- Decoking
- Boiler Feed
- Fire Suppression

System Curve

- Pilot Plant
- Heat Exchanger Feed



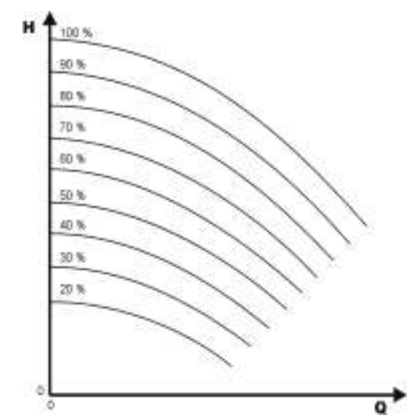


Constant Flow

- Distillation Tower
- Reactor Feed
- Filter Supply
- Pipe line

Actuator Mode

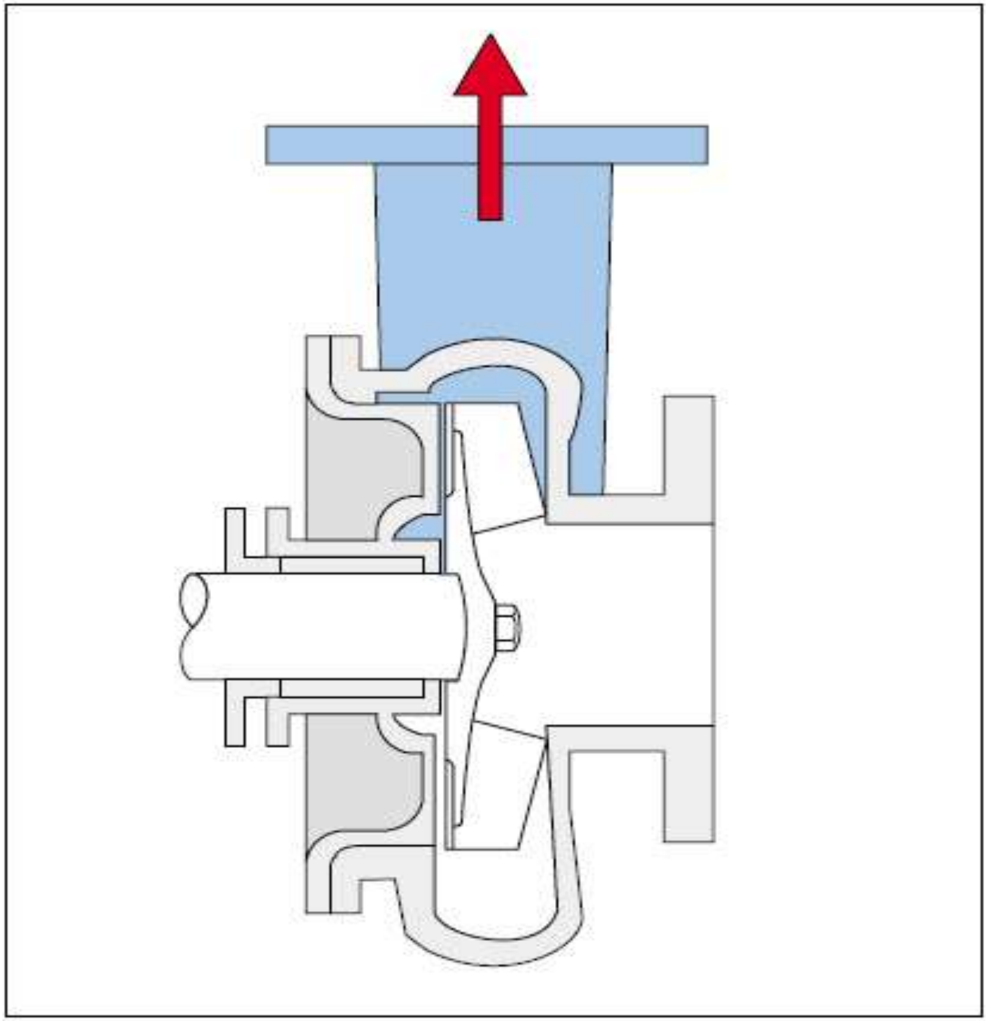
- Process Metering
- Tank\Sump Level Control
- Tank Unloading



Pumps Installation

pump discharge?

The pump discharge is the outlet or flange area where the fluid leaves the olute (casing). The discharge flange is usually oriented up (or vertically), but can also be mounted sideways (or horizontally) if the application
requires it.

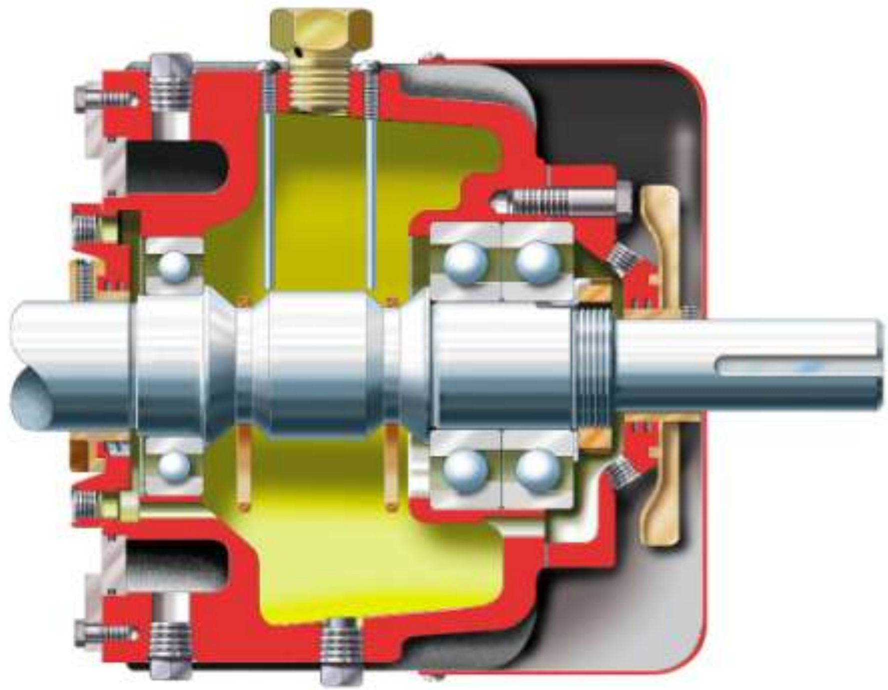


Troubleshooting a System Problem

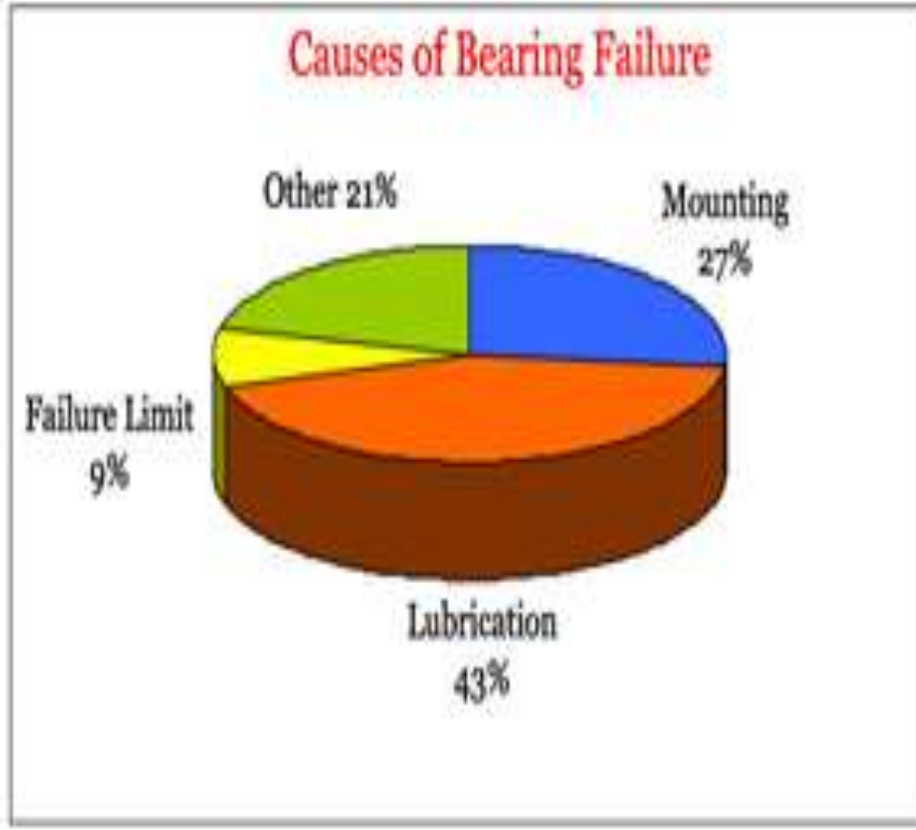
Some pumping system problems are sufficiently expensive to justify a system assessment. Examples of these problems include inefficient operation, cavitations, poor flow control, and high maintenance

Inefficient Operation.

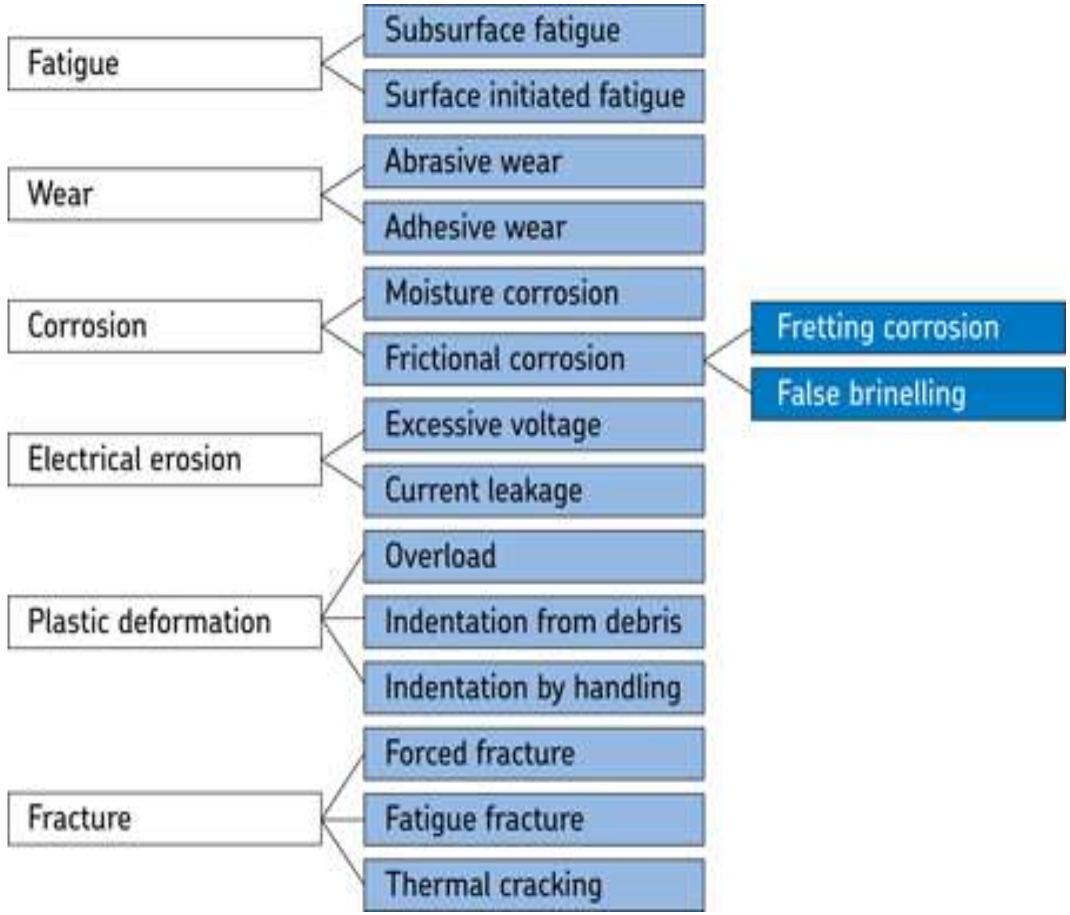
Inefficient system operation can be caused by a number of problems as:
improper pump selection.
poor system design.
excessive wear-ring clearances.
wasteful flow control practices.
Indications of inefficient system operation include:
high energy costs.
excessive noise in the pipes and across valves.
high maintenance requirements



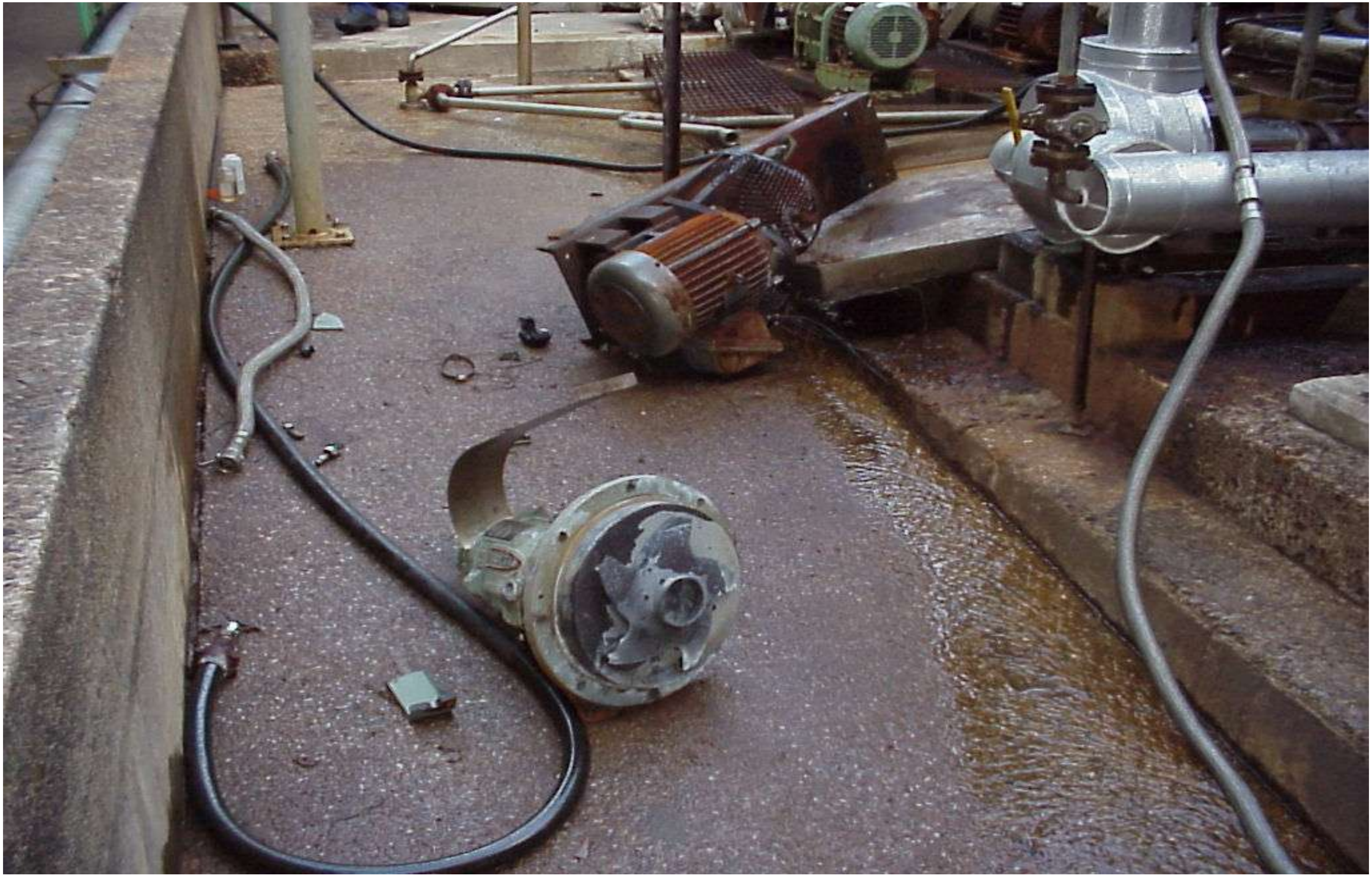
Bearing Failures and Their Causes



Bearing Failures and Their Causes



Troubleshooting a System Problem

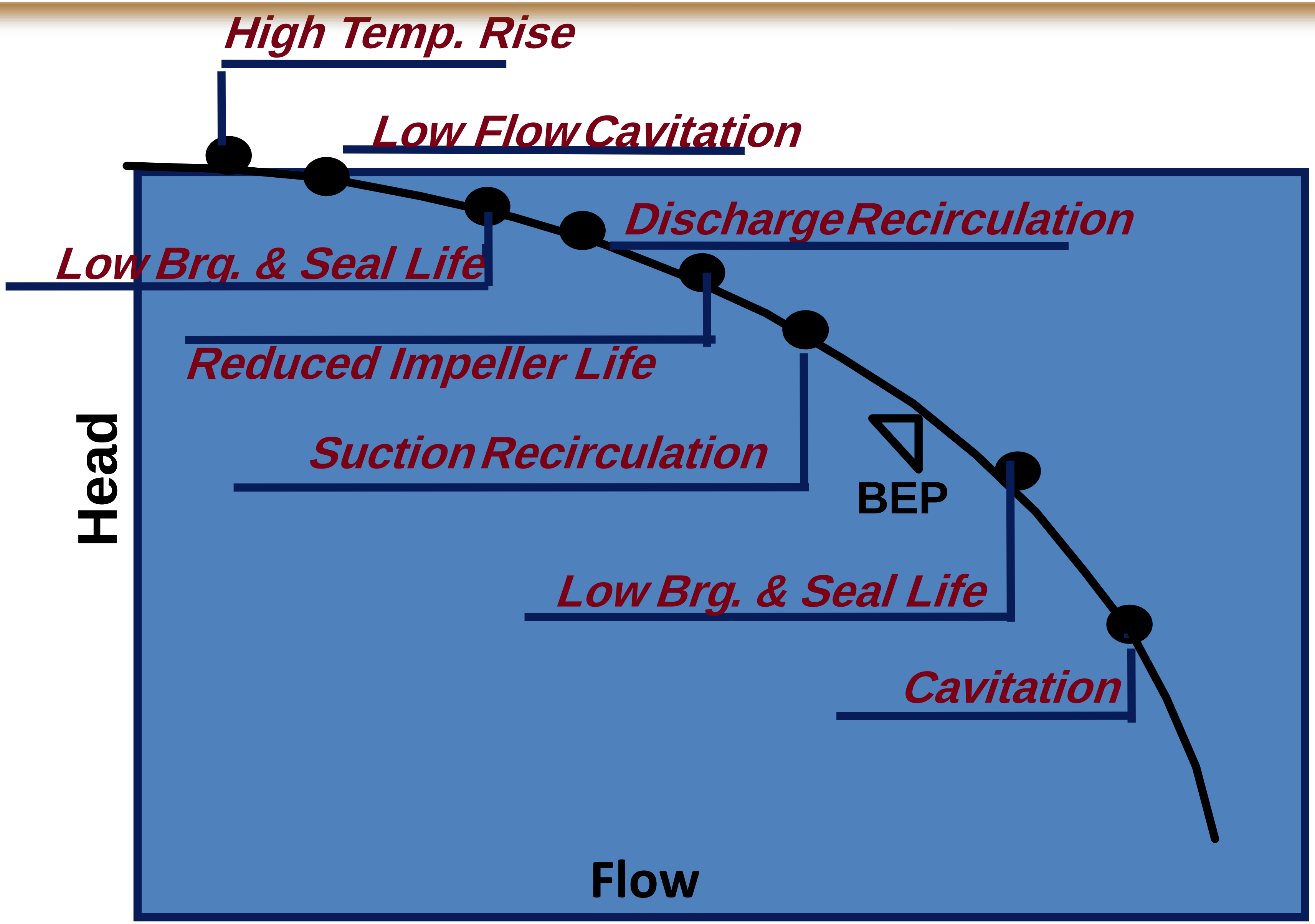


PUMP FAILURE ANALYSIS

6 month period in a typical process plant

CAUSE	NUMBER	% of TOTAL
Bearing	25	10.50
Bearing housing	1	0.42
Case wearing ring	2	0.84
Impeller	8	3.36
Rotating face	1	0.42
Screws /set screws	1	0.42
Seals - mechanical	179	75.21
Shaft	12	5.04
Sleeve	9	3.78
TOTAL	238	100.00%

Results of Operating Off BEP



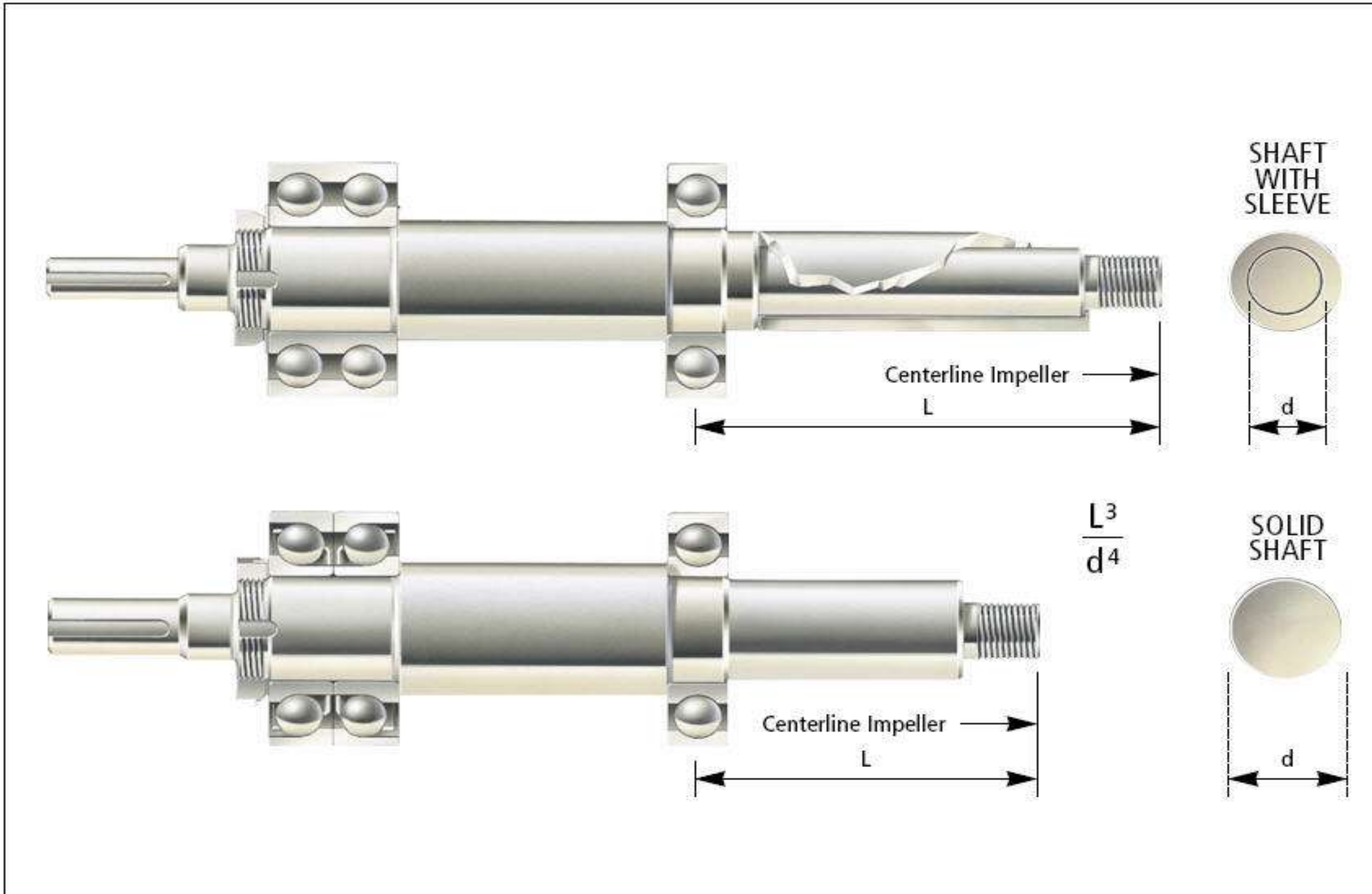
Shaft Deflection

Shaft deflection is the result of unbalanced radial loads.
The amount of shaft deflection or bending depends on the amount of unbalance radial forces and a pump's slenderness ratio.
The higher the forces or the larger the slenderness ratio, the more shaft deflection will occur. Shaft deflection results in sealing device, bearing, and other pump mechanical failures.

Shaft Slenderness Ratio

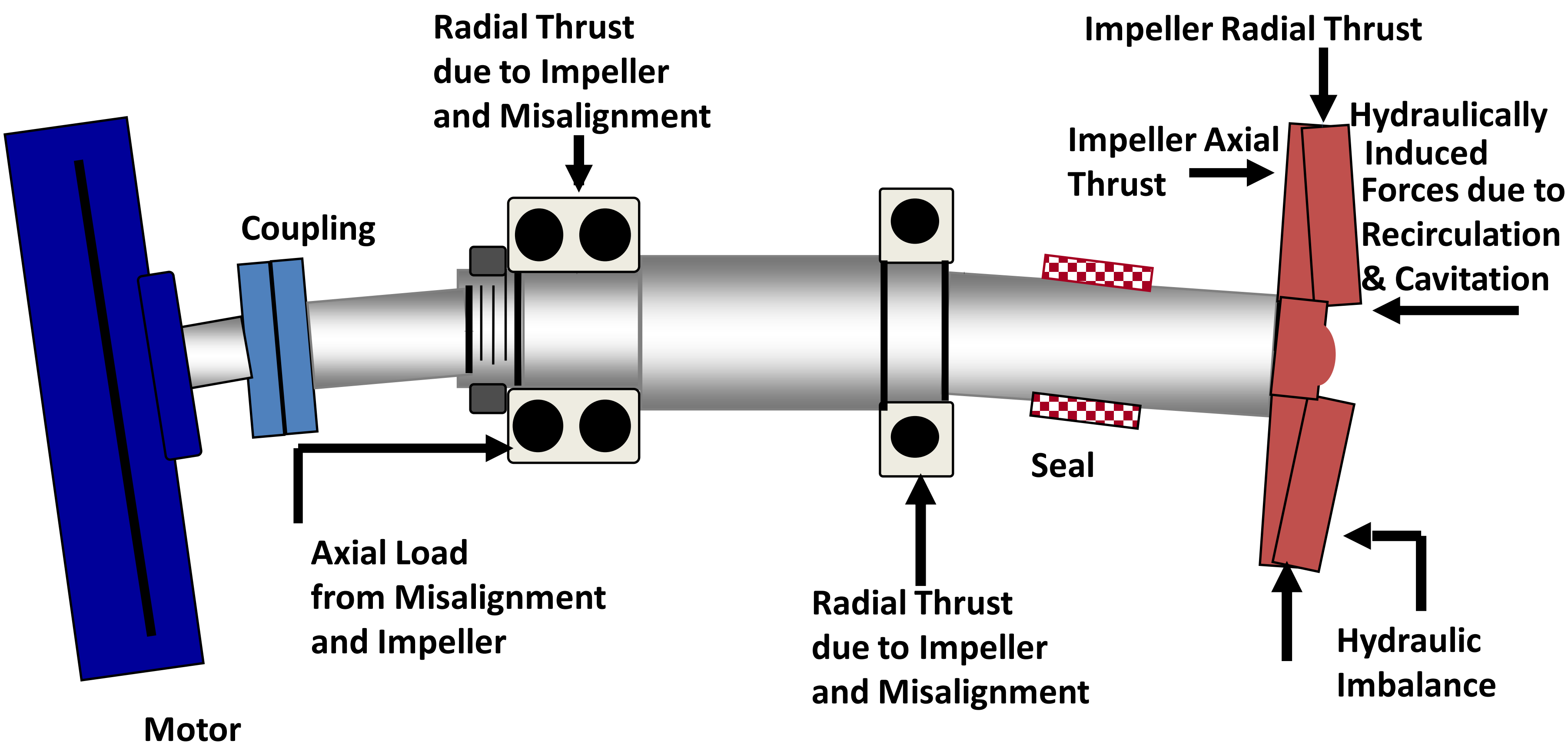
The Shaft Slenderness Ratio is a ratio of shaft length to shaft diameter.

Shaft Deflection



Shaft Deflection

SIMULTANEOUS DYNAMIC LOADS ON PUMP SHAFT



TEMPERATURE RISE

Overheating of the liquid in the casing can cause:

- *Rubbing or seizure from thermal expansion*
- *Vaporization of the liquid and excessive vibration*
- *Accelerated corrosive attack by certain chemicals*

Temperature rise per minute at shutoff is:

$$\Delta T\ ^{o}F\ (^{o}C)\ /\ min. = \frac{HP\ (KW)_{so} \times K}{Gal\ (m^3) \times S.G. \times S.H.}$$

HP_{so} = HP (KW) @ shutoff from curve

Gal. (m^3) = Liquid in casing

S.G. = Specific gravity of fluid

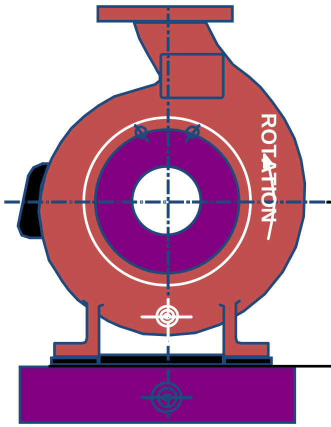
S.H. = Specific heat of fluid

Ex.: Pump w/ 100HP (75KW) @s.o. , 6.8 gal casing (.03m^3)
w/ 60°F (16°C) water would reach boiling in 2 min.

A recirculation line is a possible solution to the low flow or shut off operation problems....

CASING GROWTH DUE TO HIGH TEMPERATURE

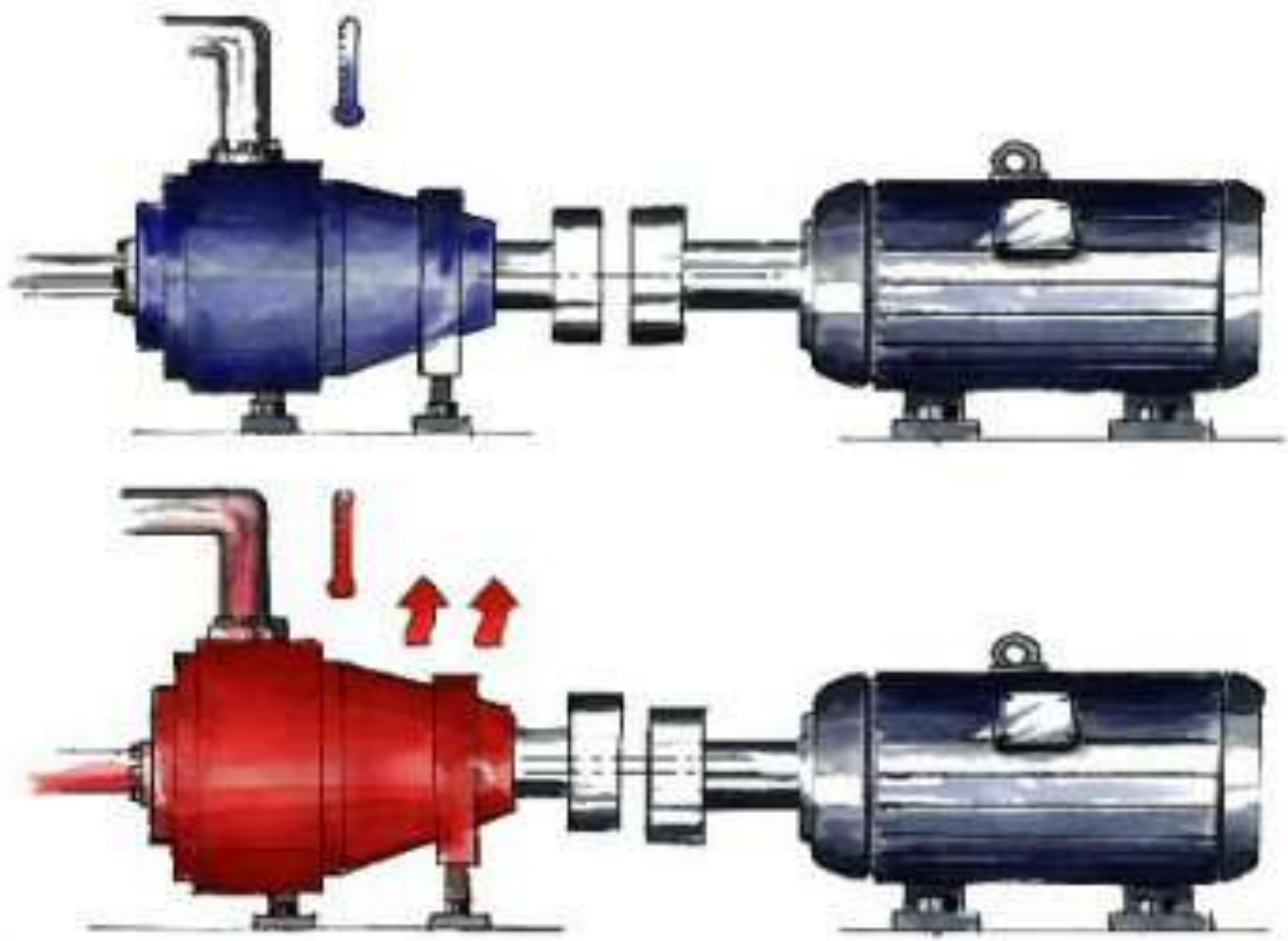
High temperature requires more clearance



COEFFICIENT OF THERMAL EXPANSION FOR 316 S/S
IS $9.7X10^{-6}$ IN/IN/°F OR 17.5 $X10^{-6}$ MM/MM/°C
CALCULATION IS △T x 9.7 $X10^{-6}$ X LENGTH IN INCHES
△T x $17.5X10^{-6}$ X LENGTH IN MILLIMETERS

△T° F	△T° C	EXPANSION INCHES	EXPANSION MILLIMETERS
100 F	55 C	0.0097 IN	0.245 MM
200 F	110 C	0.0190 IN	0.490 MM
300 F	165 C	0.0291 IN	0.735 MM
400 F	220 C	0.0388 IN	0.900 MM
500 F	275 C	0.0485 IN	1.230 MM
600 F	330 C	0.0582 IN	1.470 MM

PUMP GROWTH DUE TO HIGH TEMPERATURE



IMPELLER BALANCE

- ← **MECHANICAL**
  - Weight offset from center of impeller
  - Balance by metal removal from vane
- ← **HYDRAULIC**
  - Vane in eye offset from impeller C/L
  - Variation in vane thickness
  - Results in uneven flow paths thru impeller
  - Investment cast impeller eliminates problem
  - Careful machining setup can help


INSPECTION
PASSED

Centrifugal Pump Troubleshooting Guide

Table 4-6
Troubleshooting Guide -- Centrifugal Process Pumps

Symptoms:

- A — No Liquid Delivery
- B — Insufficient Capacity
- C — Intermittent Operation
- D — Insufficient Disch. Pressure
- E — Short Bearing Life
- F — Short Mech. Seal Life
- G — Vibration & Noise
- H — Power Demand Excessive

	Possible Causes	#	A	B	C	D	E	F	G	H	#	Possible Remedies
SUCTION PROBLEMS	Pump Is Cavitating (Symptom For Liquid Vaporizing In Suction System) -Horizontal Pumps	1	2	1	1			9	1		1	* Check NPSHa/ NPSHr Margin * If Pump Is Above Liquid Level, Raise Liquid Level Closer To Pump * If Liquid Is Above Pump, Increase Liquid Level Elevation
SUCTION PROBLEMS	Insufficient Immersion Of Suction Pipe Or Bell (VertTurbinePump)	2	1	1	1				1		2	* Lower Suction Pipe Or Raise Sump Level * Increase System Resistance
SUCTION PROBLEMS	Pump Not Primed	3	1		2						3	* Fill Pump And Suction Piping Complete With Liquid * Eliminate High Points In Suction * Remove All Non-Condensibles (Air From Pump, Piping and Valves) * Eliminate High Points In Suction Piping * Check For Faulty Foot Valve Or Check Valve
HYDRAULIC SYSTEM	Non-Condensibles In Liquid	4		2	3	1					4	* Check For Gas/Air Ingress Through Suction System/Piping * Install Gas Separation Chamber
HYDRAULIC SYSTEM	Supply Tank Empty	5	3								5	* Refill Supply Tank
HYDRAULIC SYSTEM	Obstructions In Lines Or Pump Housing	6		9		7			7		6	* Inspect And Clear
	Possible Causes	#	A	B	C	D	E	F	G	H	#	Possible Remedies

Table 4-6 (cont.)

	Possible Causes	#	A	B	C	D	E	F	G	H	#	Possible Remedies
HYDRAULIC SYSTEM	Strainer Partially Clogged	7		3							7	* Inspect And Clean
HYDRAULIC SYSTEM	Pump Impeller Clogged	8	8	8						5	8	* Check For Damage And Clean
HYDRAULIC SYSTEM	Suction And/Or Discharge Valve(s) Closed	9	9								9	* Shut Down And Open Valves
HYDRAULIC SYSTEM	Viscosity Too High	10		7		5				4	10	* Heat Up Liquid To Reduce Viscosity * Increase Size Of Discharge Piping To Reduce Pressure Loss * Use Larger Driver Or Change Type Of Pump * Slow Pump Down
HYDRAULIC SYSTEM	Specific Gravity Too High	11								2	11	* Check Design Specific Gravity
HYDRAULIC SYSTEM	Total System Head Lower Than Design Head Of Pump	12				4		11		3	12	* Increase System Resistance To Obtain Design Flow * Check Design Parameters Such As Impeller Size, Etc.
HYDRAULIC SYSTEM	Total System Head Higher Than Design Head Of Pump	13	6	5	4			10	2		13	* Decrease System Resistance To Obtain Design Flow * Check Design Parameters Such As Impeller Size, Etc.
MECHANICAL SYSTEM	Unsuitable Pumps In Parallel Operation	14	7	6		6					14	* Check Design Parameters
MECHANICAL SYSTEM	Improper Mechanical Seal	15						1			15	* Check Mechanical Seal Selection Strategy
	Possible Causes	#	A	B	C	D	E	F	G	H	#	Possible Remedies

Centrifugal Pump Troubleshooting Guide

Table 4-6 (cont.)

Symptoms

- **A** No Liquid Delivery
- **B** Insufficient Capacity
- **C** Intermittent Operation
- **D** Insufficient Disch. Pressure
- **E** Short Bearing Life
- **F** Short Mech. Seal Life
- **G** Vibration & Noise
- **H** Power Demand Excessive

MECHANICAL SYSTEM

Possible Causes	#	A	B	C	D	E	F	G	H	#	Possible Remedies
Speed Too High	16								1	16	* Check Motor Voltage - Slow Down Driver
Speed Too Low	17	4	4		2					17	* Consult Driver Troubleshooting Guide
Wrong Direction Of Rotation	18	5			3				6	18	* Check Rotation With Arrow On Casing - Reverse Polarity On Motor
Impeller Installed Backward (Double Suction Imp.)	19		10						12	19	* Inspect
Misalignment	20					1	2	4	7	20	* Check Angular And Parallel Alignment Between Pump And Driver
Casing Distorted From Excessive Pipe Strain	21					2	3	5		21	* Check For Misalignment * Check Pump For Wear Between Casing And Rotating Elements * Analyze Piping Loads
Inadequate Grouting Of Base	22							6		22	* Check Grouting And Regrout If Required
Bent Shaft	23					3	4	7	8	23	* Check Deflection (Should Not Exceed 0.002"). Replace Shaft And Bearings If Necessary
Internal Wear	24				8				9	24	* Check Impeller Clearances

Possible Causes # A B C D E F G H # Possible Remedies

Table 4-6 (cont.)

MECHANICAL SYSTEM

Possible Causes	#	A	B	C	D	E	F	G	H	#	Possible Remedies
Mechanical Defects Worn, Rusted, Defective Bearings	25						5	8	10	25	* Inspect Parts For Defects - Repair Or Replace. Use Bearing Failure Analysis Guide * Check Lubrication Procedures
Unbalance - Driver	26					5	7	9		26	* Run Driver Disconnected From Pump Unit - Perform Vibration Analysis
Unbalance - Pump	27					4	6	3		27	* Investigate Natural Frequency
Motor Troubles	28					6	8	10	11	28	* Consult Motor Troubleshooting Guide

Possible Causes # A B C D E F G H # Possible Remedies

Any Questions ?