KaNJiS ENGINEERING
ENGINEERING SOLUTIONS

Marine & Offshore Industry

Technical Presentation

PUMPS Used in Marine & Offshore Industry

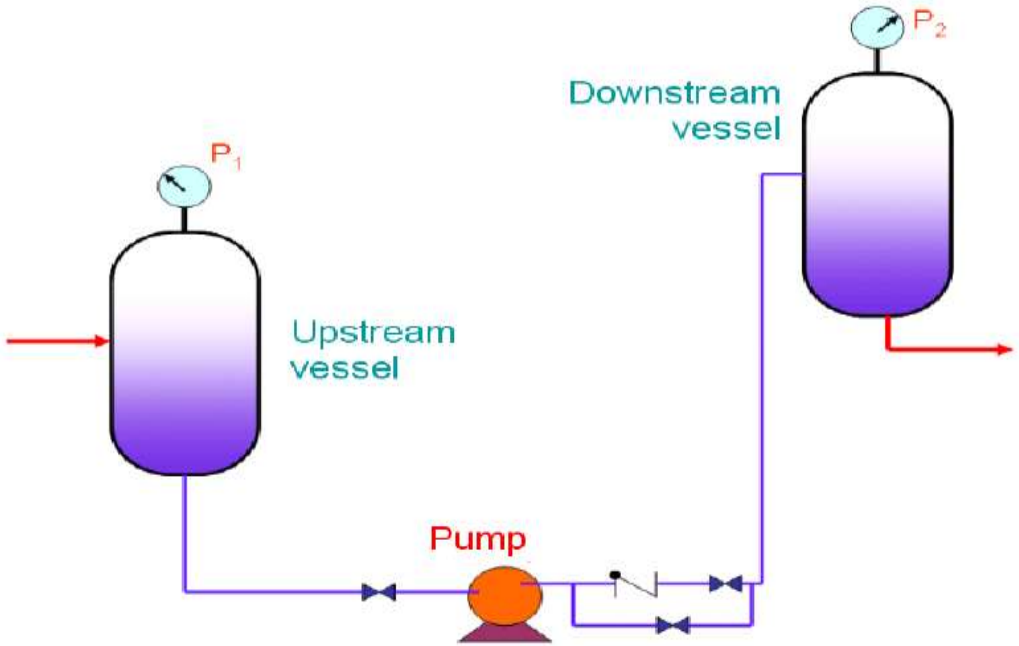
Topics

- What are pumps?
- Various types of pumps
- Operating principles of pumps
- Advantages and disadvantages of pump types
- Pump auxiliaries and accessories
- Operating parameters & normal operation
- Abnormal conditions & troubleshooting

What are pumps?

What are pumps?

- Pumps are mechanical devices used to convey liquids from one point to another point. In particular, they can be used to take a liquid at pressure P_1 and raise it to pressure P_2 (where $P_2 > P_1$).



- **What are pumps?**

  - Pumps are used for conveying liquids of all types: **water, hydrocarbons, more or less viscous liquids, chemicals or toxic substances, dispose sludge**, etc.

Various Types of Pumps

Various types of pumps

- **What determines the type of pump to choose?**

a) Product property

- Viscosity,
- Temperature,
- Density,
- Sensitivity
- etc.

b) Type of application

- Transfer,
- Mixing,
- Dosing,
- Flow rate,
- Suction pressure
- Discharge pressure
- etc.

c) Composition of effluent

Various types of pumps

The two main categories of pump, as defined by their basic principle of operation are

1. Centrifugal pumps

2. Positive displacement pumps

Various types of pumps

1. Centrifugal pumps

- Single-stage centrifugal pumps
- Multi-stage centrifugal pumps

Various types of pumps

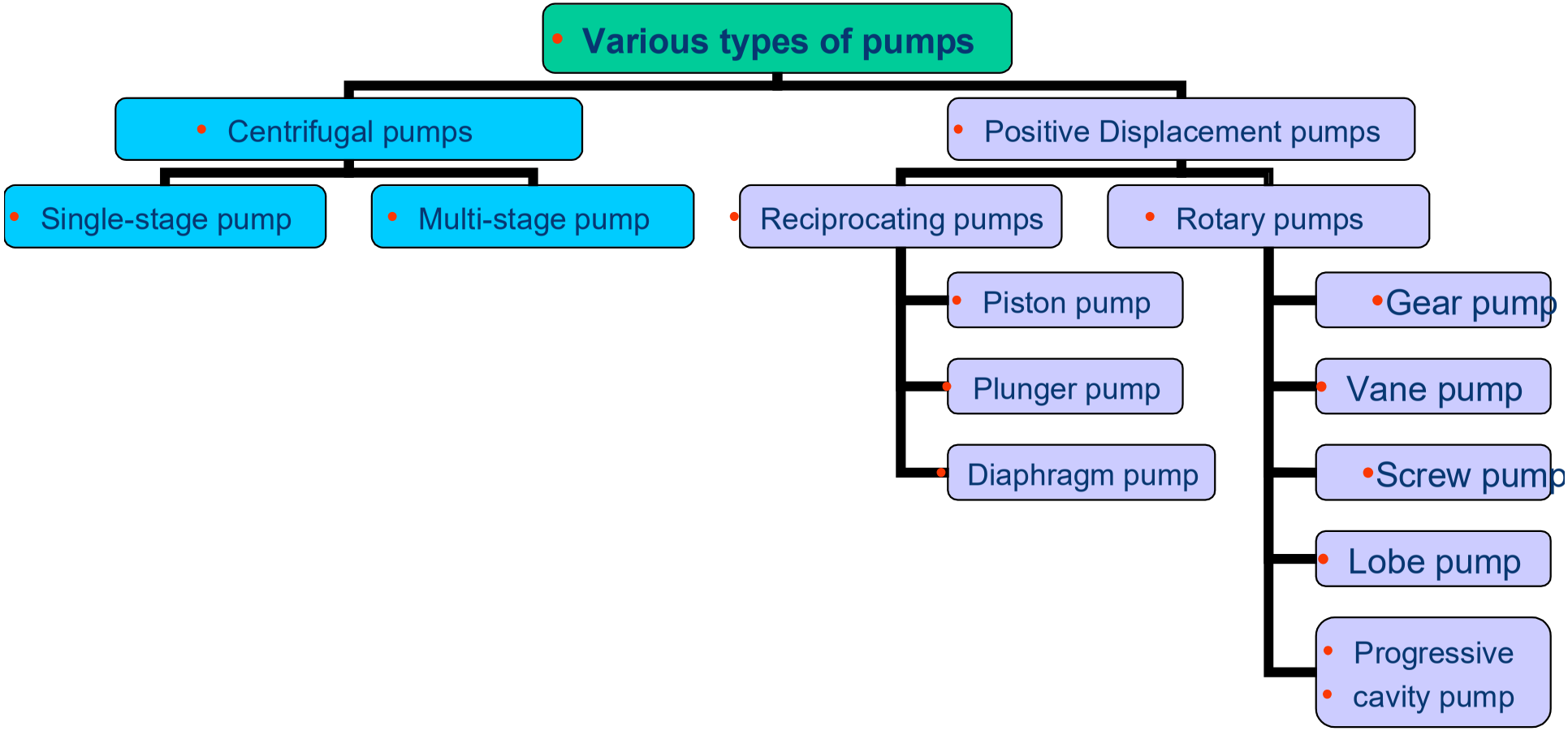
2. Positive Displacement pumps

Reciprocating displacement pumps:

- Piston pump (Single acting/ Double acting)
- Plunger pump (Single acting/ Double acting)
- Diaphragm pump (Single acting/ Double acting)

Rotary displacement pumps

- Gear pump
- Vane pump
- Screw pump
- Lobe pump
- Progressive cavity pump


Various types of pumps
Centrifugal pumps
Positive Displacement pumps
Single-stage pump
Multi-stage pump
Reciprocating pumps
Rotary pumps
Piston pump
Plunger pump
Diaphragm pump
Gear pump
Vane pump
Screw pump
Lobe pump
Progressive cavity pump

Various types of pumps

- **Centrifugal pumps**

  - Centrifugal pump is the general description for machines with impellers which displace fluid by momentum rather than positive mechanical travel.
  - The liquid moves as a result of an energy increase derived from the centrifugal force and increases the pressure of the liquid.
  - The simplest and most common means of conveying liquids (Crude, Oil, Water) is the centrifugal pump, and it is also the most economical means.
  - This family of pumps is very widespread throughout oil industry.

Various types of pumps

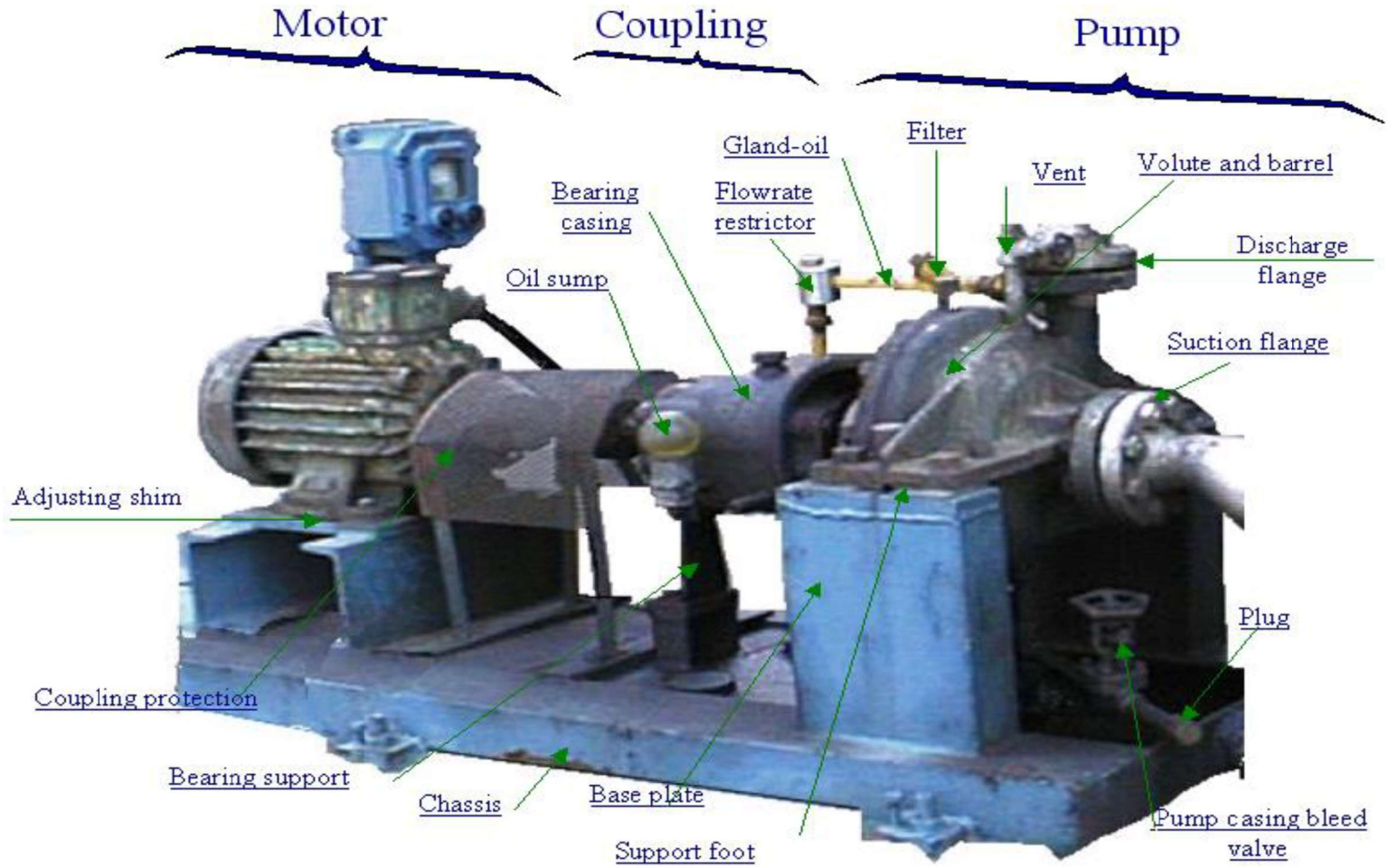
- **Centrifugal pumps**

- **However, there are some applications for which centrifugal pumps lose their effectiveness:**

  - **Pumping viscous products**: At high viscosities, using a centrifugal pump would require an oversized pump with a flow rate outside of its optimum specifications, a very poor efficiency and a very high power consumption.
  - For **accurate instantaneous dosing**, a centrifugal pump would require a flow meter to control the speed of the centrifugal pump, with the risk of the pump operating outside of its optimum specifications.

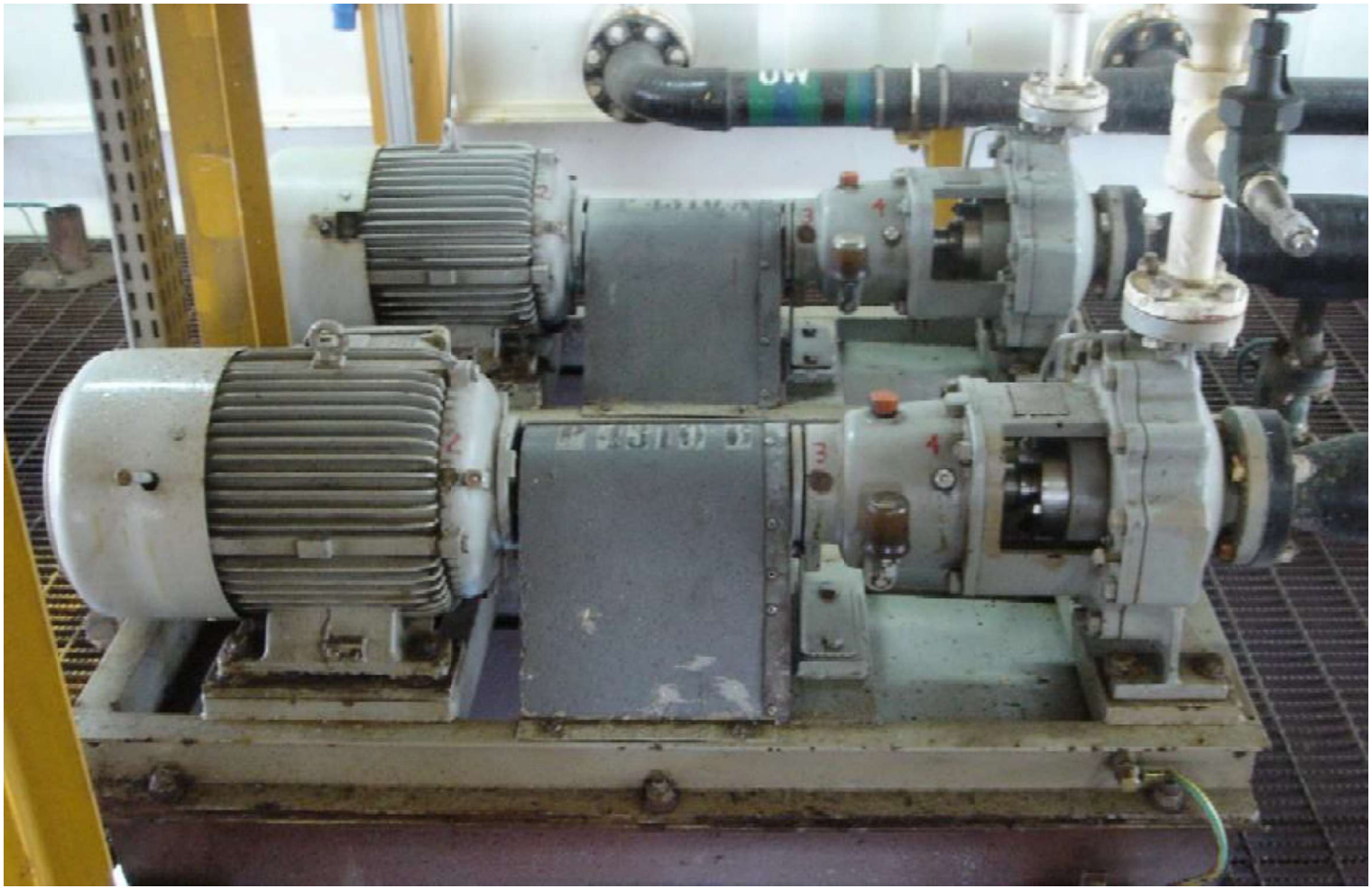
Various types of pumps

- **Centrifugal pump**



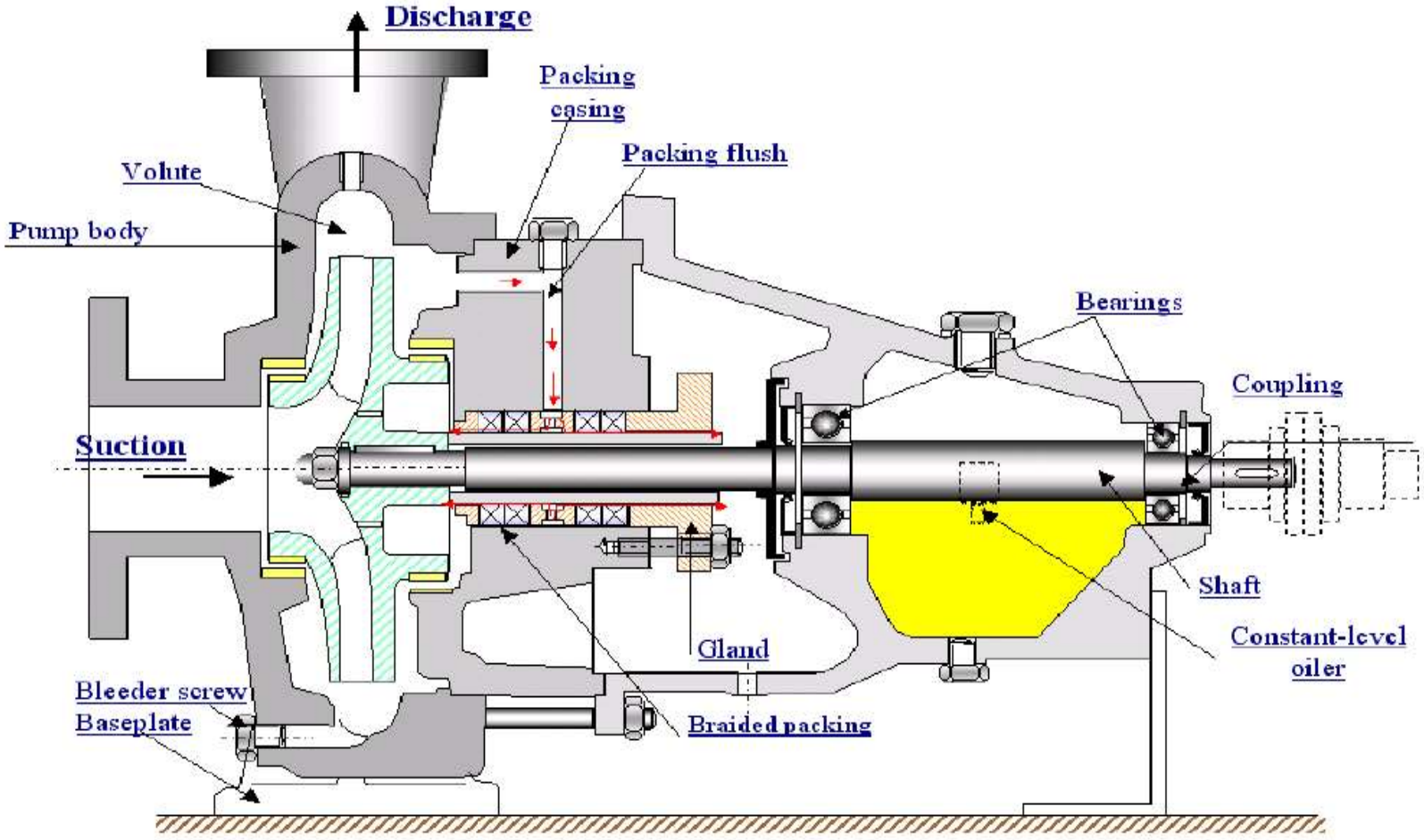
Various types of pumps

- Centrifugal pump



Various types of pumps

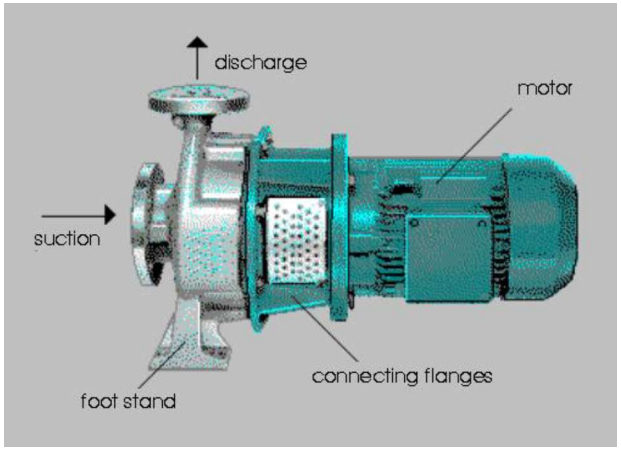
- **Centrifugal pump - cross section**



Various types of pumps (centrifugal pumps)

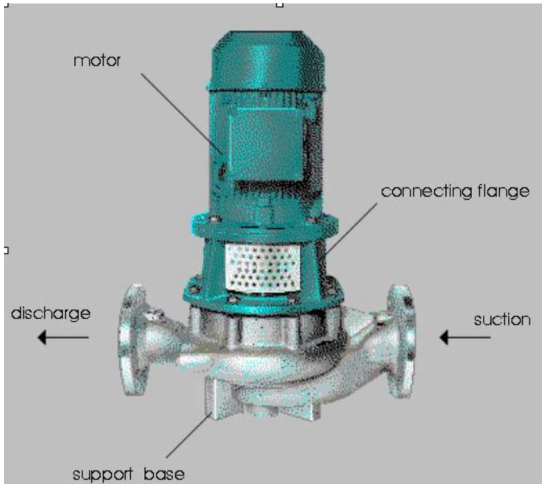
- **One-piece pumps**

They include in-line pumps and immersed pumps and whose motor is directly positioned on the pump casing.



- **In-line pumps**

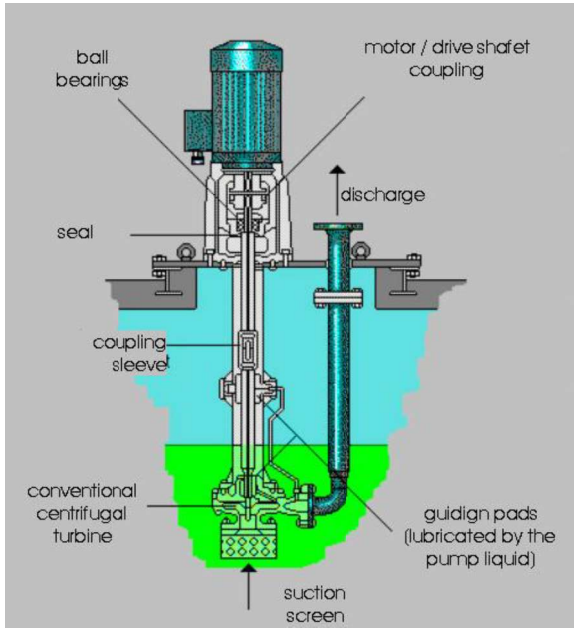
The name of this pump is due to the alignment of the suction flange and the discharge flange: the pump can be in-line mounted in the piping.



Various types of pumps (centrifugal pumps)

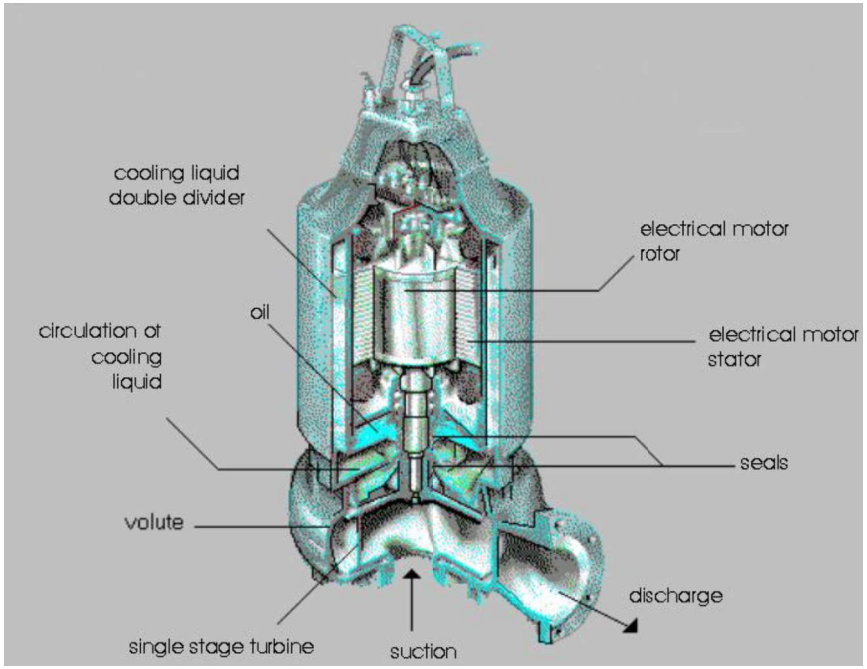
- **Vertical pumps**

  This type of pump is used for emptying pits or buried tanks, when an immersed pump cannot be used.



- **Immersed** or **submersible pumps**

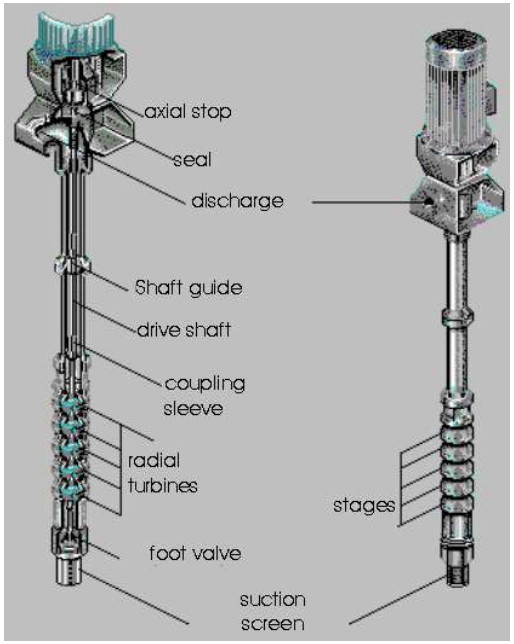
  They are traditional centrifugal pumps with a one-piece design, i.e. whose motor is directly supported by the pump barrel.



Various types of pumps (centrifugal pumps)

- **Well pumps or boring pumps (Axial flow pumps)**

  They are generally used for retrieving seawater, ground water or river water. They are also used for pumping hydrocarbons. The maximum depth is limited to 120 metres, mainly due to the length of the drive shaft.



Various types of pumps (centrifugal pumps)

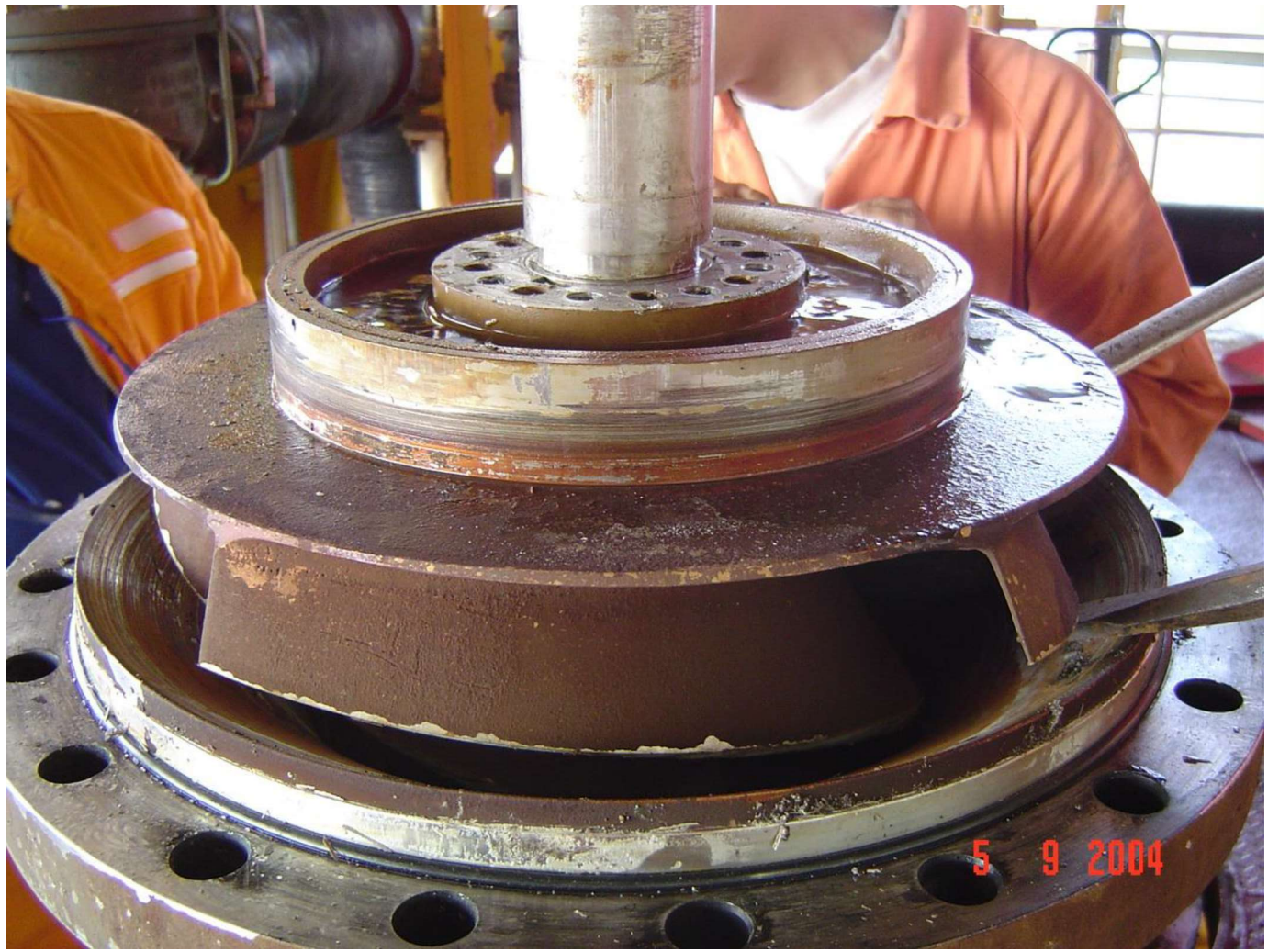
- **Multi-stage centrifugal pumps**

Various types of pumps

- **Multi-stage centrifugal pumps**

  (Axial flow pumps)

Various types of pumps (centrifugal pumps)



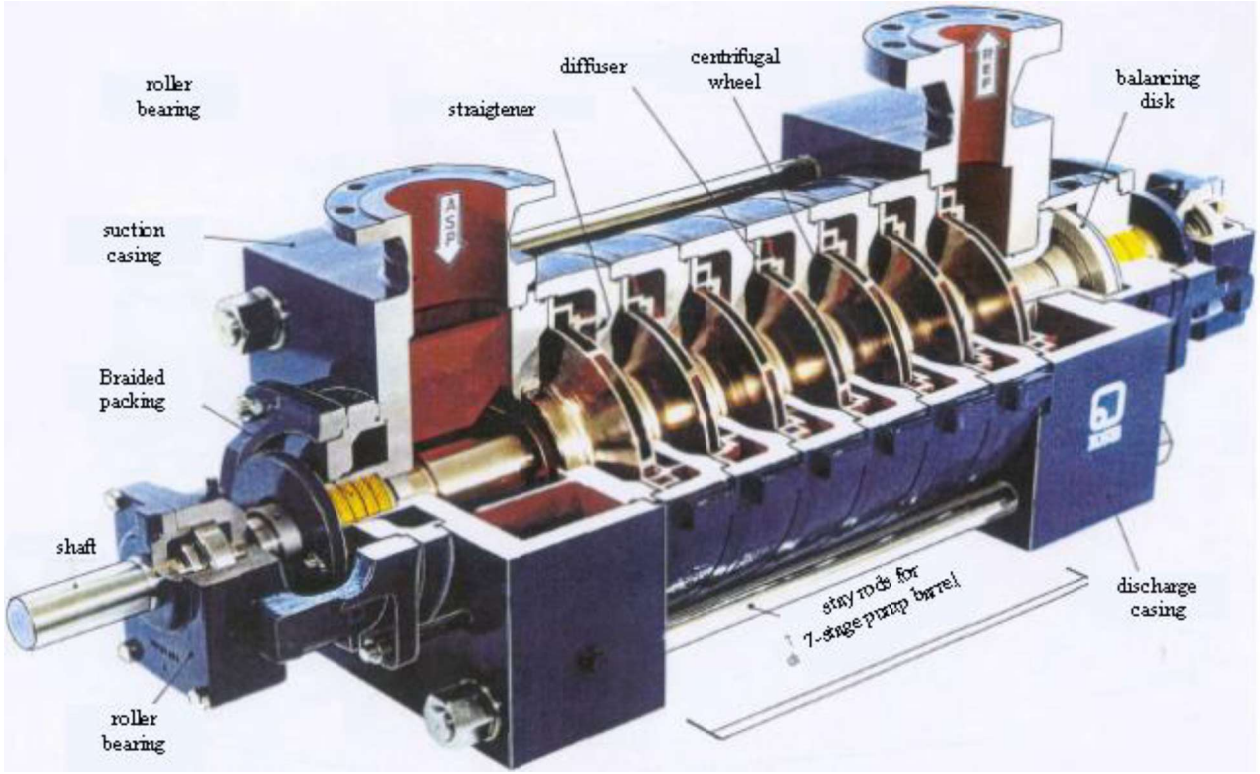
Various types of pumps (centrifugal pumps)

Various types of pumps (centrifugal pumps)

- Worn impeller

Various types of pumps

- **Multi-stage high pressure centrifugal pumps**
  - The high pressure pumps consist of stages arranged in series. Each stage corresponds to an elementary centrifugal pump, i.e., a turbine rotating in a volute or a diffuser.



Various types of pumps

2. Positive displacement pumps

- A positive displacement pump has a well-enclosed pump barrel inside of which moves a meticulously adjusted moving element. It develops its action through the following principle:
  - Execution of a cyclic movement, during which a given volume of liquid enters a compartment before being discharged at the end.

- This movement displaces the liquid between the suction aperture and the discharge aperture.
- Such pumps can be classified into two categories:
  - **Reciprocating** displacement pumps:
  - **Rotary** displacement pumps:

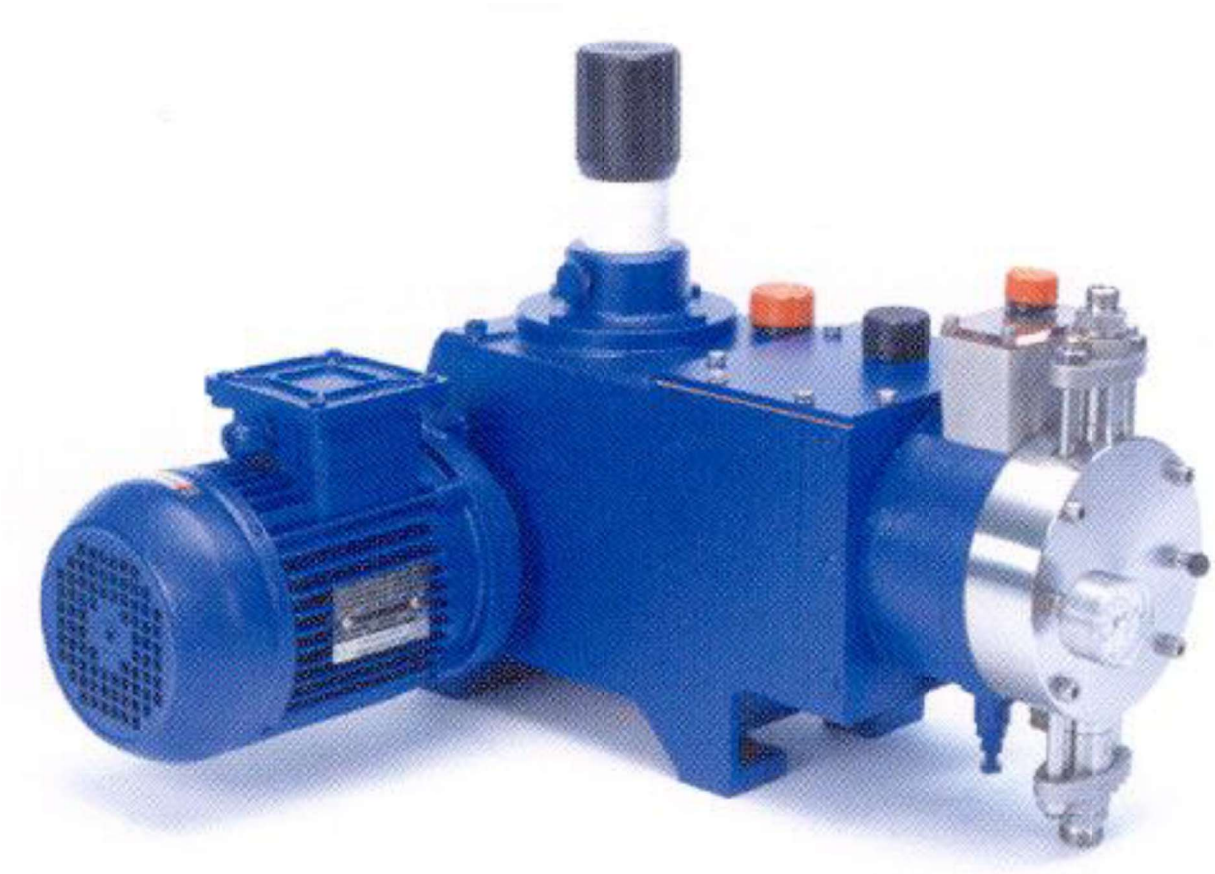
Various types of pumps (Positive displacement pumps)

- A **reciprocating pump** is a displacement pump which reciprocates the pumping element (piston, plunger, or diaphragm). The capacity of a reciprocating pump is proportional to its speed, and is relatively independent of discharge pressure.

  - They allow much higher discharge pressure.
  - On the other hand, the flow rate is generally lower.

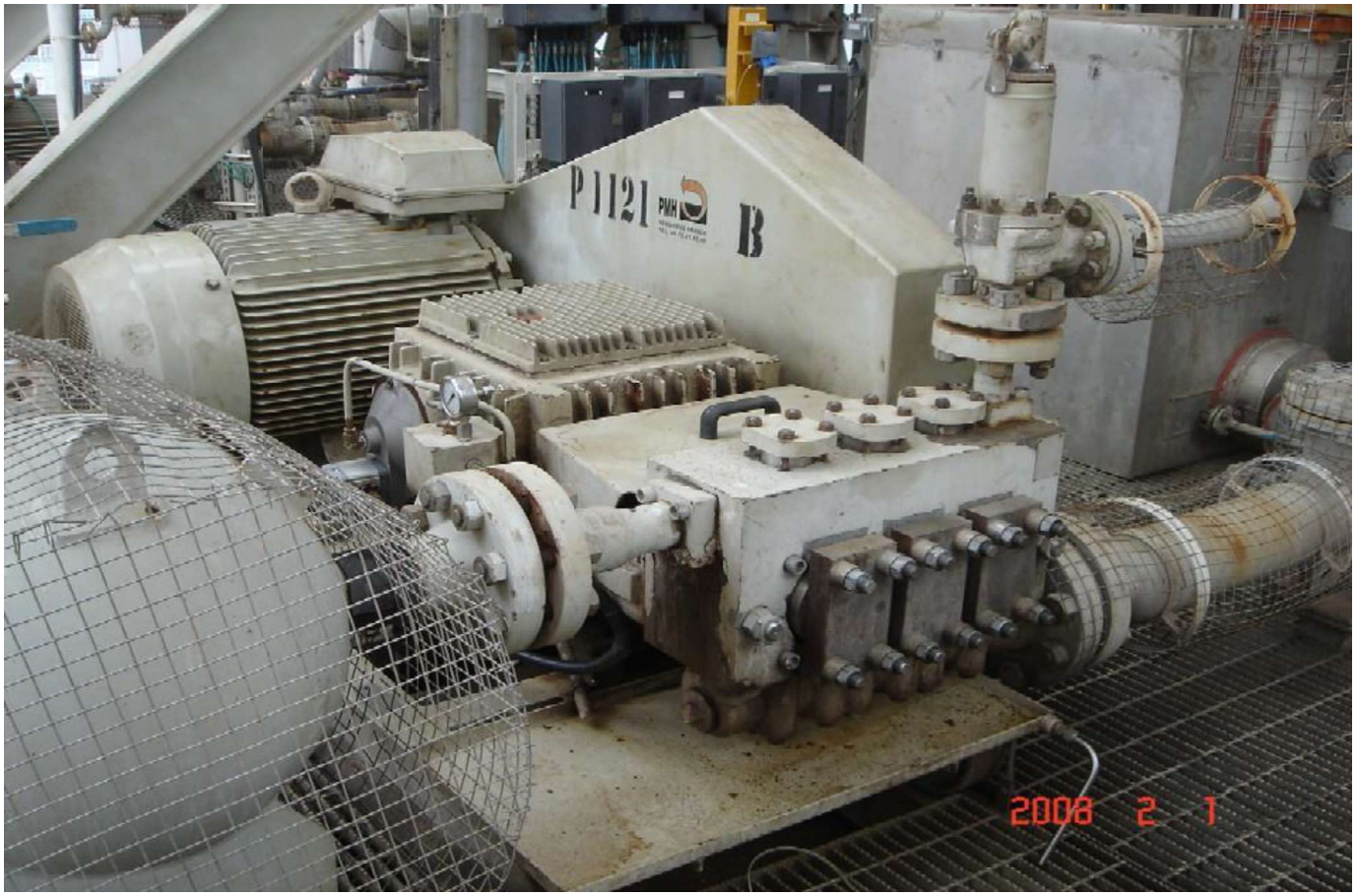
Various types of pumps

- **Positive displacement pumps**



Various types of pumps

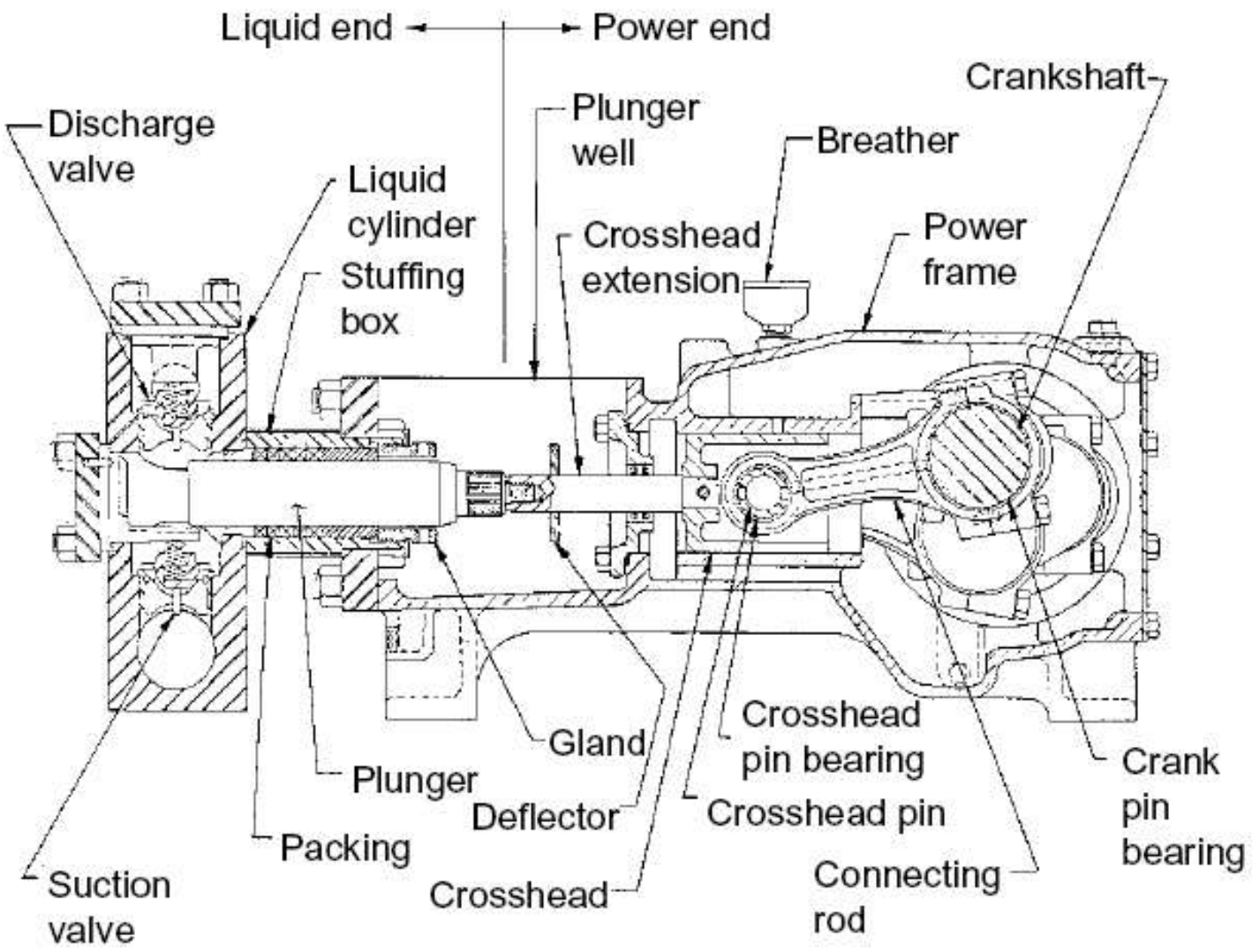
- Positive displacement pumps



Various types of pumps

- Positive displacement pumps

Various types of pumps Plunger pump



Various types of pumps

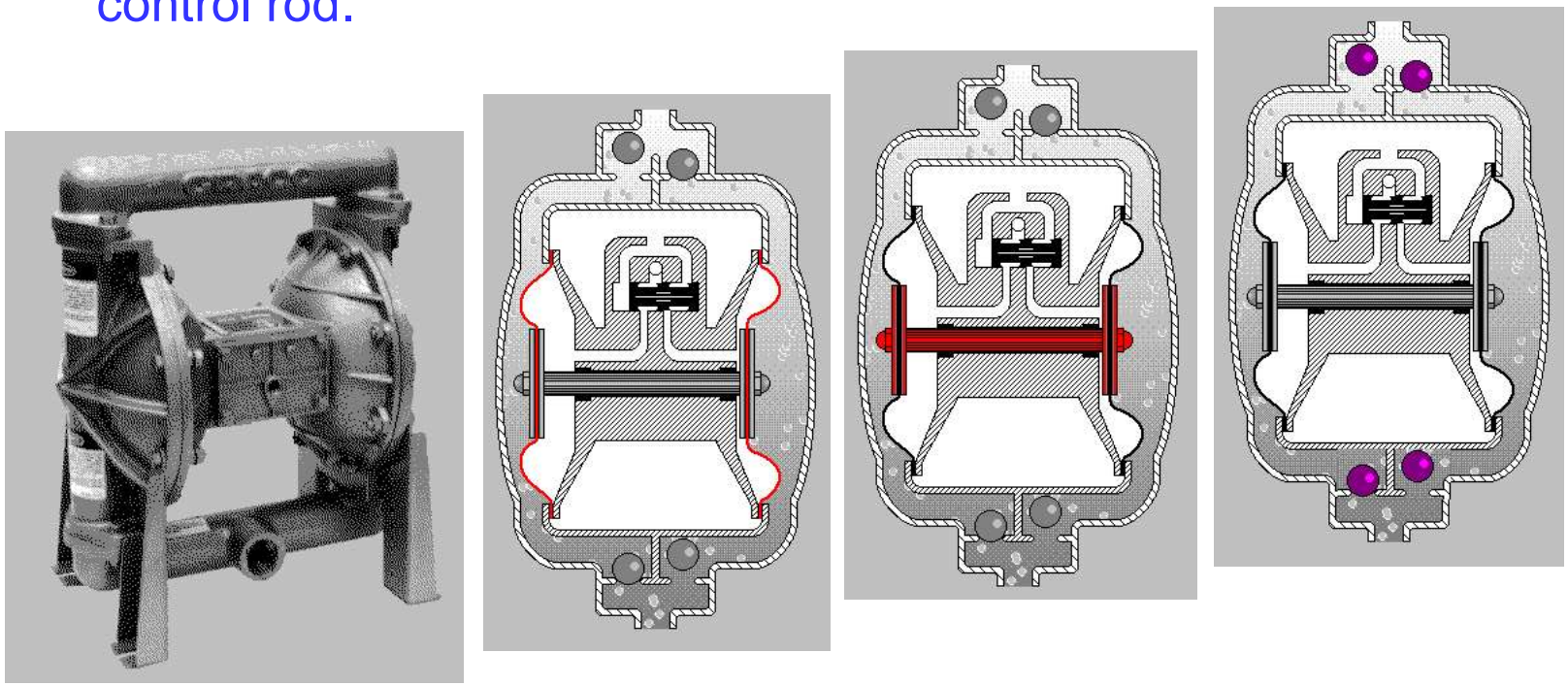
- Positive displacement pumps

Various types of pumps

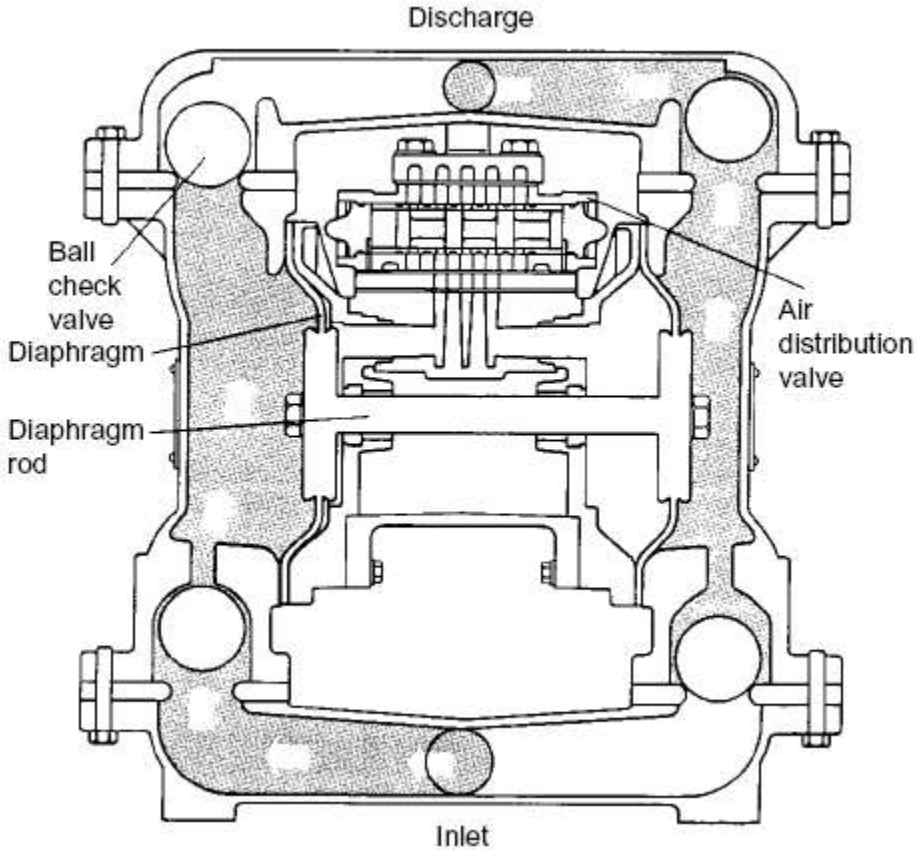
- Positive displacement pumps

Various types of pumps

- **Air-operated reciprocating pump**
  - The **diaphragms** are alternately pushed by the compressed air from a pneumatic regulator. When one diaphragm is pushed, it pushes on the liquid and it brings back the other diaphragm using a control rod.

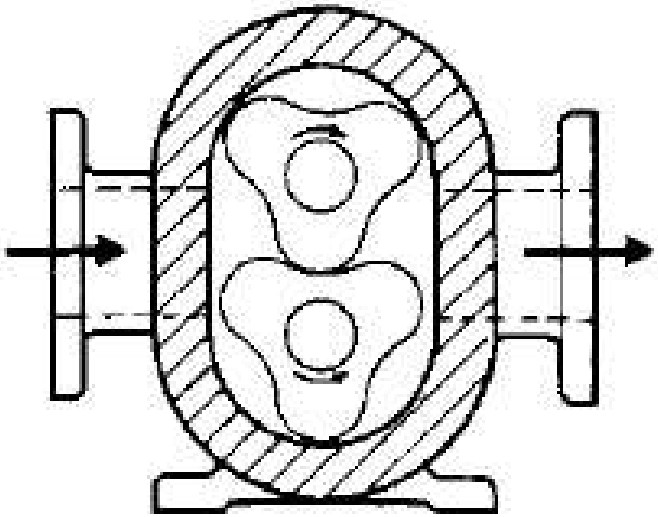


Various types of pumps (Positive displacement pumps)

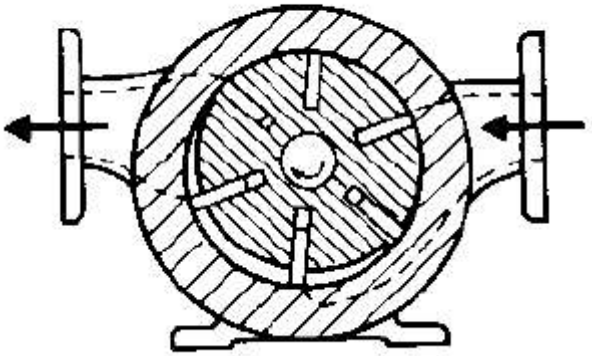


Direct acting air driven diaphragm pump

Various types of pumps
(Positive displacement pumps)

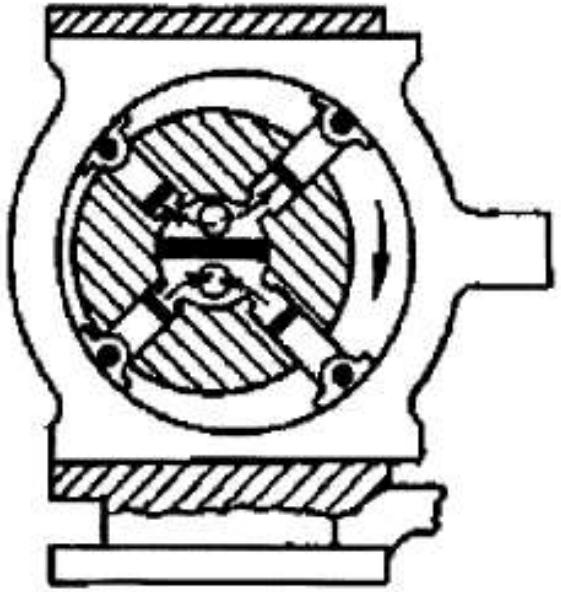


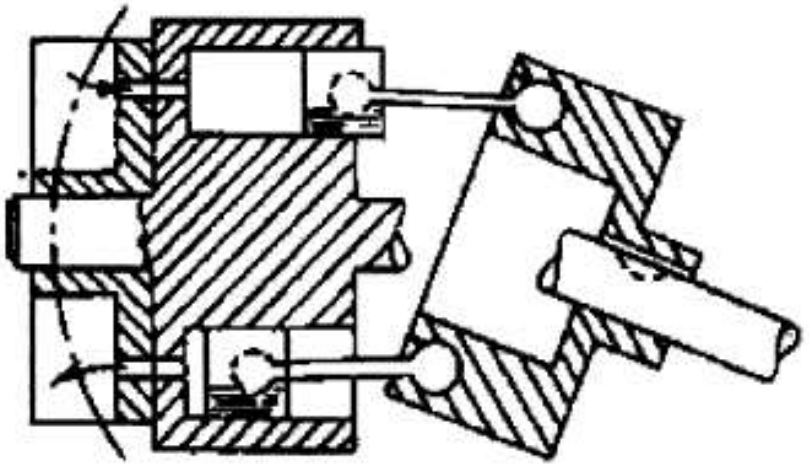
Lobe rotary pump



Sliding vane rotary pump

Various types of pumps
(Positive displacement pumps)

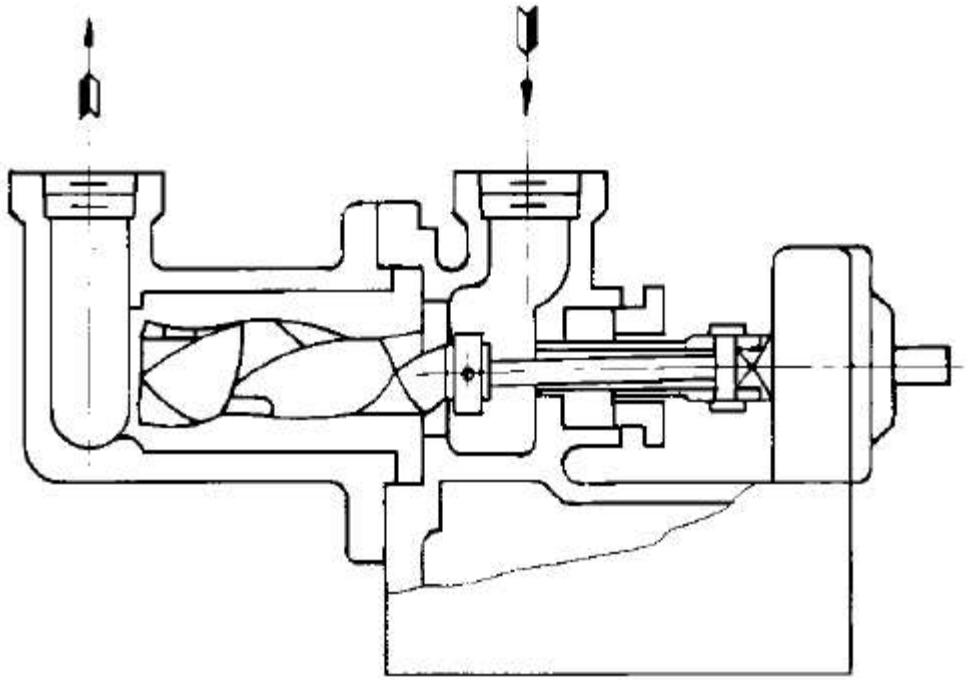




- Radial-plunger rotary pump

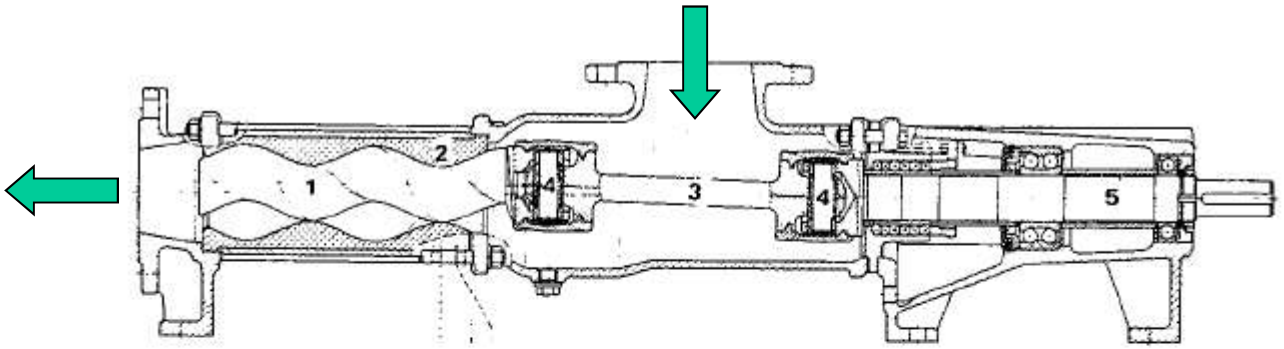
- Axial-plunger (swash plate) Rotary pump

Various types of pumps
(Positive displacement pumps)

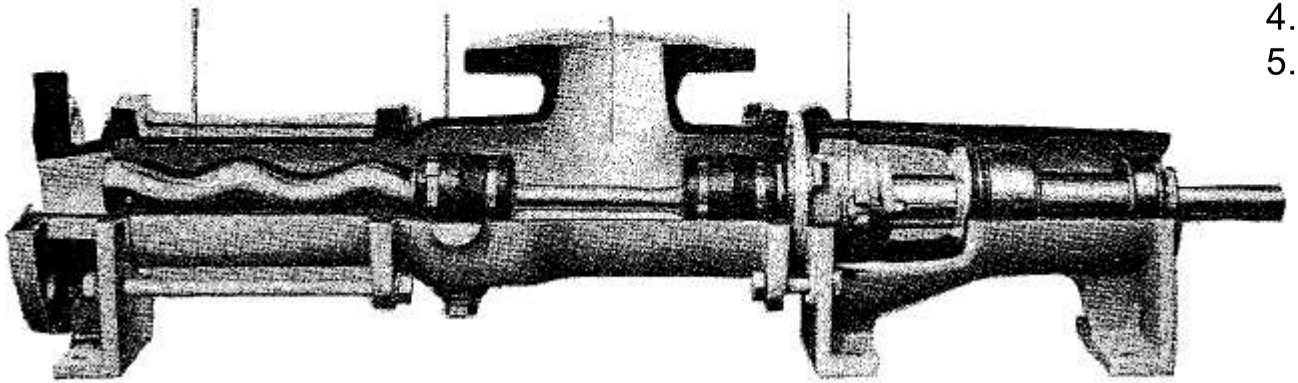


Progressive cavity single screw rotary pump

Various types of pumps
(Positive displacement pumps)



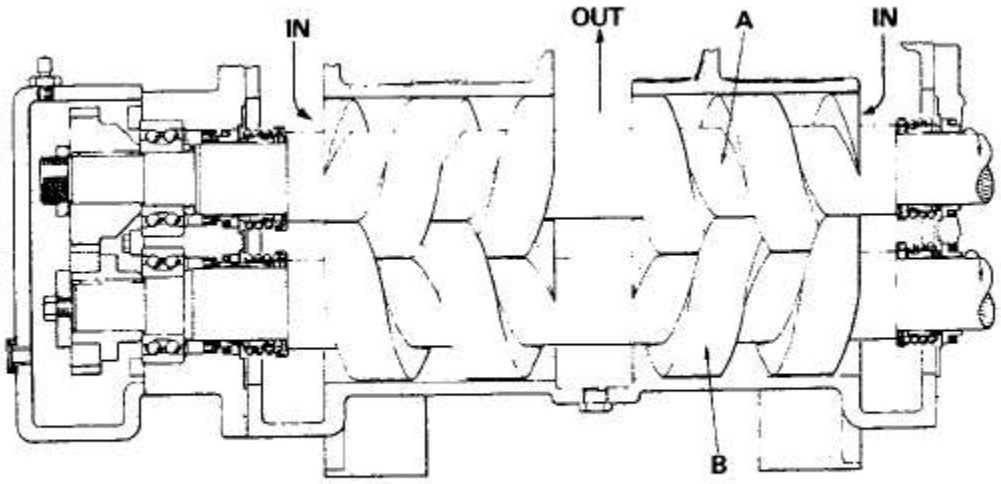
1.Rotor (screw)
2.Stator (housing)
3.Coupling rod
4.Joint
5.Drive shaft



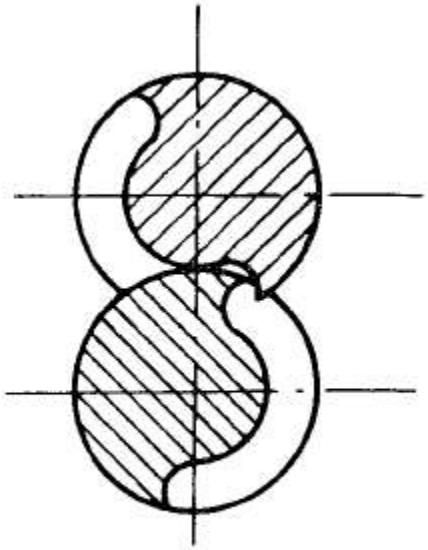
Eccentric single-screw rotary pump

- The eccentric screw pump in its basic form consists of a single helix metal rotor which revolves eccentrically within a double helix resilient stator.

Various types of pumps
(Positive displacement pumps)

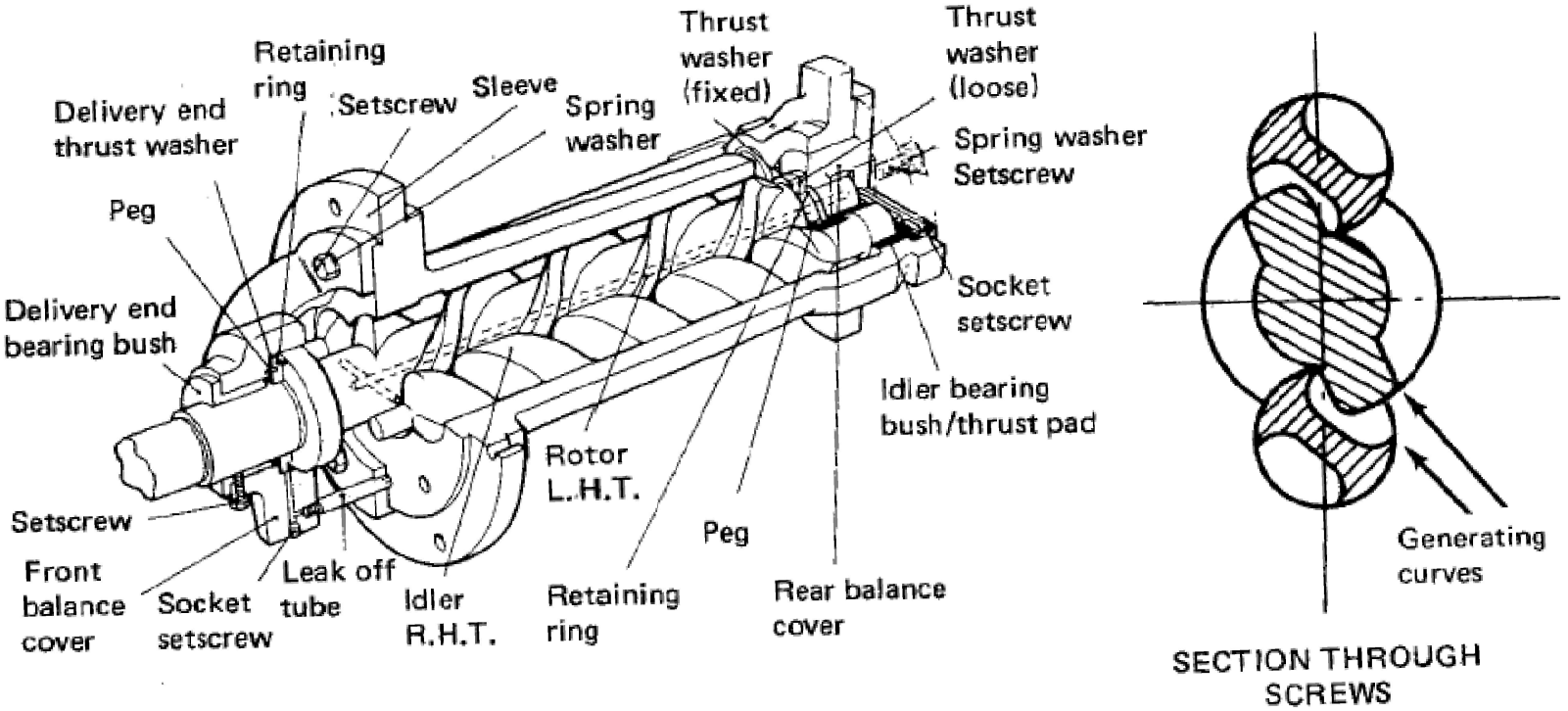


External Bearing Twin-Screw Rotary Pump



- The usual configuration of a two-screw pump is two pairs of identical screws on two shafts connected by external gears.

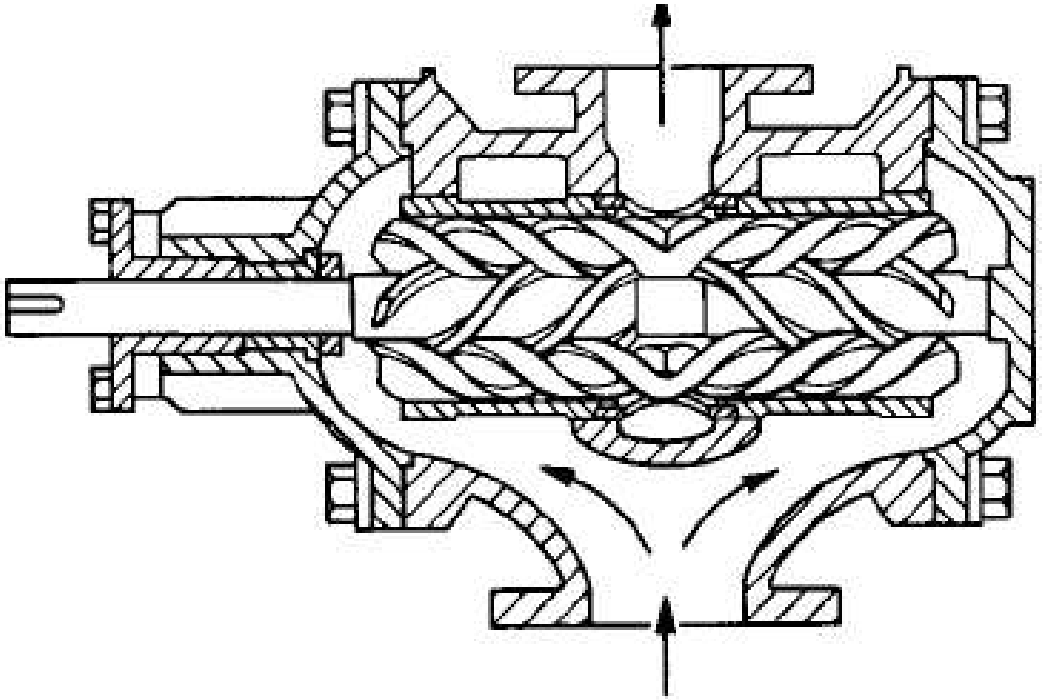
Various types of pumps
(Positive displacement pumps)



Triple-screw rotary pump

- The usual configuration for three-screw pump is a centrally driven rotor screw with two smaller idler screws meshing with and driven by it.

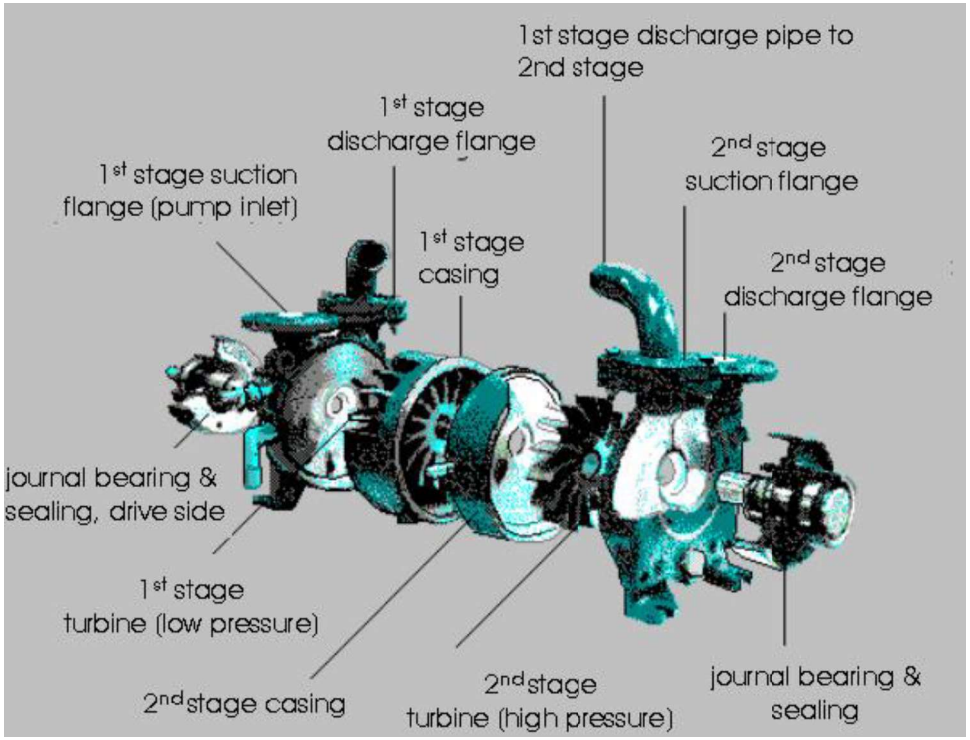
Various types of pumps
(Positive displacement pumps)

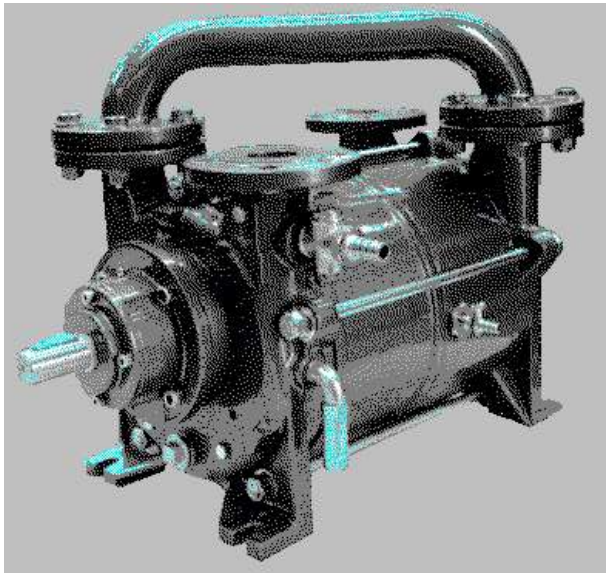


3-Screw rotary pump

Various types of pumps

- **Rotary liquid ring pump**
  - This pump does not convey liquid but **gas**. It is generally used as a vacuum pump and sometimes as a compressor.



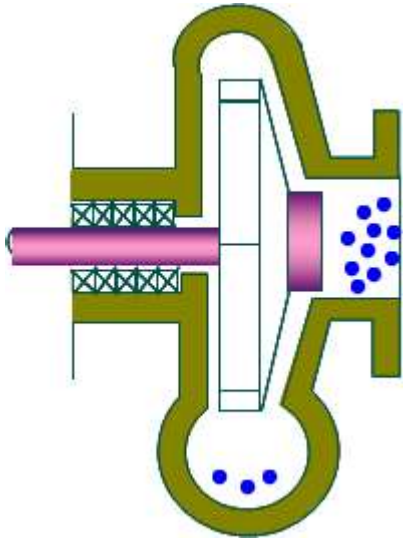


Operating principle of pumps

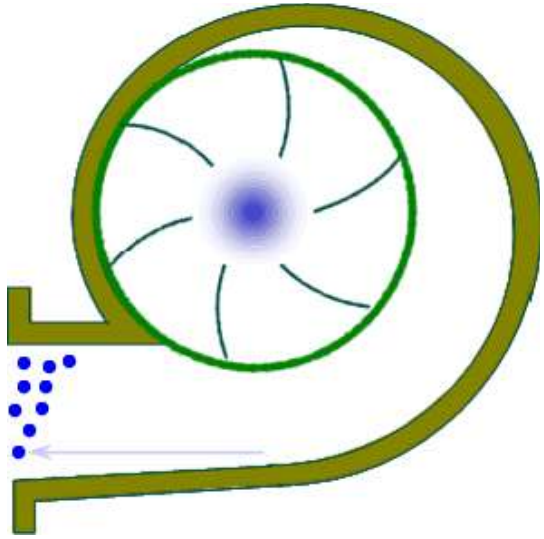
Operating principle of pumps

- **Centrifugal pump operating principle**
  - **(1)** The liquid flows in along the axis of the pump via the distributor and the centrifugal force generated by the vaned wheel's rotation drives it toward the outside of the wheel**.**
  - **(2)** It acquires high **kinetic energy**, which is converted into **pressure energy** in the manifold, where the cross-section increases.

(1)

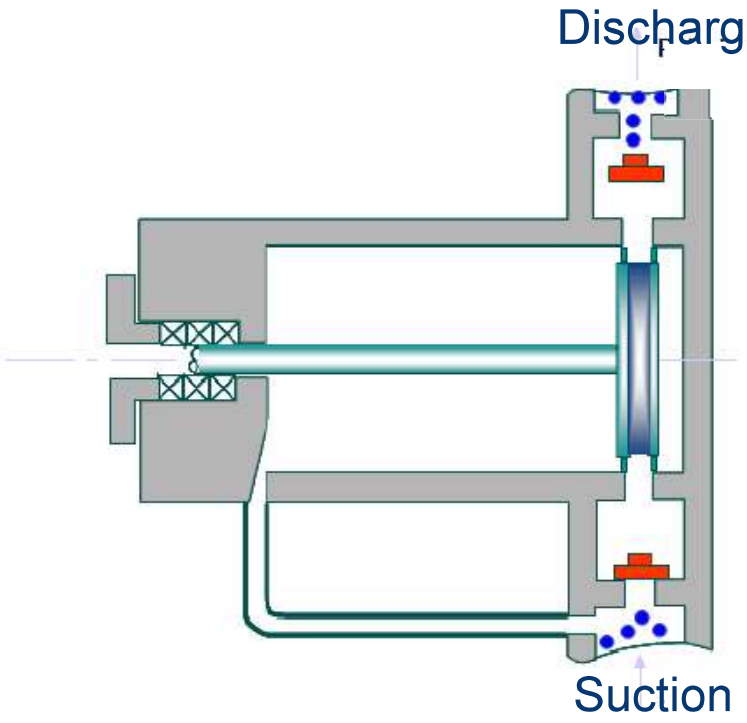


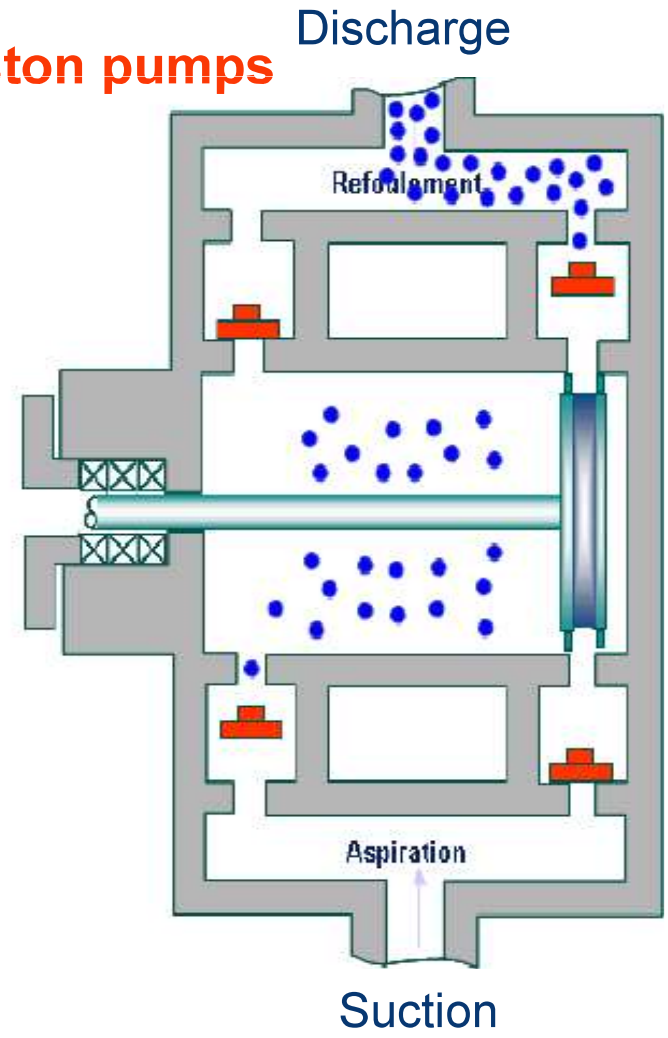
(2)



Operating principle of pumps

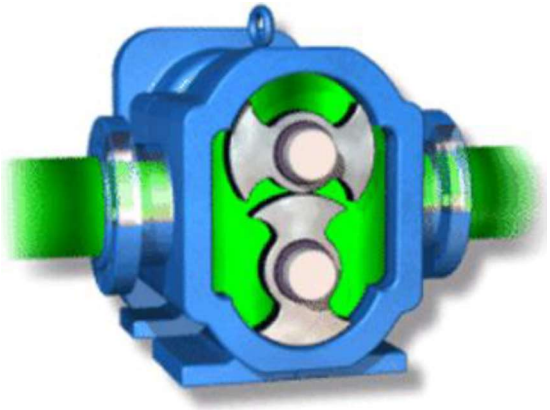
- **Singe & Double-acting reciprocating piston pumps**



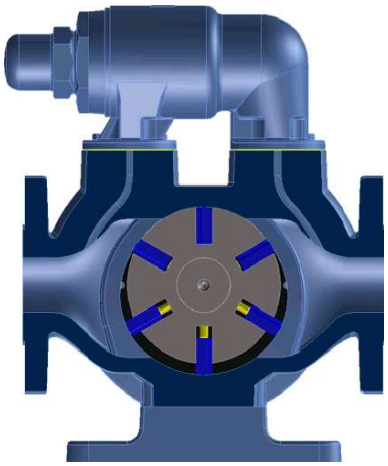


Operating principle of pumps

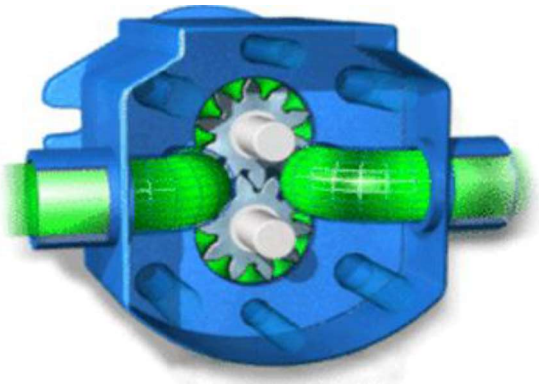
- **Rotary pump operating principle**
  - Rotary pumps consist of a moving part which rotates actuated by a rotational movement around an axis which itself rotates in the pump barrel and induces movement of the pumped liquid by displacement of the volume from the suction point to the discharge point.



Lobe



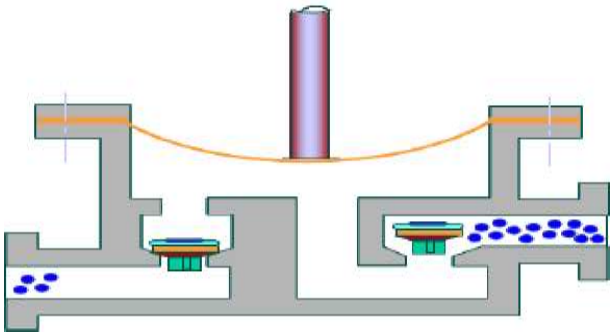
Sliding vane



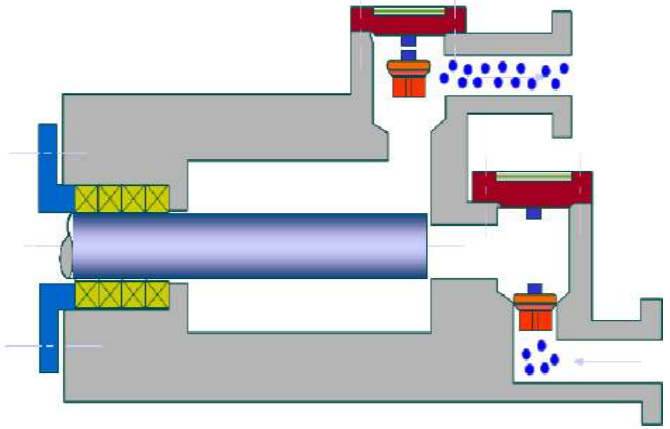
Gear

Operating principle of pumps

- **Reciprocating pump operating principle**
  - The volumes produced at suction and discharge result from the alternating displacement of a **piston** *or a* **plunger** on its axis, inside a cylinder.
  - There is a time when the cylinder is filled (suction) and a time when it is emptied (discharge). The liquid flow produced by the pump will therefore be discontinued.

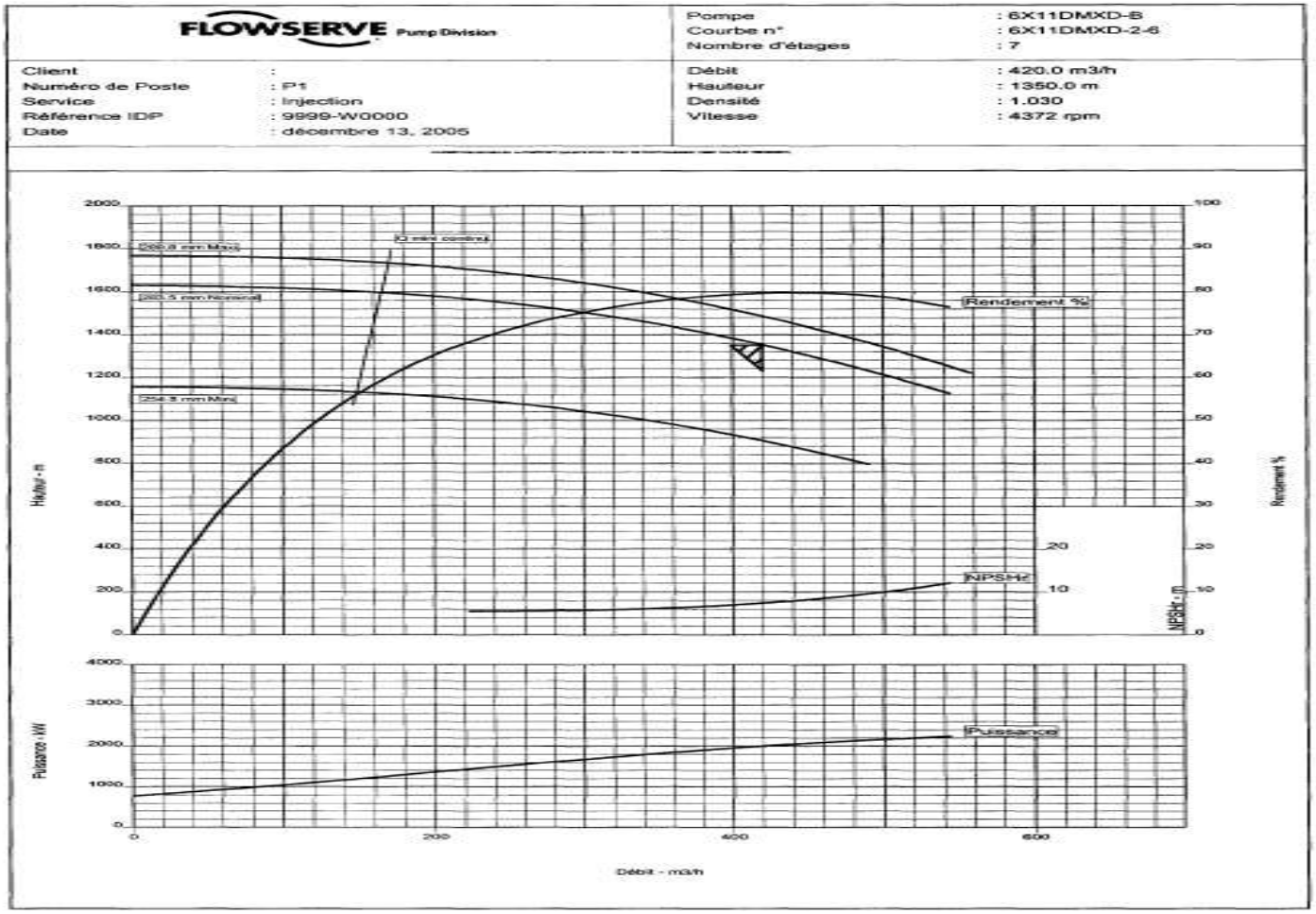


Diaphragm



Plunger

Pump operating curve



Advantages and disadvantages of pump types

Advantages and disadvantages of pump types

- **Summary table of advantages and disadvantages of reciprocating displacement pumps**

	Advantages	Disadvantages	Use
Piston	Accurate flowrate Adjustable flowrate High efficiency	Jerky flowrate High price Sensitive to particles Limited chemical resistance	Pure, slightly corrosive non–hazardous liquids P $\rightarrow$ 100 bars V $\rightarrow$ 20 m^3/hr
Diaphragm	Accurate flowrate Adjustable flowrate High efficiency Less sensitive to particles Very good chemical resistance	Jerky flowrate High price Limited operating temperature	Slurry, corrosive, hazardous liquids P $\rightarrow$ 20 bars V $\rightarrow$ 30 m^3/hr

Advantages and disadvantages of pump types

- Summary table of advantages and disadvantages of rotary displacement pumps

	Advantages	Disadvantages	Use
Gear Screw Lobe	Uniform flowrate Adjustable flowrate Flowrate accuracy High efficiency Reduced overall size	Sensitive to particles Sensitive to corrosive liquid Complicated mechanics	Pure and viscous liquids P → 100 bars V → 200 m^3/hr
Offset screw	Adjustable flowrate Slightly sensitive to solids and suspensions Stator ring easy to move	Significant overall size Limited operating temperature Stator ring wear Sensitive to corrosive liquids	Slurry and viscous liquids P → 10 bars V → 150 m^3/hr

Advantages and disadvantages of pump types

- **Summary table of advantages and disadvantages of centrifugal pumps**

	Advantages	Disadvantages	Use
General	Stable flowrate Low price Small overall size Reliable	Not self-priming Interdependent flowrate and carrying pressure Low efficiency	Significant rates Pure liquids and suspensions

Pump auxiliaries and accessories

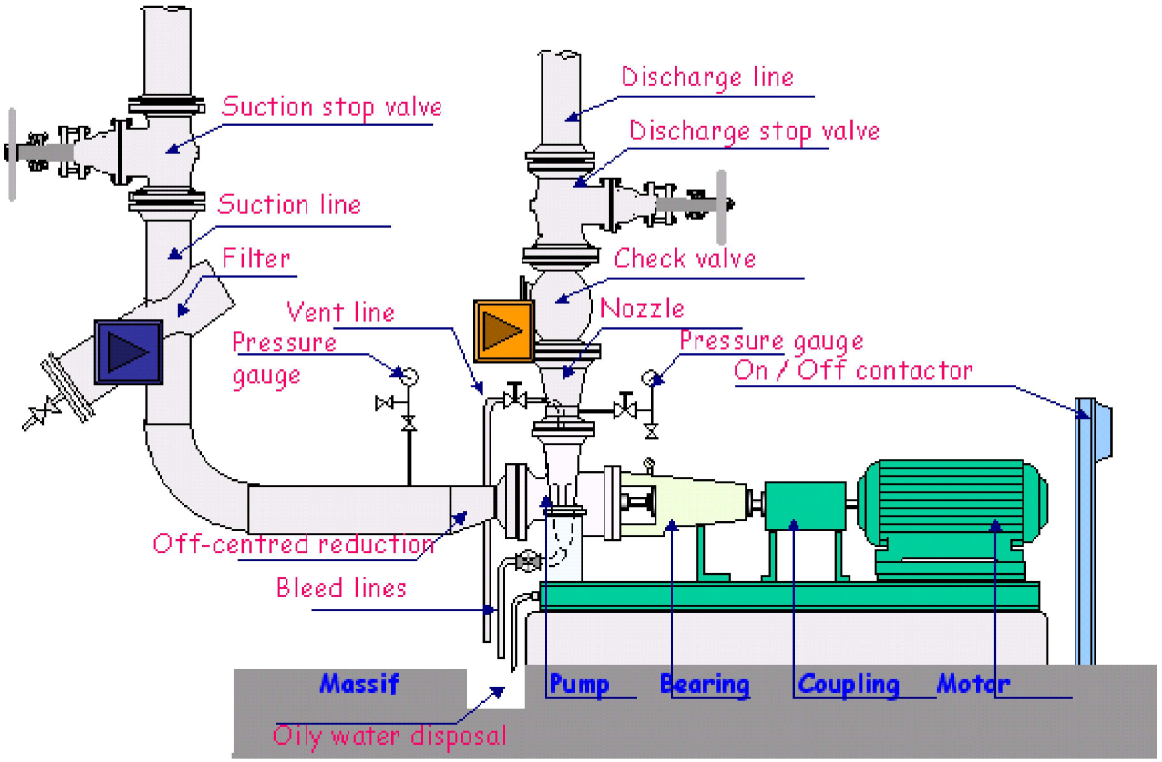
Pump auxiliaries and accessories

- **Auxiliaries**
  - Equipment surrounding (process lines, pump base & support etc.)
  - Auxiliary circuits (water, hydrocarbons, steam produced)
  - Bearing, lubricating system & greasing system

- **Accessories and Process Lines**
  - Valves, bends, filters strainers, check valves, pulsation dampeners, PSV, pressure gauges, suction / discharge pipes, reducers, divergent tubes, etc.

Pump auxiliaries and accessories

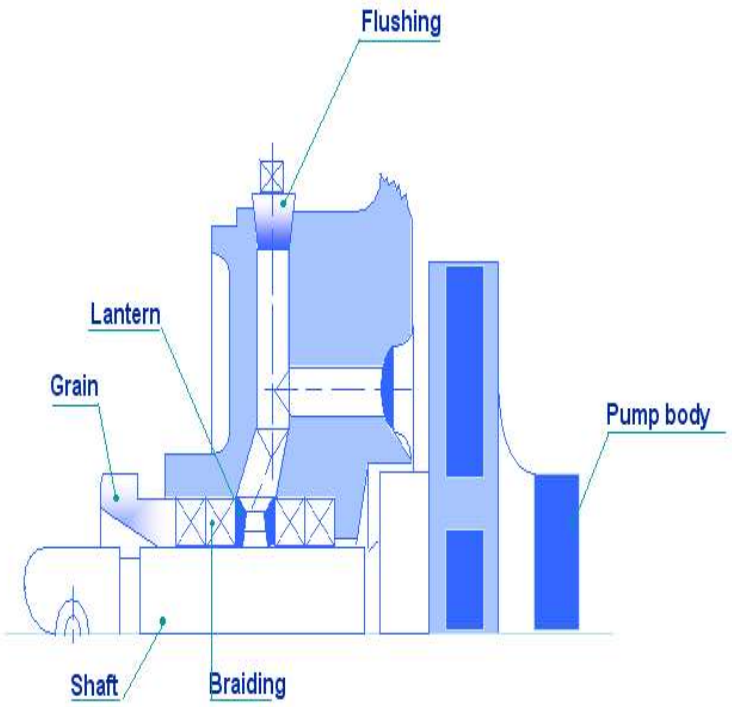
- **Accessories and process lines: centrifuge pump**



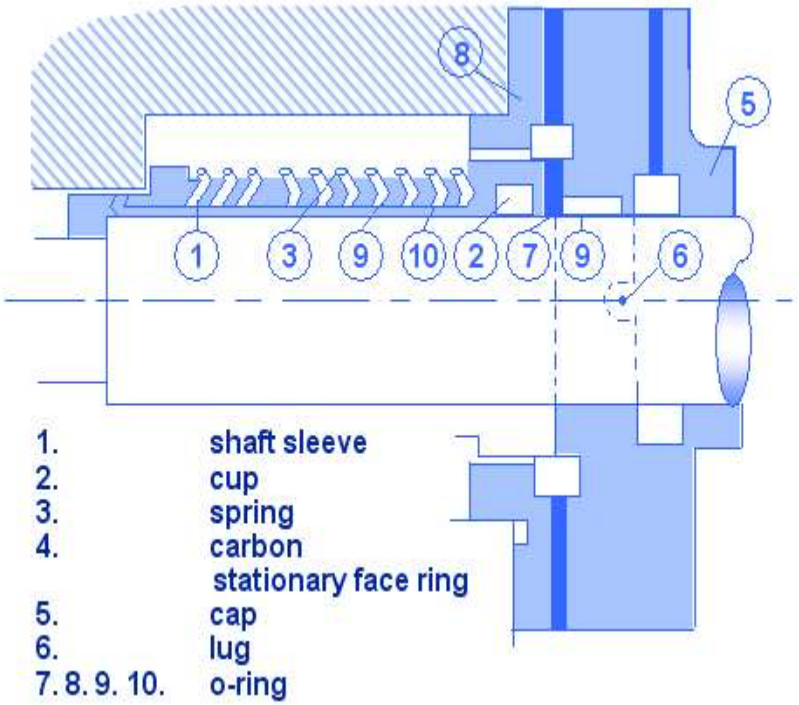
Pump auxiliaries and accessories

- **Sealing function**

Packing box



Mechanical packing



Pump auxiliaries and accessories

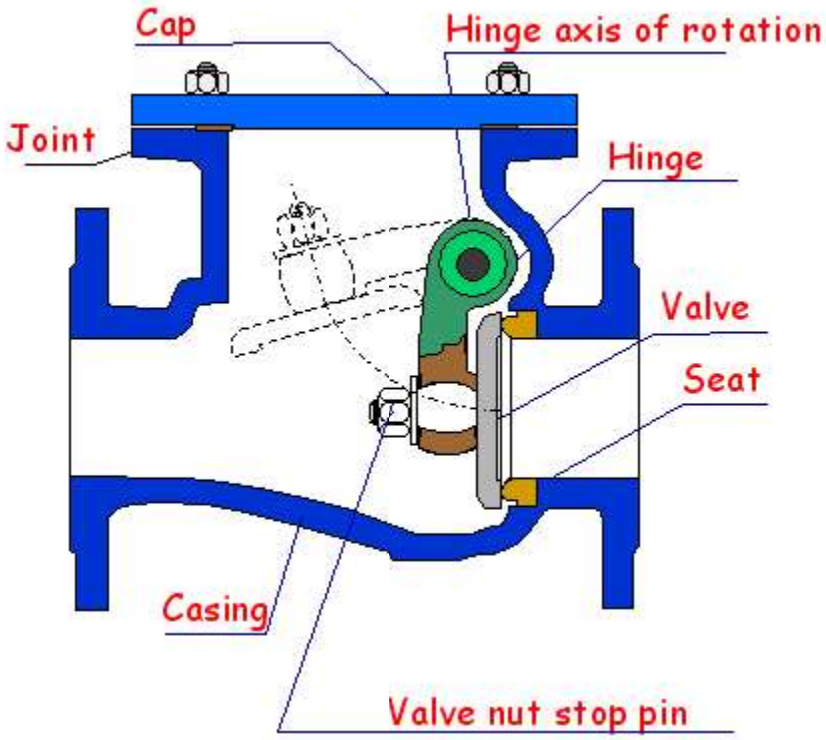
- **Sealing function**

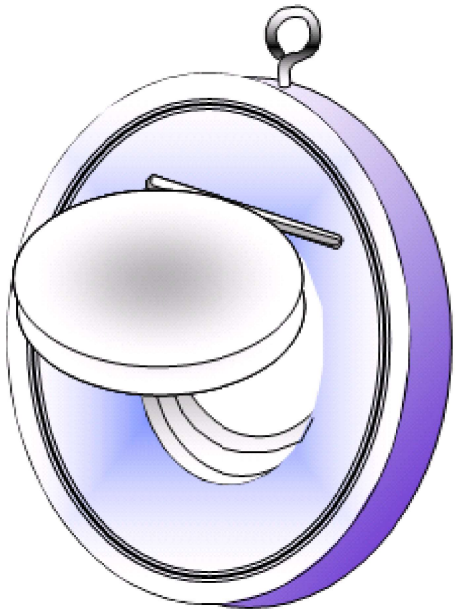
Packings

Mechanical seals

Pump auxiliaries and accessories

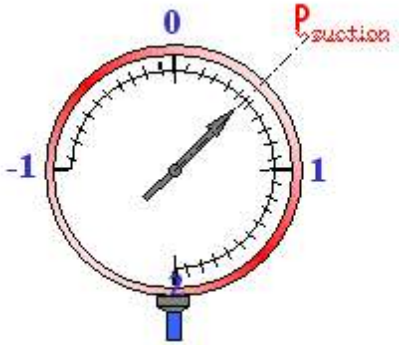
check valves



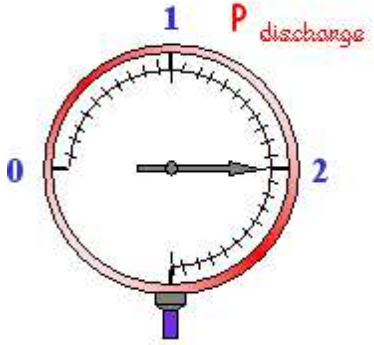


Pump auxiliaries and accessories

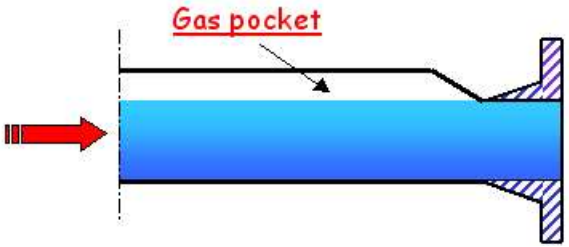
Suction manometer



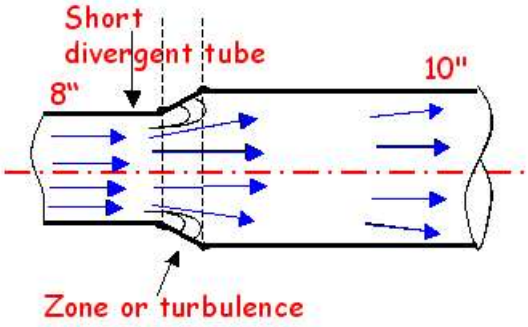
Discharge manometer



Off-centered reducer

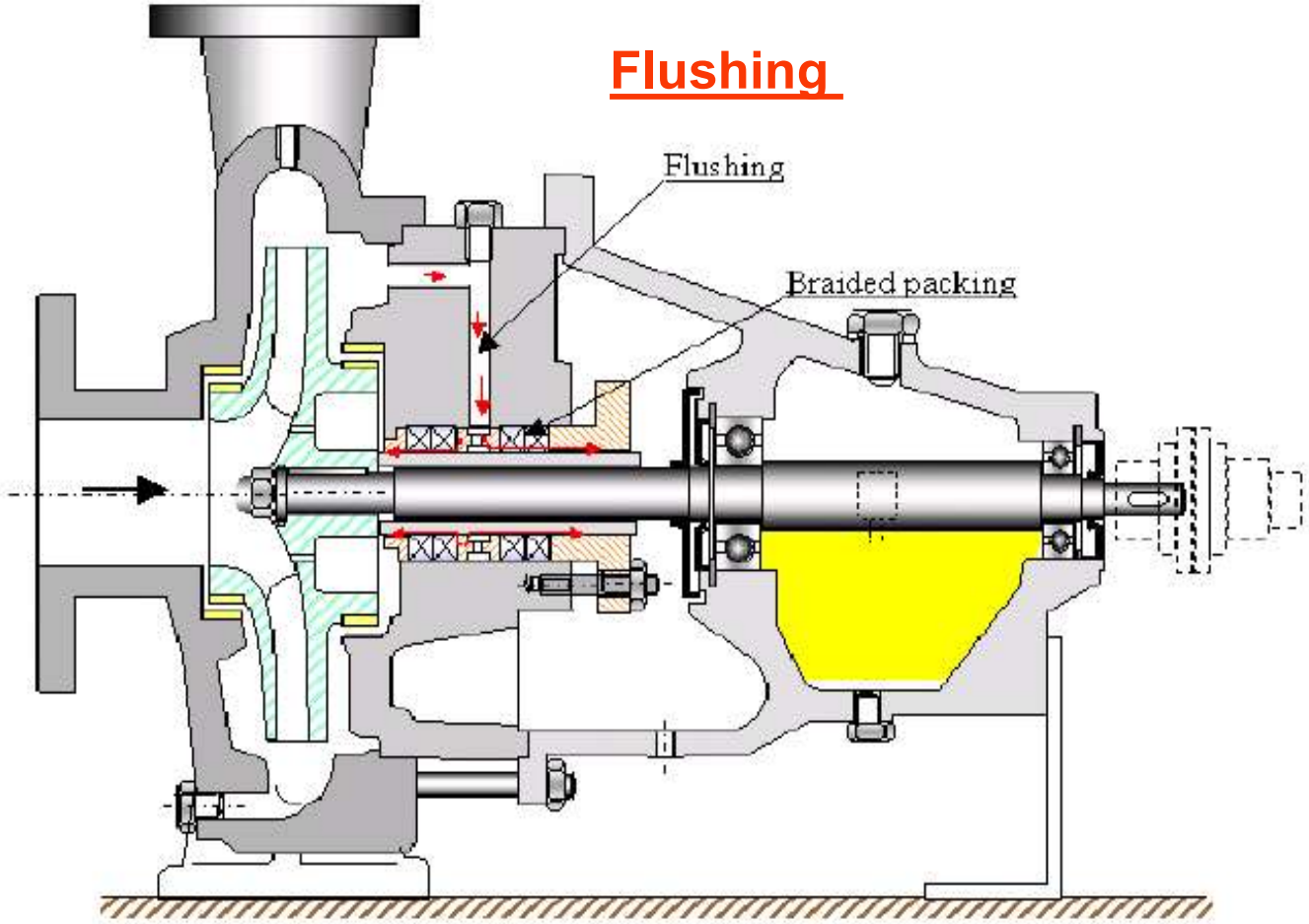


Divergent tube



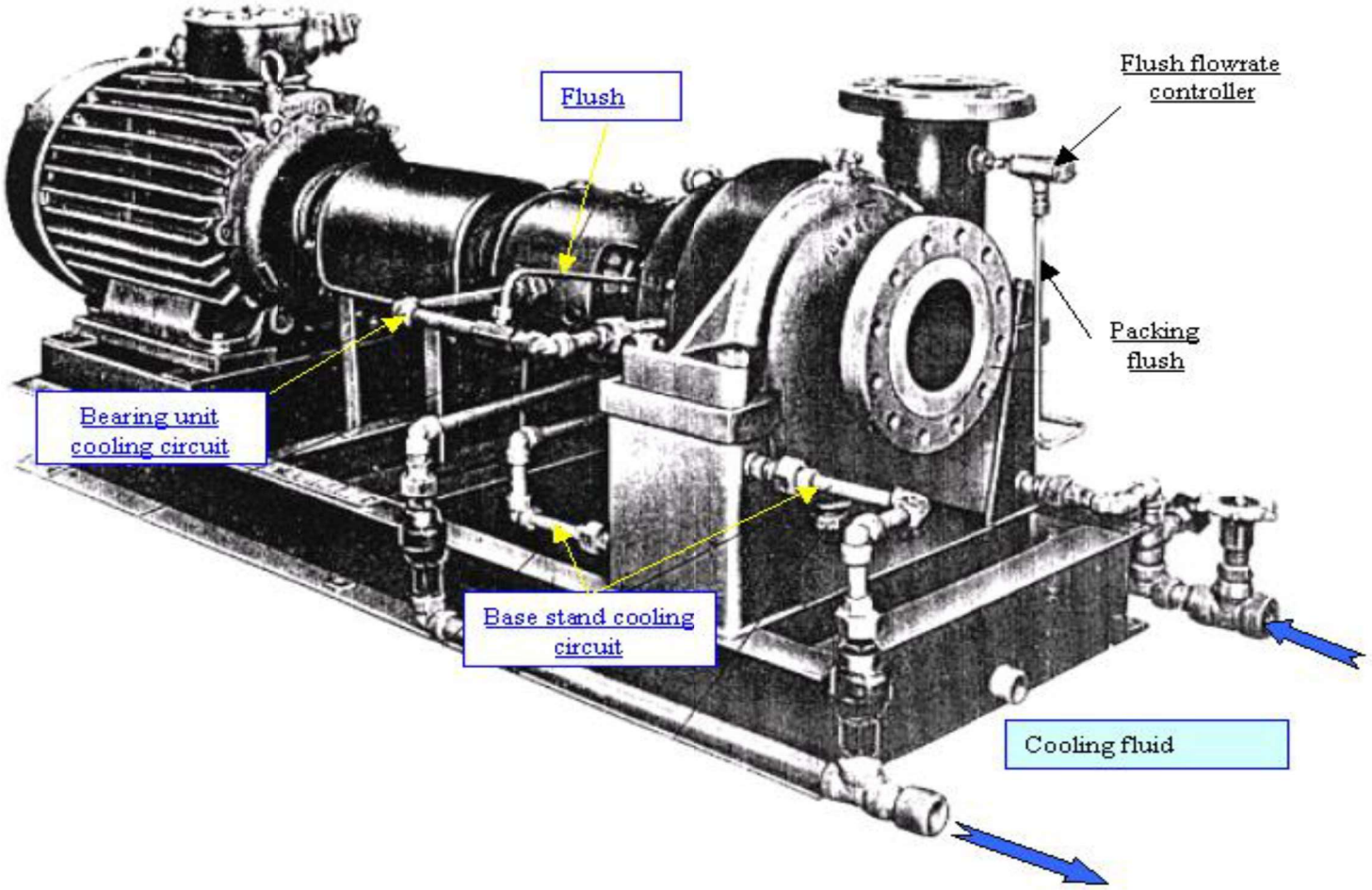
Pump auxiliaries and accessories

- **Sealing function**



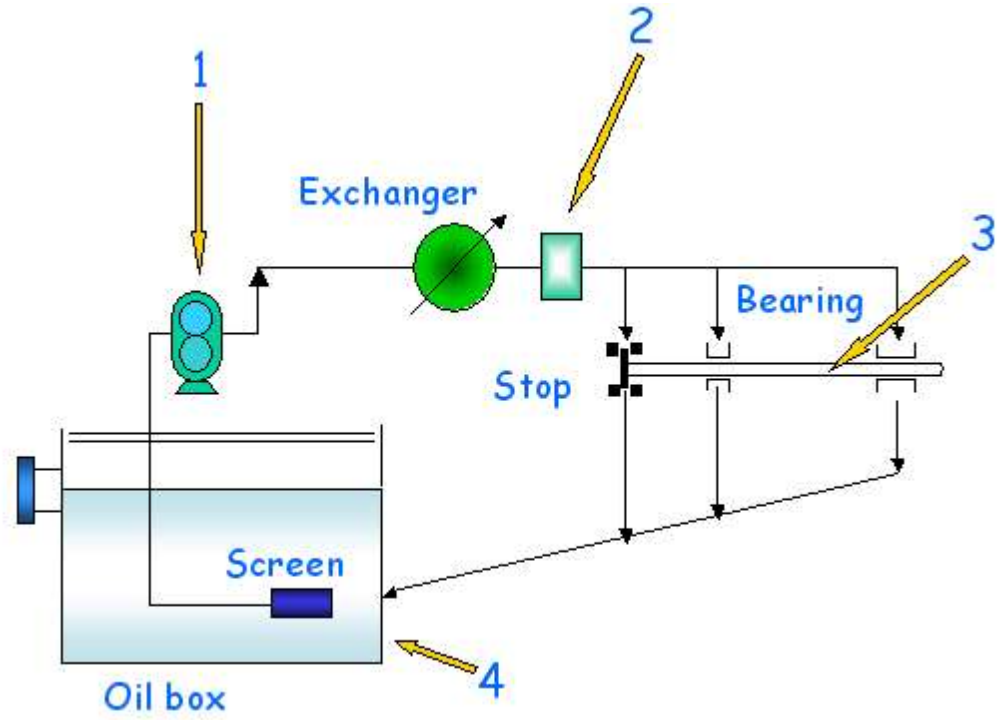
Pump auxiliaries and accessories

- **Cooling function**



Pump auxiliaries and accessories

- **Forced lubrication system**



1. Lube oil pump coupled with the machine, 2. Oil filter,
3. Lubricating points (bearing), 4. Oil reservoir

Operating parameters & normal operation

Operating parameters and normal operation

- **Normal Operation**
  - The operator must monitor the following elements whilst the machine is in operation:
  - **For centrifugal pumps**
    - The outlet pressure
    - The suction pressure
    - The pressure difference in the suction filter.
    - The bearing temperature
    - Abnormal noises (water hammer, cavitation)
    - Mechanical leaks
    - The average cooling temperature
    - The oil lubrication system (pressure, temperature and level)
    - The power consumption in amperes (intensity)
    - Less vibrations

Operating parameters and normal operation

- **Normal Operation**
  - **Volumetric pumps**

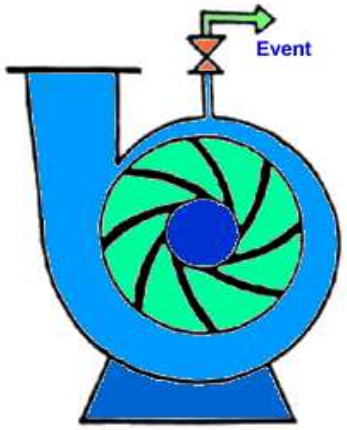
    - The outlet pressure
    - The suction pressure
    - Leaks in the pump.
    - The oil lubrication system (pressure, temperature and level)
    - The cooling system
    - Check safeguarding system.

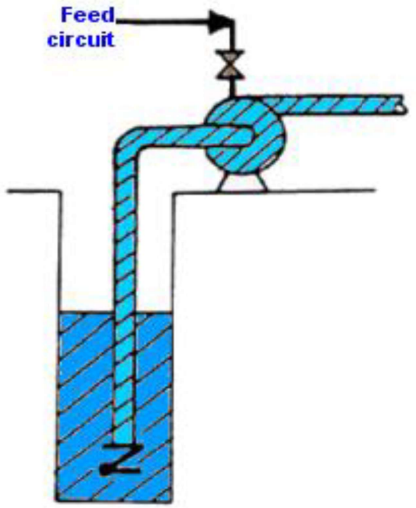
  - In addition, a certain number of hydraulic problems may disturb, or even prevent, the correct operation of the pump.
  - This is notably the case **at the time of initiation** in the event of **water hammer** or **cavitation.**

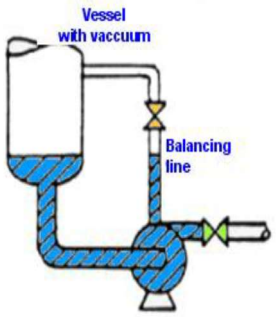
Operating parameters and normal operation

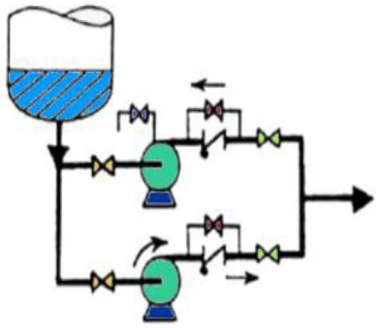
- **Pump priming**

- For a pump to be operational, it must provide sufficient pressure, which is not possible when it is full of air.
- By “purging” the air (or the gas) from the pump, the priming (or initiation) of the pump is ensured.





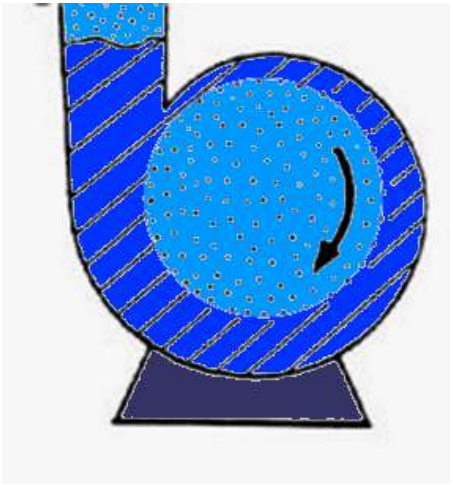




Operating parameters and normal operation

Cavitation

- If the **liquid input pressure at the wheel is lower than the vapour pressure**, **partial liquid vaporisation will** occur, which is reflected in the creation of gas bubbles (cavities).
- These bubbles, which are carried by the liquid, move in the wheel and are therefore subject to increasing pressures.
- The bubbles implode. The shock created by the bubbles bursting destroys the walls of the elements in contact with the fluid. A cavitation pump soon becomes worn.



Operating parameters and normal operation

- **Preparing Centrifugal pumps for initial start-up**
  - Ensure the pipes are clean
  - Ensure a filter is installed
  - Check the correct alignment of the suction and discharge flanges compared with the corresponding flanges on the pump to prevent the pump body being placed under pressure
  - Ensure that the pump is rotating freely
  - Verify the correct pump / motor alignment
  - Check the rotation direction
  - Check the filling of the pump, purge the pump body and the Packing quenching pipes
  - Check the greasing of the bearings

Operating parameters and normal operation

- **Checking Centrifugal pumps after start-up**
  - Check the packing leaks with correct dripping rate. A pump gland should drain
  - Check the suction and discharge pressures
  - Manometer pulsations and suction noise
- **Preparing Volumetric pumps for initial start-up**
  - Volumetric pumps generally are brought into service in a very similar way. However, it is important to remember that this type of pump must always be started with the suction and discharge valves open

Operating parameters and normal operation

- **Analysis of symptoms**
  - **Normal noises**
    - Noises due to fluid flowing through the piping
    - Noises originating in the pump wheel
      - Hydraulic shocks at the blade input
      - Passage of blades in front of the volute tongue or in front of the diffuser blade inputs
    - Bearing noises
    - Whistling noises caused by throttling (diaphragms - valves – compressor valves)
    - Motor noises
      - Ventilator
      - Bearings
      - magnetic noises

Operating parameters and normal operation

- **Abnormal noises**
  - **Noises of mechanical origin**
    - bearings (rolling or smooth bearings)
    - vibrations (pneumatic drill noise)
    - coupling noises (worn stops, poor lineage, caulked or worn serration)
  - **Noises of electrical origin**
    - Modulated overload noise which is very difficult to distinguish and analyse
  - **Noises of hydraulic origin**
    - Noise when passing through excessively narrow areas or obstacles
    - Blocked filter noise (hissing).
    - Cavitation noise (an identical noise is caused when gravel passes through the pump)

Operating parameters and normal operation

- **Vibrations**
  - **In the past, inspectors used to "check" the vibrations of a machine :**
    - Directly by hand
    - By listening to the machine (screwdriver, pencils, etc.)
    - By conducting the coin test
  - **Nowadays, proper measuring tools are used which allow for:**
    - The determination of the wear and tear of a machine
    - The determination of the deficient part of the machine, which is sufficiently precise to allow for the monitoring of the development of each machine.

Operating parameters and normal operation

- **Leaks**

  External leaks

  - **Braided pump gland –** the water should always drain **–** the pump gland should be lubricated with a normal leak
  - **Mechanical packing** - the film between the two friction surfaces is constantly renewed but no leak is apparent
  - **Joints –** poorly tightened or broken joint

  Internal leaks

  - Liquid film in the pumps balanced by a disc and counter-disc
  - Worn seal rings = internal recirculation

Operating parameters and normal operation

- **Altered parameters**

A further point to mention is the case where the pump no longer performs to its previous level.

This may be due to:

- Incorrect information provided by the manometer
- An upstream or downstream restriction.
  Example: blocked suction Filter
- A change in the fluid composition

Abnormal conditions and troubleshooting

Abnormal conditions and troubleshooting

- **Troubleshooting - What to do if...**

  Zero flow

  - Pump not primed
  - Insufficient speed (check the motor)
  - Insufficient NPSH
  - Wrong rotation direction
  - Air pockets in the suction pipes

Abnormal conditions and troubleshooting

- **Insufficient flow rate**
  - Air input at the suction point
  - Insufficient speed
  - Manometric height of the equipment greater than intended
  - Partially blocked impeller
  - Insufficient suction pressure (cavitation)
  - Worn seal rings or damaged impeller
  - Foot valve too small or not seal
  - Foot valve not sufficiently immersed

Abnormal conditions and troubleshooting

- **Insufficient pressure**
  - Air input in the suction pipes
  - Emission of air or vapour in the pipes
  - Same mechanical faults as above: seal rings – impeller

- **Unpriming in operation**
  - Air input in the suction pipes
  - Excessive suction height
  - Emission of air or vapour in the liquid
  - Air input in the stuffing box

Abnormal conditions and troubleshooting

- **Pump vibration**
  - Poor alignment
  - Insufficient foundations
  - Foreign bodies in the impeller leading to imbalance
  - Mechanic faults – non-aligned shaft
  - Friction of internal elements
  - Wear and tear of roller bearings
  - Pump without water/fluid
  - Cavitation

Abnormal conditions and troubleshooting

- **How can cavitation be rectified?**

  When a pump cavitates, it is generally due to a pressure drop at the suction point. It is therefore necessary to re-establish a correct pressure.

  Verify:

  - The total opening of the valves between the aspirator bottle and the pump
  - The level of the aspirator bottle
  - The loss of head in the filter
  - Moderate flow rate
  - The temperature and quality of the product
  - An excessive internal clearance in the seal rings caused by wear and tear or an imperfect repair.

Abnormal conditions and troubleshooting

What are the possible sources of cavitation?

- Tank level too low at suction point
- Accidental obstruction in the suction circuit
- Unplanned increase in water temperature
- Unnoticed opening of an outlet valve
- Accidental increase in flow rate
- Wear and tear of the pump wheel
- Damage to seal rings of the pump

- A pump may operate for a very short period with cavitation
- This situation should not be prolonged
- The damage is generally very rapid (depending on the
- material). So, stop the machine.

Abnormal conditions and troubleshooting

Why can the pressure fall so low?

- Increase in head loss at the suction point
- Increase in suction height
- Suction in a vacuum tank
- Insufficient head
- Increase in the temperature of the liquid transmitted

Abnormal conditions and troubleshooting

- **Safety measures for pump maintenance/ repair**
  - Stop the pump
  - Isolate the electrical power (use the electrical isolation procedure)
  - Close the suction and discharge valve
  - Depressurise the suction and outlet lines
  - Respect the safety procedures recommended on the work permit.


THANK YOU
FOR YOUR ATTENTION