Pumps & Motors

Pre-certification

Archimedes Pump
- First invented by Archimedes of Syracuse (287 BC – 212 BC)
- Called the Egyptian Screw
- Used to pull water from the Nile River to irrigate the Nile Delta.

Human Heart

Pump Classes
- Centrifugal is most commonly used & is a velocity type pump
- Positive displacement

Frame Mounted Pumps
- Are a horizontal pump
- Pump and Motor bearings are independent of each other
- Motor can be replaced without removing pump piping

Close Coupled Pumps
- Are a horizontal pump
- Impellers are supported by the motor bearings
- Piping in most cases needs to be removed to access impeller
Vertical Lineshaft Pumps
- Lineshaft Turbine
- Can Turbine
- Submersible
- Axial Flow

Lineshaft Turbine - Water Lube

Lineshaft Turbine - Oil Lube

Can Turbine
- Operates in flooded suction or pressure condition

Submersible

Axial Pumps
**Bowls**
- Impellers Located in Bowls
- Multi-stage – bowls add pressure not volume
- Flow is restricted to the size of the bowl

**Diffuser Vanes**
- Diffuser vanes convert velocity to pressure

**STUFFING BOX**
- Packing or mechanical seal
- Lantern ring
- Packing glands
- Seal water - 5 psi higher than maximum suction pressure

**External Seal Water**
- Clean water source
- Used when pumped water has grit in it
- Needs to be turned on several minutes before starting pump
- Should have backflow preventer on clean water source.

**Impellers**
- Vertical Pump Location

**Positive Displacement Pumps**
Impellers

- Horizontal Position

- 3 types - open, semi-open, & closed
- Heart of the pump
- Made from metal, plastic, rubber
- Impeller eye - low pressure zone
- Suction of water is created at the center of the impeller, then it is pushed away from impeller by centrifugal force

Open Impellers

Semi-Open Impeller

Closed Impeller

Pump Rotation
**Volute Case**
- Houses the impeller
- Curved vanes inside volute case are called volutes & convert velocity energy to pressure energy.
- Should be primed full of water on start up

**Wear Rings**
- Keep water from recirculating from the high pressure zone to the low pressure zone.
- Used to protect the volute case and impeller from wear.
- Worn rings cause recirculation of water costing more to operate.

**Wear Ring**
- Worn out wear ring

**Split Case Pump**
- Wear Rings act as a restriction between the impeller discharge and suction areas.

**LANTERN RING**
- H-shaped cross section
- Made of metal or plastic
- Located inside the stuffing box where seal water enters
- Not used with a mechanical seal
- Allows water to flow evenly through the packing

**Seal Water**
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SHAFT
- Driven by motor to turn & support the impeller
- Shaft sleeve - pressed on the shaft, located inside stuffing box
- Shaft sleeve is an expendable part used for wear

No Shaft Sleeve
- Worn shaft that had no sleeve

Worn Shaft Sleeves

CENTRIFUGAL PUMP COMPONENTS

BEARINGS
- Anti-friction bearings
  - Roller bearings
  - Ball bearings
- Manufacturer determines type & frequency of lubrication
- Sleeve bearings

Proper Bearing Lubrication
- Remove plug in grease relief port
- Press new grease into grease fitting displacing old grease
- Allow motor to run and let excess grease exit
- Replace plug in grease relief port
External Seal Water
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BALL BEARINGS
- Outer Ring
- Inner Ring
- Cage
- Rolling Element

ROLLER BEARINGS
- Supports radial loads and/or thrust loads depending on the design and where the rolling elements are placed

ROLLER TYPE BEARINGS
- Roller Bearings
- Needle Bearings

Sleeve Bearings
- Located in Spider

SHAFT SEALS
- Packing
- Mechanical seals
- Separate the wet from dry end of the pump
- Mechanical seals are for high suction head, metal packing can also be used
PACKING
- Should be adjusted to allow a steady drip of water from the packing gland
- Made out of braided animal, flax, plant, mineral or synthetic material
- Impregnated with some type of lubricant
- Comes in contact with shaft sleeve

PACKING CONDITIONS
- **CONDITIONS**
  - Less than 100 psi or 1000 FPM
  - Above 100 to 150 psi or 1000 to 2000 FPM
  - Above 150 psi or 2000 FPM
- **PACKING**
  - Plant fibers lubed with Teflon, silicon, TFE, or PTFE
  - Graphite, acrylics, TFE, kevlar, PTFE, & carbons
  - Metal, packing with metal cores or combination of synthetics & metals.
  - Asbestos no long used

PACKING PROCEDURE
- Remove old packing, never stack new on top of old
- Cut in scarf or butt cuts
- Cut 1/16 - 1/8 shorter than shaft circumference
- Lubricate 1st ring & seat at the bottom of the stuffing box
- Stagger rings 90 degrees
- Line lantern ring with seal water
- Finger tight adjustment nuts

MECHANICAL SEALS
- Located inside stuffing box
- Two surfaces: one is stationary and the other is rotating
- Stationary surface is made of a harder material than the rotating surface
- Spring keeps tension on the surfaces
- Seal components must match properly

START-UP
- Rotate shaft by hand
- Run seal water 15 min. prior to start up
- Finger tight adjusting nuts
- Start pump, run 15 min., don’t adjust
- Adjust nuts equally, 1/6 turn every 15 min., until desired leakage is reached
- Stuffing box should be cool
START-UP
- Check valve positions
- If pump has set for an extended period of time, the shaft should be turned to oil the bearings
- Check oil levels, amp readings, volt readings, flows, well info., Comments

SLINGER RING
- Made of either leather or rubber
- Fits on shaft near the motor
- Prevents water from entering the motor bearings

COUPLINGS
- Connect shafts of different diameters
- Transfer energy
- Most allow for slight misalignment
- Absorb starting torque
- Dampen vibrations
- Insulate units from electrical current
- Allow for end movement of shafts

ALIGNMENT TECHNIQUES
- Straight edge and feeler gauge
- Dial indicator
- Severe vibration upon pump start up would indicate misalignment between motor and pump shafts

PUMP MAINTENANCE
- Oil Drip rate = 5 drops per minute
- Use approved food grade mineral oil
- If a pump has been pulled for repair, you must have satisfactory bac-t results before putting back in service

Pump Station Flow
- Each pump must be able to deliver the maximum flow of the station
- Make sure the shaft bearings are wet before starting the pump
- Flow increases with decreased pressure head
- Alternating pump operation will help keep windings dry & serviceable
- Booster pumps fill tanks & supply pressure to mains
PUMP WEAR AND TEAR
- Pumps condition can be checked by comparing performance when new.
- Wear is the main cause of loss in pumping efficiency.
- Pump will run longer because of wear, increasing power costs.
- Particles from wear can be seen in cooling water from stuffing box.

PIPING
- Eccentric reducer - suction side
- Concentric increaser - discharge side
- Eccentric installed with the flat side up, reduces air entering casing & one size larger than suction inlet.
- Concentric increases pipe one size, reducing velocity and head loss, for higher pump efficiency.
- Should be drained in freezing conditions & when the pump is shut down for long periods of time.

REDUCERS & INCREASERS

VALVING
- A check valve prevents the shaft from spinning backwards and causing damage to the pump.
- If no check valve, you can start and stop a pump with the discharge valve closed to prevent water hammer by opening it slowly.

CHECK VALVES
- Swing Check Valve
- Silent Check Valve
- Keep pump from spinning backwards.

Pump Control Valves
**Foot Valves**
- Located at the bottom of suction pipe to hold prime

**Air Vacuum Release Valves**
- Air vacuum release valves - prevent vacuum conditions during shut-down, they also release air pockets during start-up.
- Placed at high points of the system

**RATCHETING DEVICES**

**Motor Maintenance**
- Follow manufacturer’s recommendations
- Over greasing - grease acts like an insulator, holding in heat, causing premature bearing failure
- Two most common speeds are 1800 and 3600 rpm
- Oil seals hold in the lubricant

**Pump Motor Operation**
- Motor could overheat with low head pressure
- In a low pressure head situation, throttling the discharge valve would cool the motor cool down due to the increase of pressure head
- Losing a phase on a 3-phase motor would cause the motor to single phase and heat up.
- Voltage imbalance can cause the motor to overheat & burn out windings
- Blow dust off to clean motor housing
- Brake HP is HP supplied by the motor

**Vertical Motors Cutaway**
TROUBLESHOOTING

- Losing a phase on a 3-phase pump:
  * motor would continue to run
  * motor would overheat
  * damage could occur

Cavitation

- Main cause of losing pump suction
- Sounds like pumping rocks or pinging
- Vibration & popping noises caused by low pressure in volute
- Generally caused by vapor bubbles
- Vapor bubbles implode causing damage to pump
- Volute case needs to be full of water
- Prevented by having adequate suction pressure and proper bowl depths

Types of Cavitation

- Vaporization of the liquid in volute
- The "vane passing syndrome" from too small an impeller
- Too high suction speed
- Air ingestion on the suction side of the pump
- Turbulence of the fluid

Priming a Pump

- Priming displaces the air in the volute case
- Helps the pump create suction so the pump will pump
- It also helps reduce cavitation
TROUBLESHOOTING

- Bearing failure is first detected by a change in operating sound of the pump and vibration.

Accurate Record Keeping

- Shows loss of pumping efficiency along with record of flows & pressures.
- Shows drawdown levels to evaluate condition of the well.
- Drawdown level is elevation difference between static & pumping levels.
- Helps determine proper depths for bowls.
- Shows when preventive maintenance or repairs were last performed.

Well Seals

- Well casing maintains an open hole for the well.
- Sanitary seal - all openings around well head are sealed off to prevent contamination.

Well Casing

- Well casing perforations provide a way for water to enter pump.
- Well casing helps protect the quality of the water.
- Surging a well form of plunging or cleaning the gravel pack around the screen.

WELLS

- Well casing size is determined by the amount of water that is safe to yield.
- Acidizing a well is a process used to rehabilitate a well for higher flows.
- When a well pump is not running, the level of the water is the static level.
- After a well pump runs for a period of time, the level is known as the pumping level.

Pressure Head

- Pressure at which a pump operates against expressed as feet of head or head feet.
- Total static = static discharge head - the static suction head.
- Static suction head is the height of the water above the suction inlet & is the pressure created by elevation or depth.
- When calculating total dynamic head, static discharge head is part of the equation.
- The total operating head is the vertical distance of pumped water along with all other head losses.
Pump Curves

- Generally show capacity (flow rate), total head, power (brake horsepower), and efficiency
- The pressure at which a pump operates against is head pressure

Flooded & Lift

- Suction lift is the water level on the inlet side of the pump that is lower than the pump
- Suction lift should be limited to 15 feet
- Flooded means the pump has either an elevation of head feet or water system pressure to operate with

Hydraulic Gradient
HYDROPNEUMATIC TANKS

- Operate by applying air pressure to tank
- Tank levels controlled by pressure switches to pumps
- Air leaks can cause pumps to cycle on and off
- 1/3 to 2/3 air to water ratio limiting storage capacity

Positive Displacement Pumps

- Suction and discharge valves must be open all the way
- Used mainly for chemical dosing
- Not velocity-type pumps

Peristaltic Pumps

PISTON PUMP

Bilge Pump
Diaphragm Pump

Double Diaphragm Pump

Screw Pump

Progressive Cavity

Rotary Lobe Pump