Troubleshooting Pumps

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Troubleshooting Pumps

MMS 9470

7 Contact hours

9 CC10 hours

Operators will be introduced to the basic troubleshooting skills needed when a centrifugal pumps shows signs of failure. The course includes a review of basic hydraulic terminology and component functionality. Additionally, a study of a typical pump curve and a discussion of water, brake and motor horsepower will provide the operator with a background in centrifugal pumps and their operating principles. Troubleshooting typical centrifugal pump problems based on given symptoms will be covered in detail.

Describe the relationship of feet of water, inches of vacuum, head and force.
Describe NPSH Available & NPSH Required
Describe the centrifugal pumps fundamental operating principle
Describe the typical component and their function
Read and interpret a gauges and a pump curve.
Troubleshooting pump related problems based on symptoms.

Review common hydraulic terms. 60 min.

- atmospheric pressure, cavitation, head (dynamic, static, friction).
- pressure (absolute and gauge) & vacuum
- vapor pressure
- Suction lift, Flooded Suction

Describe the relationship of feet of water, inches of vacuum, head and force. 60 min.

- atmospheric pressure vs. feet of water
- vacuum vs. feet of water
- pressure & feet relationship
- Calculation psi/head & inches mercury/head

Describe NPSH Available & NPSH Required 30 min.

- $NPSH_A$ / $NPSH_R$
- Flooded suction vs. suction lift determination

Describe the centrifugal pumps fundamental operating principle. 30 min.

- Positive displacement vs. Variable displacement
- Classification of variable displacement pumps.
- What is centrifugal force

Describe the typical component and their function. 90 min.

- Impeller
- Casing / volute
- Seal

- Bearings
- Wear ring
- Pump Priming

Read and interpret a gauges and a pump curve. 30 min.

- Head vs. capacity
- Efficiency
- Brake Horsepower
- $NPSH_R$
- Water, Brake & Motor horsepower
- Pressure Gauges & gauge reading / interpretation.

Troubleshooting pump related problems based on symptoms. 90 min.

- Operator troubleshooting tools
- Problems and their cause
- Component failure/symptom and cause

Post Test & Review 30 min.

Total: 420 min.

TROUBLESHOOTING CENTRIFUGAL PUMPS

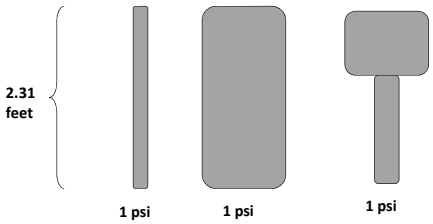
Tom Spalding

Please put phones on vibrate

Pump Hydraulic Terms

- **Atmospheric Pressure:** Weight of atmosphere at sea level = 14.7 psi
- **Cavitation:** Water vapor implosions
- **Dynamic:** In motion, pumping.
- **Feet of Water:** Measurement of head. 1 psi = 2.31 feet of water.
- **Friction Head:** Head expressed as feet required to overcome friction through a pipe system. Factors: size, length, flow, diameter, "C" factor, viscosity,
- **Head:** Pressure or resistance to flow.

Feet of water vs Pressure



Force = psi X's area Which figure has the greater force?

Pump Hydraulic Terms

- **NPSH (Net Positive Suction Head):**
  - $NPSH_R$ and $NPSH_A$
- **Pressure:** The force exerted per unit area.
  - PSI = Pounds per square inch
  - Atmospheric =14.7 psi (sea level)= 33.9 feet **lower as elevation increases
  - Gauge = corrected pressure less atmospheric (14.7 psi absolute, 0 psi gauge).
  - Absolute = Gauge psi + Atmosphere psi
- **Static Head:** At rest. Not pumping
- **Vacuum:** Is a pressure less than atmosphere.
  - 14.7 psi = 33.9 feet = 30"mercury = 1.13 feet per inch of mercury.
- **Vapor Pressure:** Related to the liquid temperature

Net Positive Suction Head

$NPSH_R$:

Net Positive Suction Head Required – *Design*

$NPSH_A$;

Net Positive Suction Head Available - *Actual Conditions*

Available must be greater than Required !!!! Cavitation

CAVITATION

- Cavitation is the formation and collapse of air bubbles within a pump
- It can occur in both positive displacement and centrifugal pumps
- This can cause noise and internal damage to the pump

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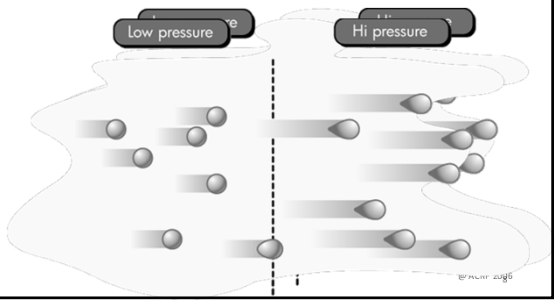
CAVITATION occurs when the impeller vaporizes the water creating air bubbles that implode when entering the high pressure side of the pump



When these air bubbles implode, the surrounding water slams into the pump interior, eroding the metal.

Causes of Cavitation

- Usually a result of
  - A loss or reduction of suction pressure
  - An increase in fluid velocity
  - Discharge pressure too high or too low

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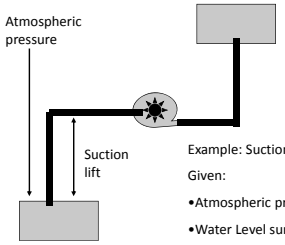
Net Positive Suction Head Available



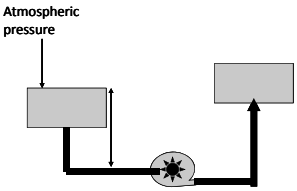
Example: Suction lift application.

Given:

- Atmospheric pressure = 14.7 psi = 33.9 feet.
- Water Level surface to centerline of pump is 20 feet.
- Friction loss (FL) in suction pipe = 1.5 feet

$NPSH_A$ = 34 feet - 20 feet lift -1.5 feet FL = 12.5 feet

Net Positive Suction Head Available

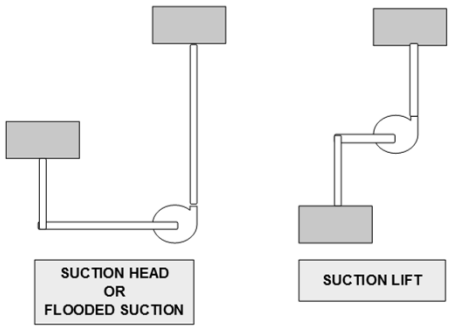


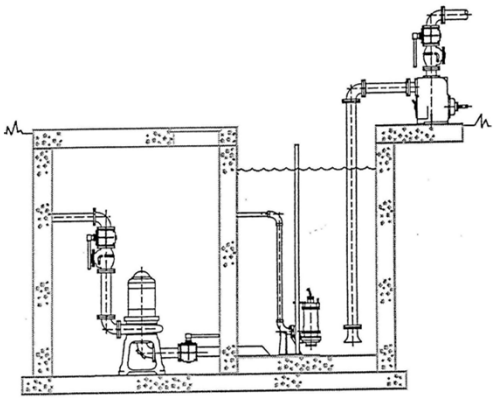
Example: Suction Head application.

Given:

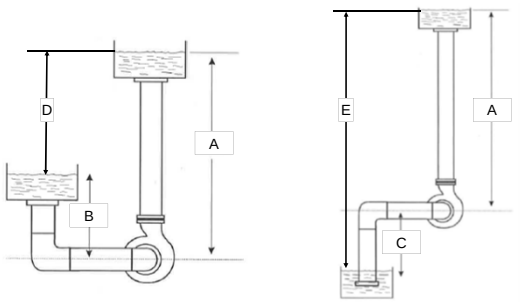
- **Atmospheric pressure = 14.7 psi = 33.9 feet (34 feet).**
- **Water Level surface to centerline of pump is 10 feet.**
- **Friction loss (FL) in suction pipe = 1.0 feet**
- **$NPSH_A$ = 34 feet + 10 ft head – 1.0 feet FL = 43 feet**

Classic Pump Installations





Static & Dynamic Head



Static Suction Head - Static Suction Lift - Static Discharge Head – Total Static Head

Dynamic Suction Head - Dynamic Suction Lift - Dynamic Discharge Head – Total Dynamic Head

TDH refers to:

a. Elevation head
b. Pressure head
c. Velocity head
d. a and b only
e. a, b and c
f. None of the above

Pump Types

- **Positive Displacement**
- **Variable Displacement**

Variable Displacement

- **Centrifugal**
- **Regenerative Turbine**

Centrifugal Pump

Flow or Capacity Depends On

Pump Design

Speed

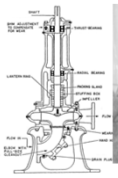
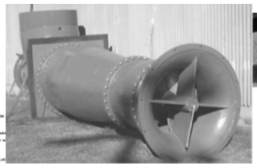
Impeller Diameter

Total Dynamic Head

Centrifugal Pump

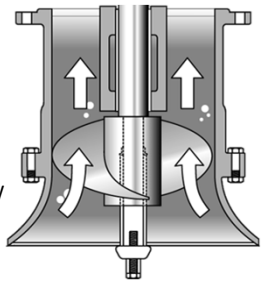
Pump Flow Patterns

- **Radial Flow** – Discharge 90 degrees to the suction
- **Axial Flow** – Water is pushed upward by propellers
- **Mixed Flow** – combination of Radial & Mixed flow

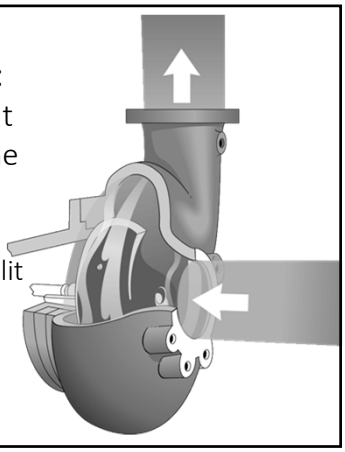

AXIAL FLOW:
Energy is applied in line with the shaft.

Provides high flow at low pressure



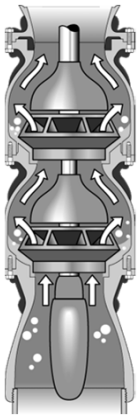
RADIAL FLOW:
Energy applied at right angles to the flow

End Suction and Split Case Pumps

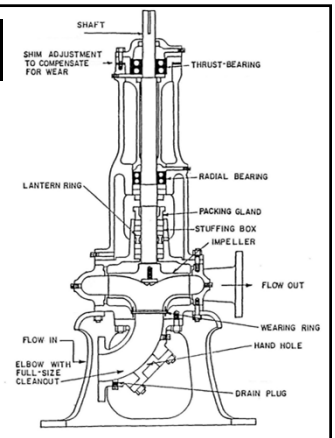


MIXED FLOW:
Imparts both axial and radial flow

- Lineshaft turbines
- Submersible turbines



- Lantern Ring
- Stuffing Box
  - Packing
  - Mechanical Seal
- Shaft Sleeve
- Bearings
  - Radial
  - Thrust
- Wearing Ring

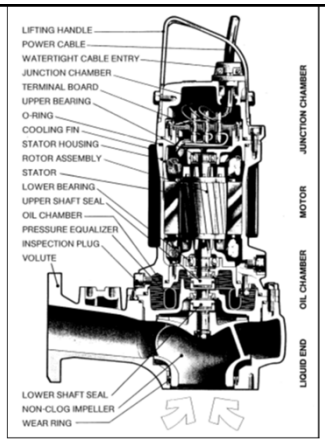


How do you know when it is time to replace the packing?

Packing Gland is all the way down, or the leak cannot be controlled

Leakage from a packing gland should be approximately?

One drop per second



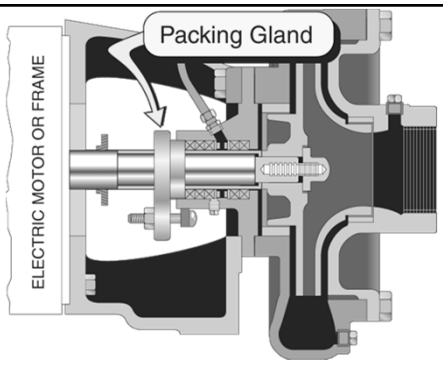
Centrifugal Pump

Impellers

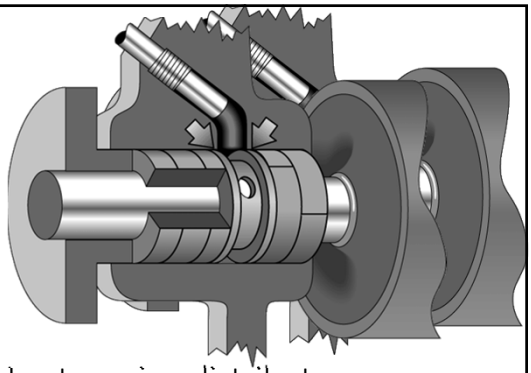
OPEN **SEMI-OPEN** **ENCLOSED**

Centrifugal Pump
Mixed Flow Impeller

Variation of the axial Flow
Capable of slight suction lift
Operate at lower speeds

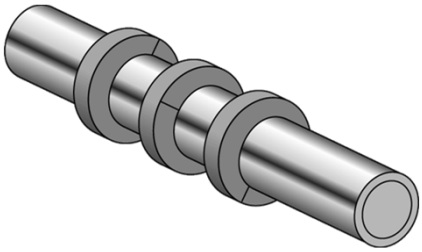


Packing gland compresses packing and controls leakage

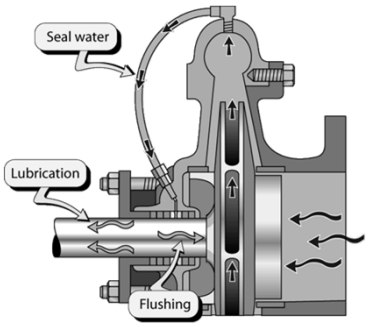


Lantern ring distributes seal water

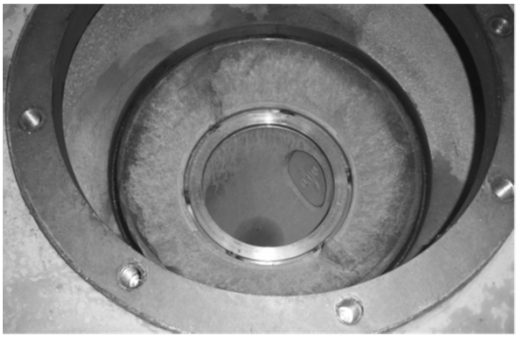
Packing joints must be staggered



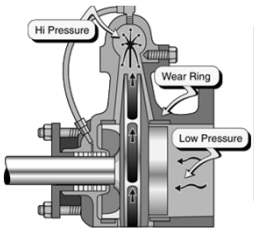
Controlled leakage is required to lubricate and flush the packing

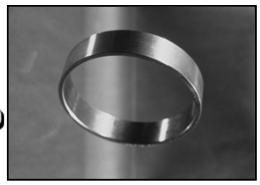


Wear Ring

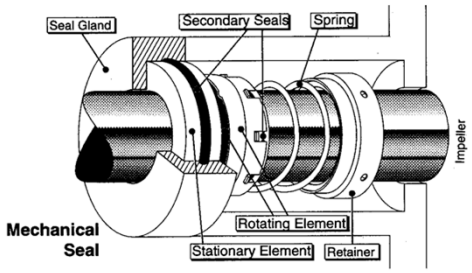


WEAR RINGS





Mechanical Seal



Advantage: no leakage

Centrifugal Pump

Split Case Pump

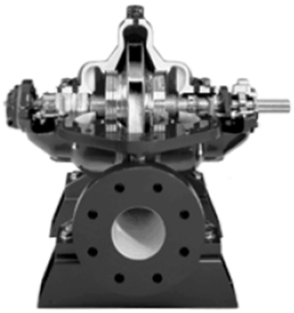
Double suction impeller

Two wear rings

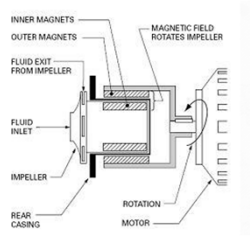
Two seals

Typically clean water pump

Easy view of parts

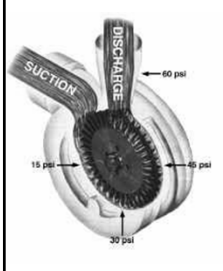


Magnetic Drive Pump



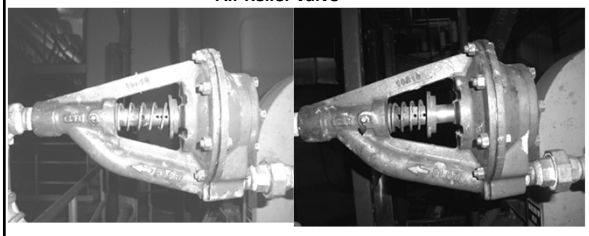
Centrifugal Pump

Regenerative Turbine

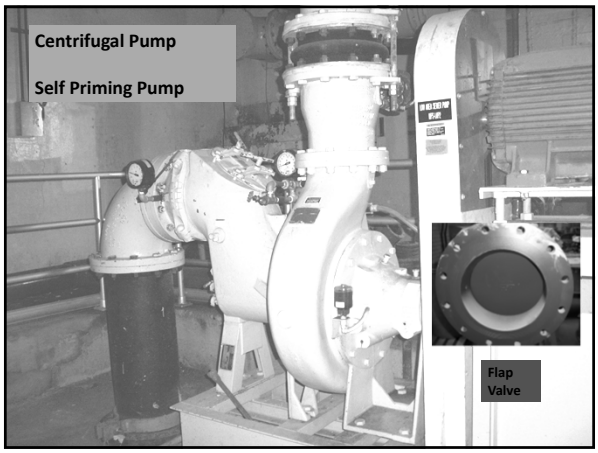


Pump Priming

Air Relief Valve



What are other methods used?



Pressure Gauges

- Importance of Gauges
- Pressure Conversions
- Type of Gauge
- Gauge Mounting
- Determining Total Dynamic Head (TDH)
- Pressure Gauge As Indicators

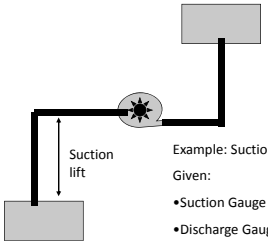
Gauge Readings

Static

Dynamic

Suction Lift

TDH = Discharge Pressure + Suction Vacuum



Example: Suction lift application.

Given:

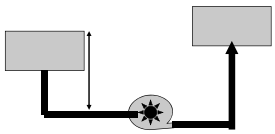
•Suction Gauge reading = 5" mercury (5.6 ft.)

•Discharge Gauge reading = 20 psi (46.2

TDH = 46.2 feet + 5.6 feet = 51.8 feet

Suction Head

TDH = Discharge Pressure - Suction Pressure



Example: Suction lift application.

Given:

•Suction Gauge reading = 10 psi = 23.1 feet

•Discharge Gauge reading = 20 psi = 46.2 feet

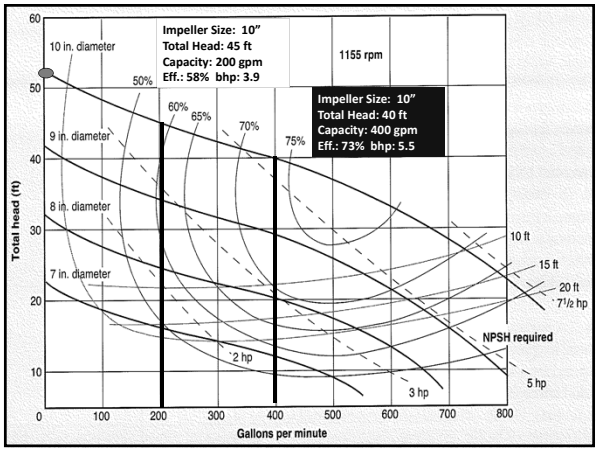
TDH = 46.2 feet – 23.1 feet = 23.1 feet

Pressure Gauges As Indicators

Discharge Pressure ↑ Suction Vacuum ↓
Problem is on the discharge side of the pump

Discharge Pressure ↓ Suction Vacuum ↑
Problem on suction side of pump

Discharge Pressure ↓ Suction Vacuum ↓
Problem is inside the pump

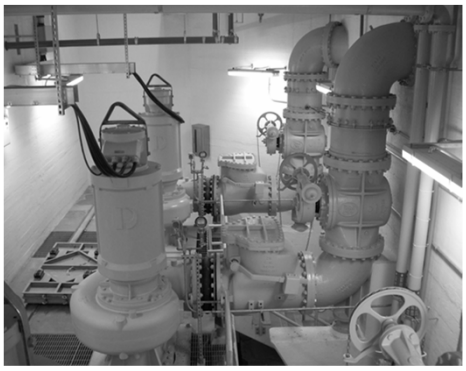


A centrifugal pump operated at the far right of its pump curve will:

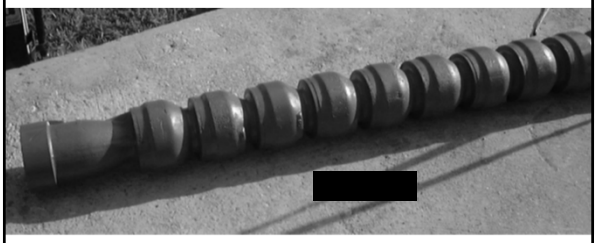
a. Run very inefficiently
b. Cavitate
c. Trip the breaker
d. All of the above
e. None of the above

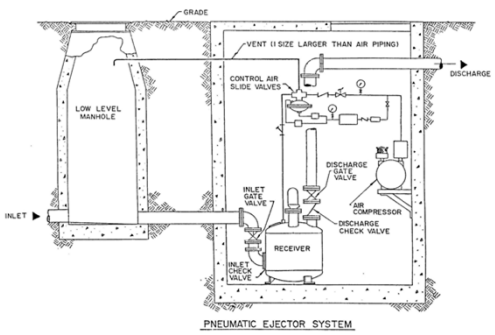
What about operating to the far left of the curve?

PUMPS or IMPELLERS IN PARALLEL INCREASE FLOW



PUMPS or IMPELLERS IN SERIES INCREASE PRESSURE





PNEUMATIC EJECTOR SYSTEM

A pneumatic ejector transports liquids using:

a. An air compressor
b. An axial flow pump
c. A centrifugal pump
d. A plunger-type pump

TROUBLESHOOTING TOOLS

- Operator
- Pressure Gauges
- Tachometer
- Time meters & Flow Meters
- Operating Records
- Performance Curves
- Other Tools

Causes of Problems

- Misapplication
- Vortexing
- Clogged Suction Pipe
- Clogged Impeller
- Clogged Discharge Pipe
- Cavitation
- Worn – Impeller, Wear Plate, Volute

Bearing Failure

- Poor Lubrication
- Fatigue
- Faulty Mounting
- Contamination / Dirt / Water
- Misalignment
- Defective shaft or housing
- Vibration
- Electrical Pitting

Packing Failure

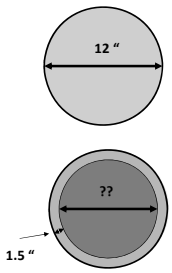
- Wrong size or type
- Excessive Abrasive Material
- Pump Conditions
- Loss of Lubricant

Mechanical Seal Failure

- Pump Conditions
- Wrong Seal for installation
- Scratched seal face
- Loss of Lubricant

Flow Rate / Velocity / Area

- Q = V x A
- A = π x r ^{2} or .785D 2
- Pipe Wall Buildup
- Area Reduction
- Velocity Increase
- Flow Decrease
- Determine Velocity Difference in these two pipes.



Troubleshooting

- PUMP WILL NOT START
  - Auto control not functioning properly
  - HOA switch in OFF
  - Shaft is binding: rubbing impeller, tight packing gland, or pump clog
  - Electrical problems (call electrician)
    - Lost a phase if 3-phase motor
    - Fuse blown or breaker tripped

Troubleshooting

- NO FLOW, REDUCED FLOW
  - Pump not primed
  - Air mixed in wastewater
  - Motor speed too low
  - Impeller clogged
  - Discharge line clogged
  - Air leaks in suction line or packing box
  - Suction inlet too close to water level (Vortexing)
  - Valves partially closed
  - Check valve clogged
  - Impeller damaged, turning on shaft (key)
  - Flexible coupling broken

A pump's discharge is less than expected. Which of the following is NOT a possible cause?

a. Check valve stuck
b. Discharge head too low
c. Impeller clogged
d. Pump not primed
e. Speed of motor too slow

Troubleshooting

- HOT MOTOR OR HIGH AMP DRAW
  - Break in force main
  - Pump operating at lower rate than designed for
  - Specific gravity or viscosity of pumped liquid too high
  - Pump is clogged
  - Packing boxes are too tight
  - Wear rings are binding
  - Impeller is rubbing
  - Lost a phase if a 3-phase motor (call electrician)

Troubleshooting

- NOISY PUMP and / or PIPING
  - Pump not primed
  - Inlet clogged (cavitation)
  - Inlet not submerged (air binding)
  - Pump not lubricated
  - Debris in pump
  - Pump mounting loose
  - Discharge valve partially closed
  - Coupling misaligned
  - Bearing failure

Causes of Bearing Failures

- Fatigue
- Poor lubrication
- Faulty mounting
- Contamination
- Dirt intrusion
- Misalignment
- Defective shaft / housing
- Vibration
- Electrical pitting

HORSEPOWER

Water Horsepower (WHP) = $\frac{100 \text{ gpm} \times 39.6 \text{ Ft}}{3960}$ = 1whp

Brake Horsepower (BHP) = $\frac{100 \text{ gpm} \times 39.6 \text{ Ft}}{3960 \times .72 \text{ PE}}$ = 1.39 bhp

Motor Horsepower (MHP) = $\frac{100 \text{ gpm} \times 39.6 \text{ Ft}}{3960 \times .72 \text{ PE} \times .90 \text{ ME}}$ = 1.54 mhp

PE: Pump Efficiency

ME: Motor Efficiency

PUMP HORSEPOWER REQUIREMENTS