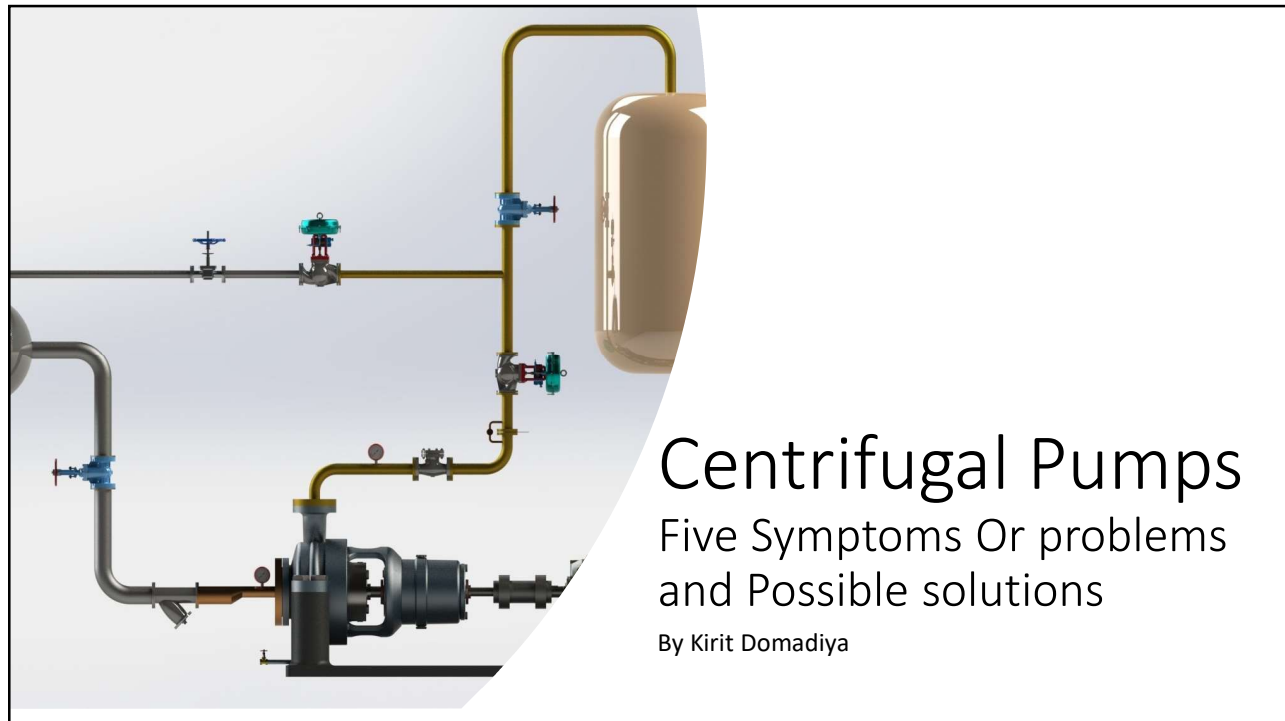
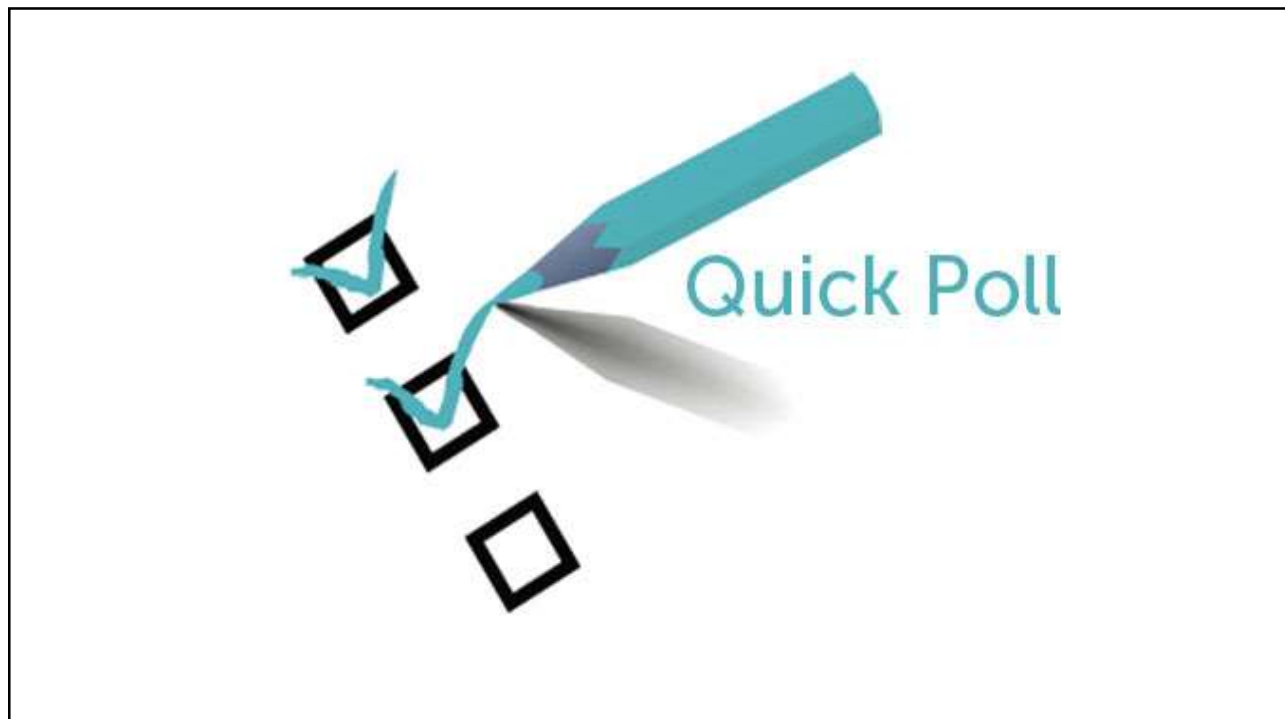




1



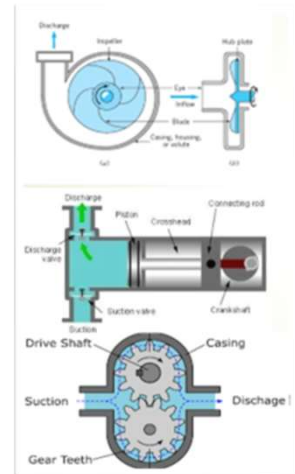
2

Why Pump ?

- Moving fluids plays a major role in every aspect of our life, whether it is about pumping water for our daily usage or transferring hazardous chemicals in any Industry.
- Pump systems consume almost 22% of all electric energy generated throughout the world. Predominant addressable segment for energy saving and reduce carbon footprint.
- Coming back to Industry, Pump consumes 25% to 50% of the total energy usage in industrial plant operations.

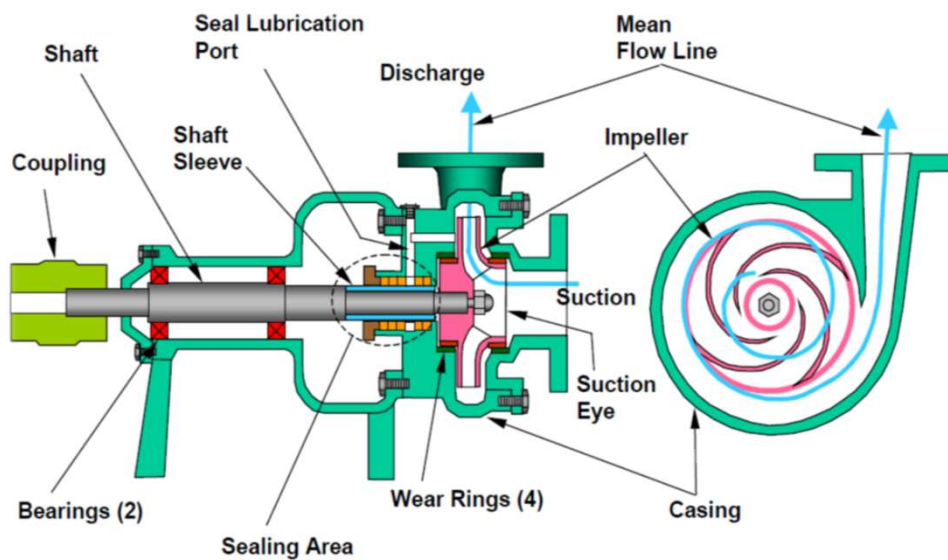
Why Centrifugal Pump ?

- Next to electric motors, centrifugal pump is the most frequently utilized machine on earth. It has been estimated that over 10,000,000,000 of them are in use worldwide.
- More than 80% pumps in Industry are Centrifugal pumps among all types of pump.
- Simplicity, Wide operating range, Smooth flow rate, Reliability, ease of O&M, Safety are some of the reason behind dominance



Source : LEWA Pump

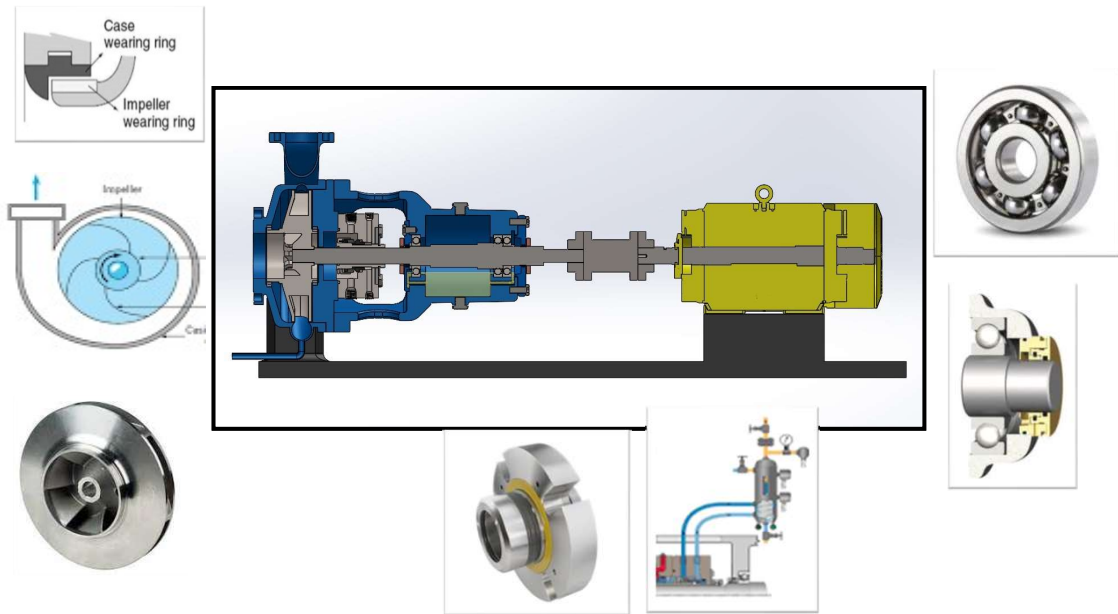
3



Source : Pump Handbook - BHGE

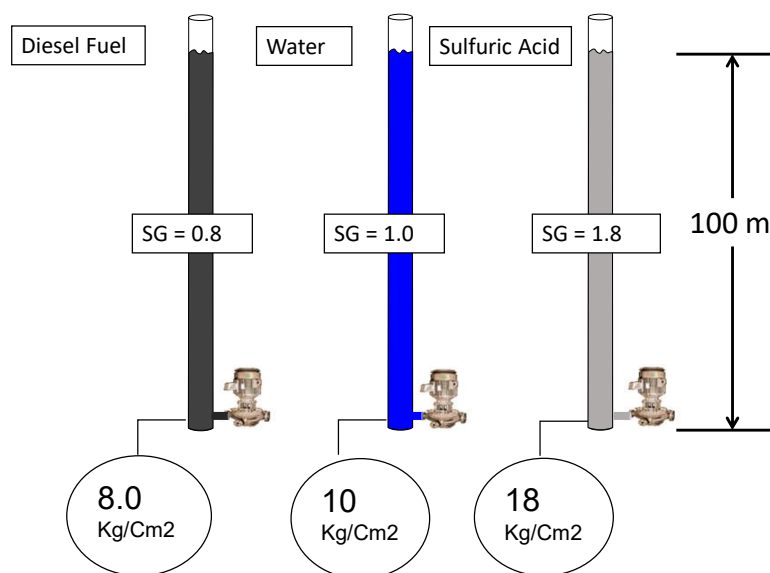
4

Close look at the major parts.....



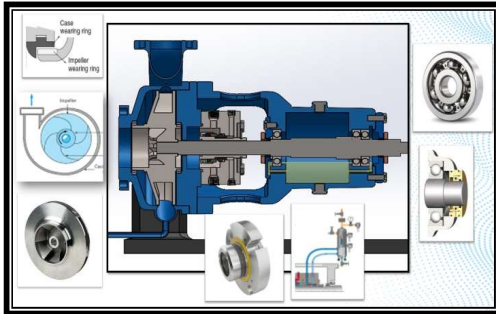
5

Head vs. Pressure

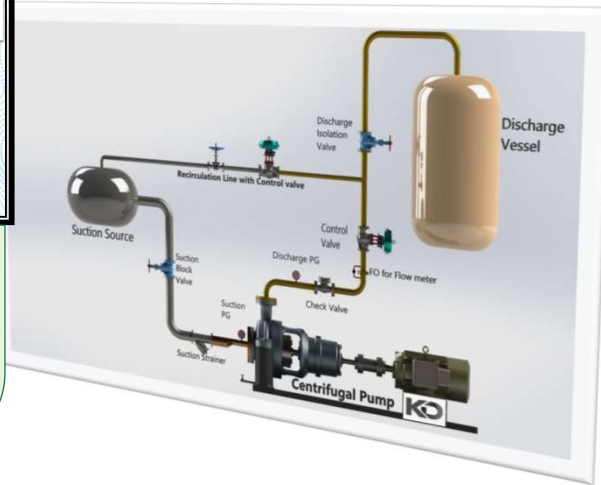


6

Pump is not only about Pump.....



**Fluid Characteristics,
Viscosity
Specific gravity
Vapor pressure at op. temp
Presence of solid
Corrosiveness**



7

Top 5 Problems with pumps

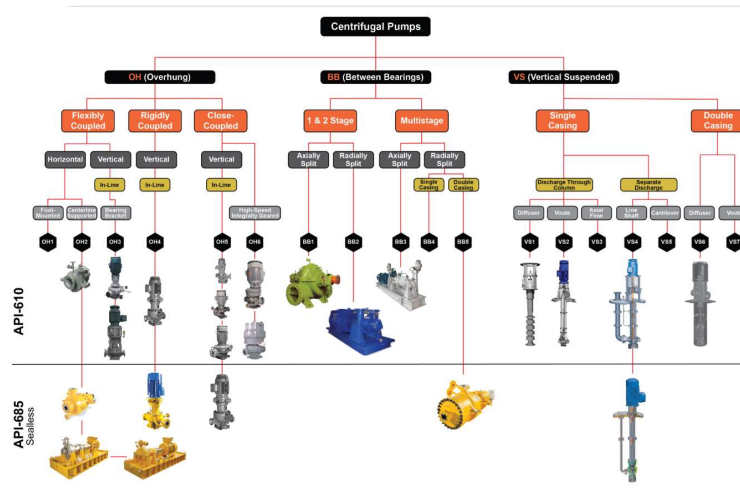
- 1. Performance issue**
- 2. High Vibration**
- 3. Unusual sound**
- 4. Abnormal temperature**
- 5. Excessive Leakages**

**Sometimes the problem,
We think problem,
may not be the problem**

- Essential to dig out the exact underlying problem to eliminate unplanned shut down or risk of breakdown, expensive repair, production loss or sometimes HSE incident
- Problems are valuable inputs or indicators of presence of big problems.
- If any of these are real problems, how to protect the pump from it's consequence ?

8

Centrifugal Pump Classification / Types



Each Pump types will have Impeller, Casing, Suction / Discharge Nozzle, Shaft, Mechanical Seal, Bearings etc.

Source : Sundyne LLC

9

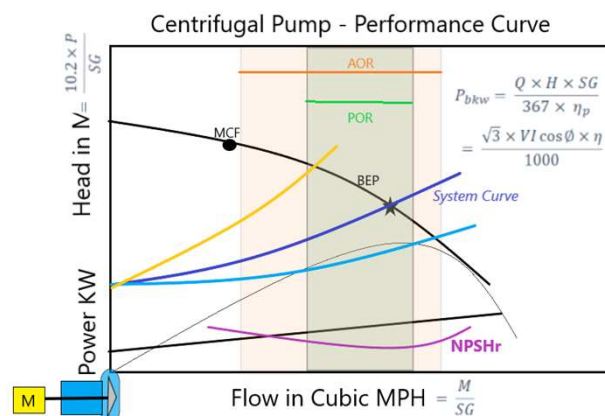
Problem 1 : Performance Issues

Major Issues

- Low Flow
- No Flow
- Erratic flow
- Inadequate dis. pressure
- Motor tripping at FLC

Available Field parameters

- Flow
- Suction Pressure
- Discharge pressure
- Input Current



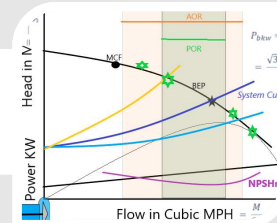
'I interact well with the people who comes to me with the datasheet and performance curve'
– By Anonymous pump

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Performance Issue and possible causes

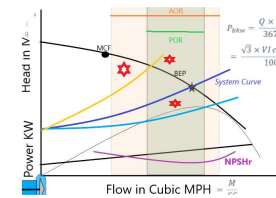
Operating away from BEP On the Curve

- System resistance
- Control Valve opening
- Modification in downstream pipe work



Operating point off the curve

- Undue wear and tear of pump component
- Impeller diameter or DOR is different
- Change in viscosity or specific gravity
- Suction strainer or impeller clogged
- Suction starvation or air / vapor ingestion
- Hidden flow before flow meter (Possibly, recirculation line or valve passing)



Focus on pump's designed hydraulics, instead of only desired hydraulics

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Consequences of Off-design pump operation

Unstable operating condition or running pump far off BEP is the major cause of many reliability issues like

- High Vibrations
- Excessive Temperatures
- Abnormal Sound
- Seal failures

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Problem 2 High Vibrations

Vibration is a normal, unwanted but typically unavoidable outcome of any rotating machine.

Source of Vibrations

- Fault within pump
- Flow Induced vibration
- Resonance



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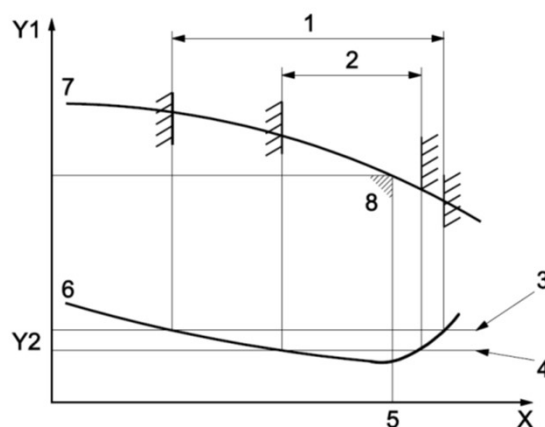
Vibration Causes and process

Category	Source / cause of vibration
Fault or anomalies within pump	Bent shaft, imbalance, Looseness, Bearing fault, Excessive wear
Fluid dynamics Or instability	Cavitation, Internal recirculation, Pressure pulsation, Oil whirl
Resonance	It is a phenomenon that amplifies a vibration. Due to operating speed is at natural frequency.

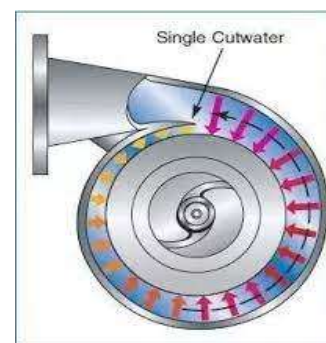


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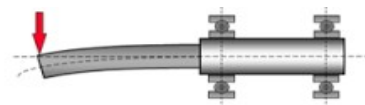
Flow induced vibration



Operating range Vs Vibrations
Source : API 610 standard , 12th edition



Radial load on the shaft



Shaft deflection

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Effect of High Vibrations

- It accelerates rate of wear, create noise, consume power
- In general, [bearing lifetime](#) (L10) decreases rapidly with even small increments of vibration value.
- Taking an example mentioned in ANSI/HI 9.6.4 standard, assuming that a vibration intensity of 2.5 mm/sec corresponds to 100% of nominal bearing lifetime, simply increasing the vibration level to 5 mm/sec could reduce bearing lifetime to 60-70% of nominal bearing lifetime.

Standards for pump vibration limits

- Hydraulic Institute (HI), namely with ANSI/HI 9.6.4 standard
- American Petroleum Institute, API 610 standard
- International Standards Organisation ISO 10816 standard

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Normal Vs Abnormal vibration, Setpoints

		Vibration velocity limit mm/s rms value			
		Category 1		Category 2	
Zone	Description	≤ 200 kW	> 200 kW	≤ 200 kW	> 200 kW
A	Newly commissioned machines in POR	2.5	3.5	3.2	4.2
B	Unrestricted long term operation in AOR	4.0	5.0	5.1	6.1
C	Limited operation	6.6	7.6	8.5	9.5
D	Hazard damage	> 6.6	> 7.6	> 8.5	> 9.5
Maximum ALARM limit (≈ 1.25 times upper limit of zone B) ¹		5.0	6.3	6.4	7.6
Maximum TRIP limit (≈ 1.25 times upper limit of zone C) ¹		8.3	9.5	10.6	11.9

Source : ISO 10817

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Problem 3 : Abnormal Sound

- Noise is normally considered as unwanted sound, quite pumps are good, but not possible.
- Very often noise is not a problem but indicator of bigger problem
- Unlike vibration, sound is the language pump use to express its pain, pleasure, annoyance, anger etc.
- Major source of abnormal sounds are excessive wear, excessive recirculation, turbulence, cavitation, bearings, coupling.
- Condition monitoring stethoscope is handy and useful tool to detect some of the typical machine fault.

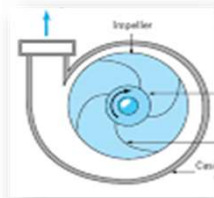


Smart mother can decode kid's noise better than the Doctor.
Can same logic be applicable for Pump ?

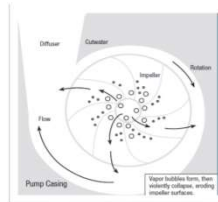
20

Sound, Best understood by listening rather
than expressing in words

Normal
[..\Desktop\ASME
Webinar\normal.aac](#)



Cavitation
[..\Desktop\ASME
Webinar\Cavitation.aac](#)



Bearing fault
[ASME Webinar\bearing
noise.aac](#)



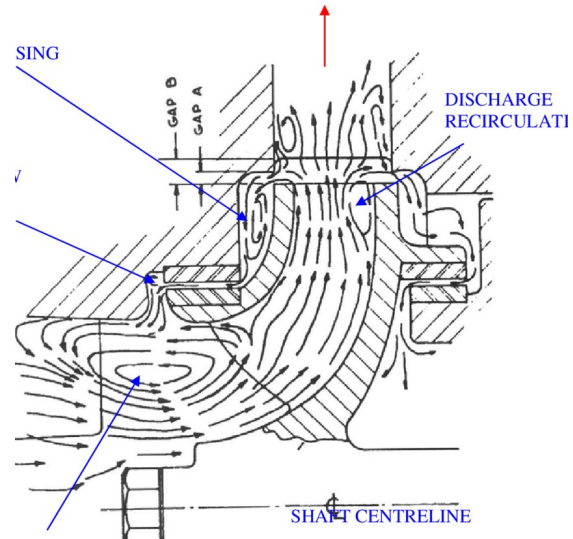
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Problem 4 : Abnormal temperature

- Process end
- Mechanical Seal
- Bearing housing



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Temperature rise in the pump

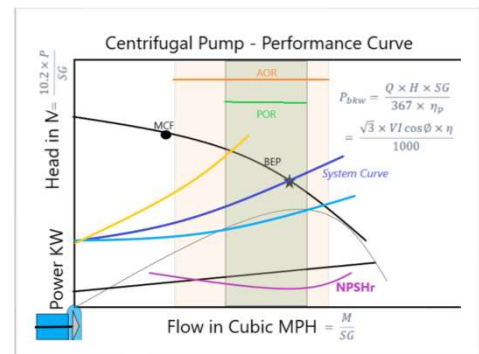
$$\Delta t = \frac{H}{102 \times C_p} \left(\frac{1}{\eta} - 1 \right)$$

Δt = Temperature rise through the pump, in °C

H = Total developed heat in m

C_p = Sp. heat of pumping fluid, in kJ/kg K

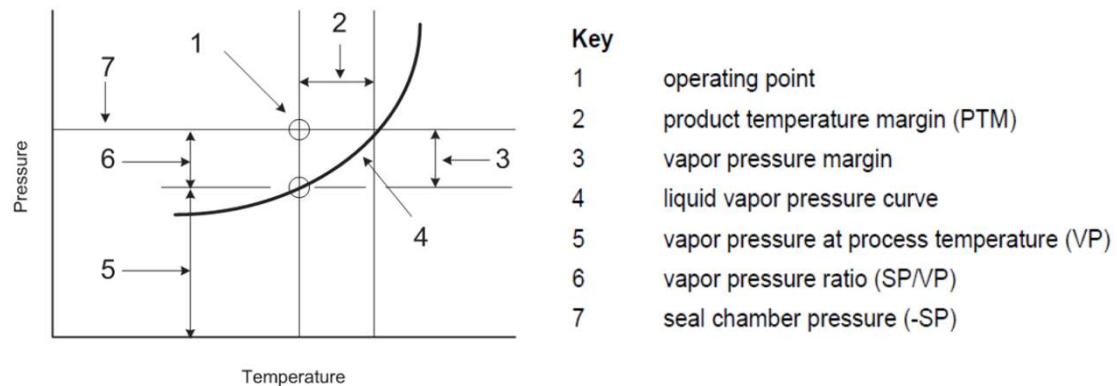
η = Efficiency at operating flow, expressed as a decimal



Unless otherwise specified, Temp. rise should be < 8 °C, (HI 1.3)

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Temperature rise in Seal stuffing box

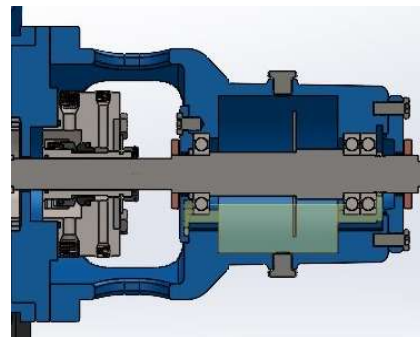


Source : API 682 standard , 4th edition

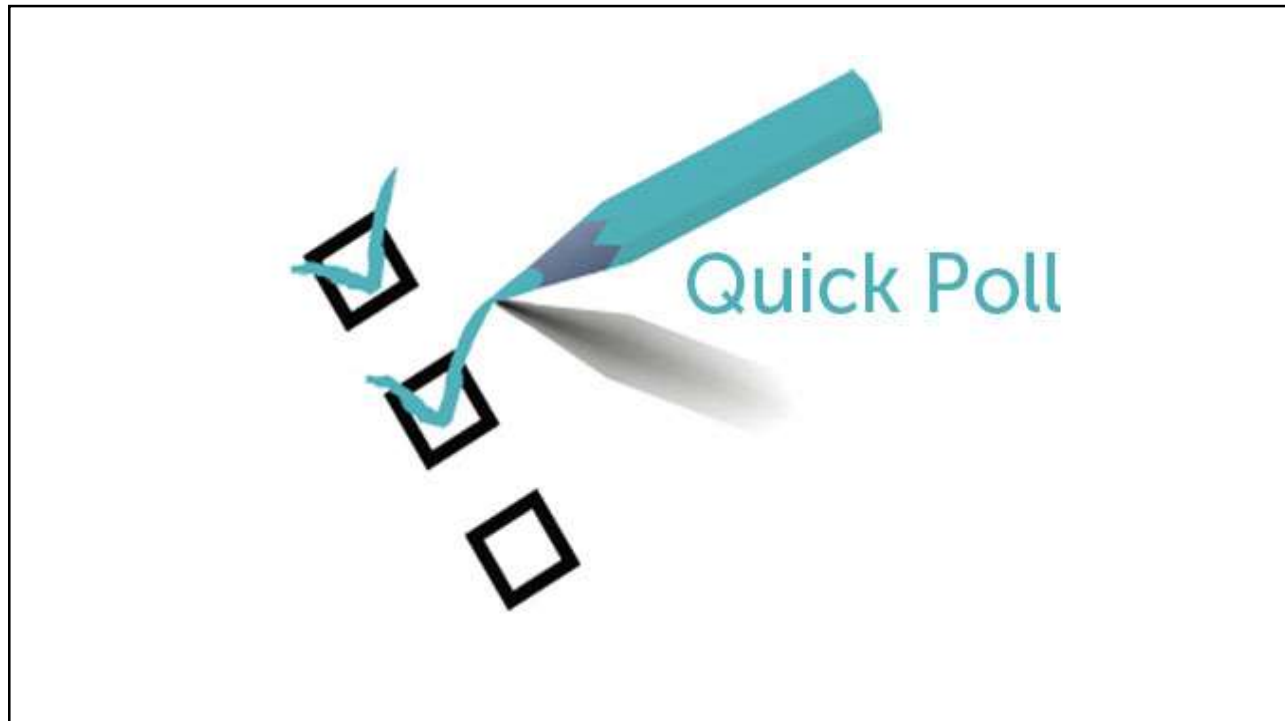
25

Bearing and Lube temperature : Normal Vs Abnormal

- Oil life decreases by 50% for every 11° C rise in temp. above 60° C
- The sump oil temperature rise < 39 °C above the ambient temp Or Bearing-temperature < 93 °C.
- For oil sump temperatures higher than 77 °C, the additives in the oil will deteriorate and coke formation will accelerate.



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Problem 5 : Excessive leakages

Static Sealing → Gasket, O ring



Dynamic Sealing → Gland packing, Mechanical Seal

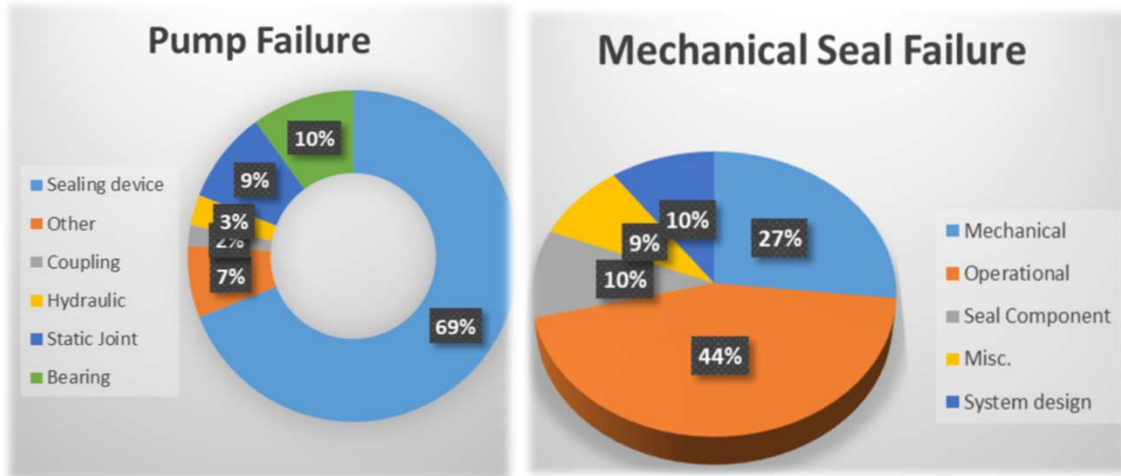


Bearing housing sealing → Lip seal, Labyrinth, Bearing isolator



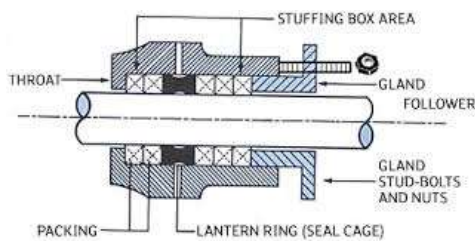
28

Mechanical Seal is an integral part of pump



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Prevalent Dynamic Sealing methods

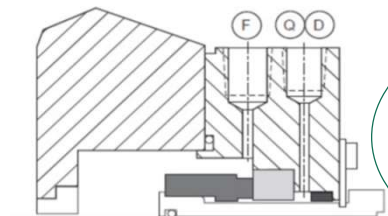


Gland packing, Normal leak 2-20 drops / minute



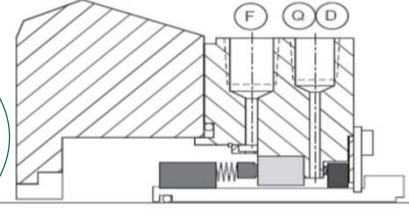
Source
:Sundyne
HMD

Sealless pump – Zero leak



Pusher type Mechanical Seal

Permissible
leakage 6 cc/hr
Or 1000 ppm
vapor



Non-pusher type Mechanical Seal

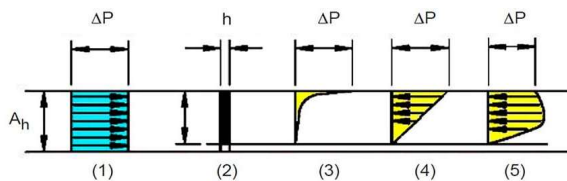
30

Seal face lubrication and Leakage Rate (rough estimate)

$$Q = \frac{\pi \times R_m \times h^3 \times \Delta p}{6 \times \eta \times b}$$

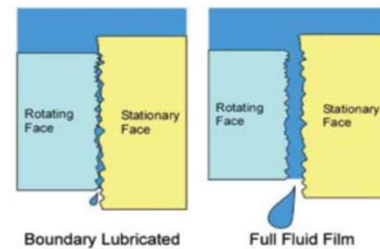
Q → leakage rate in m³/sec
 b → Face contact width in mm
 h → gap height in μm
 ΔP → pressure differential in Pa
 η → dynamic viscosity in Pa·s

Stable liquid lube film must be maintained between the seal faces at all the times.



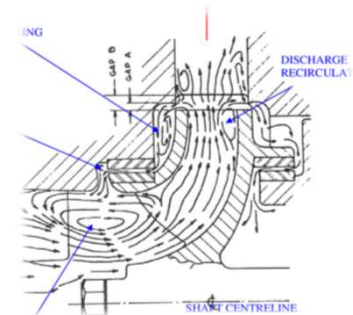
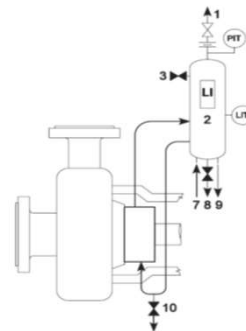
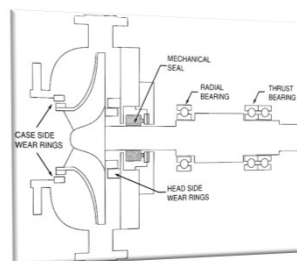
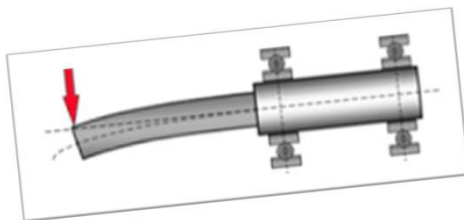
- (1) Hydraulic closing force
- (2) Lubricating film thickness h
- (3) Pressure curve in static condition of the pump
- (4) Linear pressure drop
- (5) Pressure curve with hydrodynamic component

Source : Hydraulic Institute



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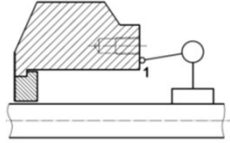
Major causes of seal leakage / Failure



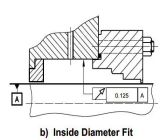
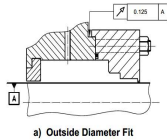
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Important check points for Seal installation

Shaft runout 25 – 40 micron depending on flexibility factor, → Seal faces parallelism and concentricity



Seal chamber squareness $0.5 \mu\text{m}$ / mm of seal bore dia. → it ensures Seal faces parallelism



Seal chamber Register concentricity within 0.125 mm → it ensures Seal faces concentricity

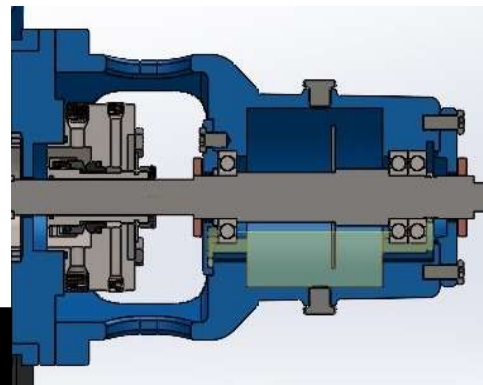
O-ring sealing surfaces, shall have a maximum surface roughness average value, R_a , $1.6 \mu\text{m}$ for static O-rings, $0.8 \mu\text{m}$ for the surface against which dynamic O-rings slide, and $6.4 \mu\text{m}$ at gasket sitting area

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Lube leakages / Contamination

- Water breaks down lube directly reducing bearing life .003% water in oil reduces life of oil 50%.
- Lip seal is outdated concept, now replaced by Labyrinth, bearing isolator, magnetic isolator etc.
- Lack of lubrication and contaminations are the main cause of bearing failure.

It doesn't mean, Overfilling the bearing housing is a safer option. Perhaps it invites even more risk.



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Keep Learning.....
Keep Sharing.....
Keep Growing.....

