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Session 15 –

Start-Up, Commissioning & Troubleshooting Centrifugal Pumps

Simon Smith March 2022

Presenter Profile – Simon Smith

Simon graduated with an honours degree in Chemical Engineering from the University of Surrey in 1978 and began a long career in the engineered pump industry spanning 40 years (so far!) with Peerless Pump, BW/IP International / Flowserve, SPP Pumps, Ruhrpumpen and Ebara Cryodynamics.

Over his long career he has filled various roles as Applications Engineer / Manager, Project Manager, Key Account Specialist, Vertical Pump Product Specialist, International Sales Engineer / Manager / Director and he has considerable experience in Training & Mentoring young engineers.

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RuhRPumpen Short Courses

Here is a listing of all the previous courses.

- No 1 – API610 12th v 11th editions
- No 2 - Curve Shape
- No 3 – The Importance of System Curves
- No 4 - Selecting the Right Pump for the Application
- No 5 - NPSH & Nss
- No 6 - Mechanical Seals & Systems
- No 7 - Firepumps
- No 8 - BB5 Barrel Pumps
- No 9 - Pump Instrumentation
- No 10 – Non-Destructive Examination
- No 11 - Vertical Pumps (Part 1) Type VS1, VS2, VS3
- No 12 – Vertical Pumps (Part 2) Type VS4, VS5, VS6 & VS7
- No 13 – Performance Testing of Centrifugal Pumps; the What, the Why & the How
- No 14 – Testing & Inspection of API 610 Pumps

Any you have missed you can get from our website using this link https://short-courses.ruhrpumpen.com/

Or from www.ruhrpumpen.com and follow the link to RP Short Courses

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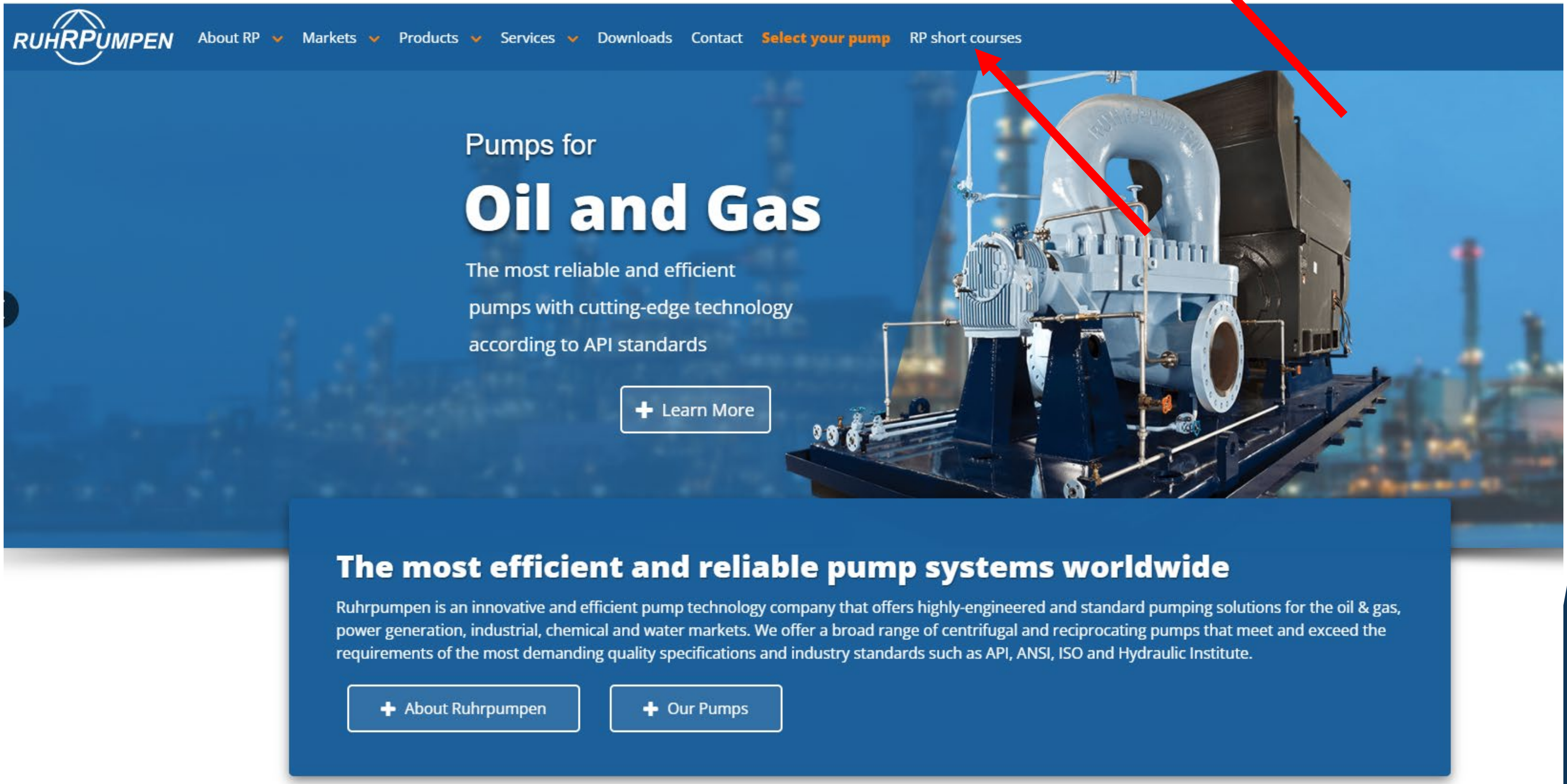

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All Courses

Ruhrpumpen short courses are a platform that boosts knowledge to all those interested in understanding the theoretical principles of centrifugal pumps, pump operations, hydraulics, pump performance curves, and/or receiving practical insights into the safe operation of your equipment.
You'll find below all the past courses and the coming ones. Join us and learn with us!

Comparison of API-610 12th vs 11th edition.

With 12th edition now issued, many End Users, Consultants and Licensors will be incorporating it into their Standards...

→ Go to Course

Curve Shape, Head-Rise to Shutoff and Zero Tolerances on Equipment Selection, Reliability, & Pricing.

Aimed at Process and Mechanical Engineers and Consultant Engineers specifying pumping equipment...

→ Go to Course

The Importance of Using System Curves in Pump Selection and Successful Pump Operation.

Aimed at Process and Mechanical Engineers and Consultant Engineers specifying pumping equipment as well as Applications Engineers selecting and quoting them...curves

Session 15 –
"Start-Up Commissioning & Troubleshooting Centrifugal Pumps"

Aimed at Process and Mechanical Engineers, and Consultant Engineers who specify pumping equipment as well as Applications & Sales Engineers selecting and quoting them.
This session is not going to turn you into qualified Installation & Commissioning Engineers but it will help you to have an intelligent conversation with them!

Source Material – Jennifer Knox Global Product Line Manager BB4/BB5
- Ian James – former Chief Engineer Ruhrpumpen Tulsa

Content

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  - What is commissioning & Start-up?
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  - What is Troubleshooting?
  - Basic Requirements for trouble free operation
  - Centrifugal Pumps – 5 Common Problems
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  - Troubleshooting – Checking 5 Major pump parameters
  - Common Reasons Why Seals Fail
  - 5 Types of Sealing Failures
  - Seal Troubleshooting

Commissioning & Start-up

Commissioning: Process by which an equipment, facility, or plant (which is installed, or is complete or near completion) is tested to verify if it functions according to its design objectives / conditions of services & or specifications.

Start-up & Commissioning are essentially the same

- Steps are taken to properly prepare equipment for start-up & eventual commissioning into fully operational process conditions.
- Once equipment is up and running it is brought to operational conditions and run for a period of time to ensure there are no issues.
- If any problems arise, then the troubleshooting process is started.

General Precautions & Start-up Checks

General Precautions Centrifugal Pump for Start-up & Commissioning

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1. Rotate pump shaft by hand. It should be free with no rubbing.

2. Check driver for correct rotation. Pump start-up in reverse rotation can result in the contact of metal parts, heat generation, and breach of containment.

3. Internally flush and clean the system thoroughly to remove dirt or debris in the pipe system in order to prevent failure at initial pump start-up.

4. Generally if the temperatures of the pumped fluid will exceed 200°F (93°C), then warm up the pump prior to pump start-up. The pump case and rotating assembly could distort from uneven heat transfer.

5. Do not operate the pump below the minimum rated flows or with the suction or discharge valves closed. These conditions can quickly lead to pump failure and physical injury.

1. Seal assembly fixtures.

2. Pipe connections tightened so that the connection can hold pressure.

3. Disposal connection (seal leakage) installed environmentally safe.

4. Check rotation of seal matches rotation of pump.

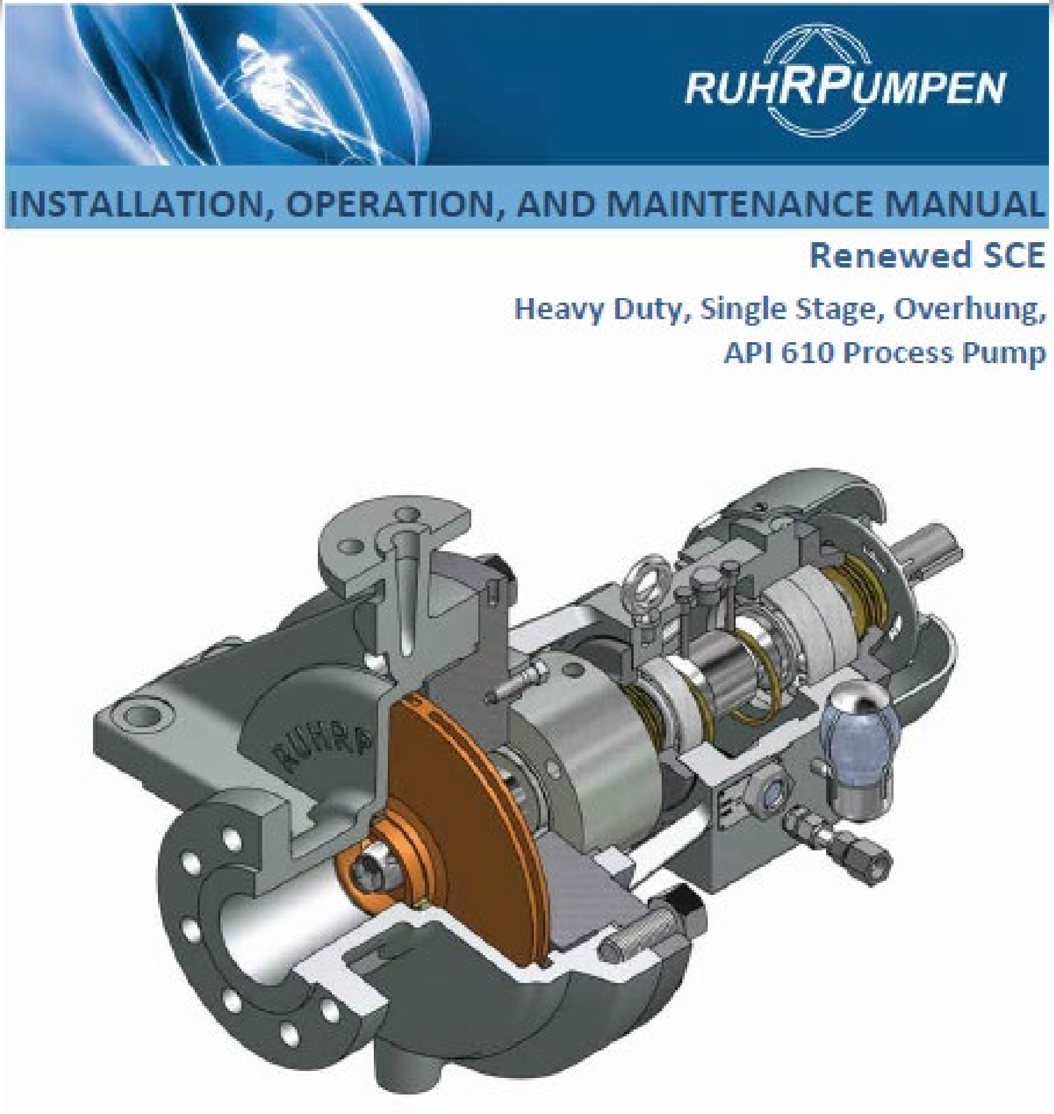
5. The pump should be installed & properly grouted to foundation.

6. Flood pump and seal area with pressureless flushing medium.

7. Thoroughly vent the seal chamber.

Start-up Procedure

Before start up review pump IOM manual to check installation is per IOM.



1. Before starting the pump, check the security of all bolting, piping, and wiring.
2. Check all gauges, valves and instruments for proper working order.
3. Check all equipment for proper lubrication and correct rotation.
4. Open and look through the oil fill/breather to verify that the oil rings are in their grooves.
5. Verify that the discharge valve is closed.
6. Open the suction valve.
7. Crack open discharge valve, but don’t fully open. A partially closed discharge valve also will prevent initial cavitation. Allow pump to fill with fluid (pump is self-venting).
   - For non-self venting pumps vent pump case and seal chamber (open vent at top of pump casing until all air is expelled from casing.)
8. Keep the valves open approximately 60 seconds to ensure that pump is completely full of fluid.
9. Close discharge valve.

10. Uncouple the driver and the pump.
11. Start, and IMMEDIATELY STOP, the driver and observe the rotation of the shaft.
12. Correct rotation should be in direction of rotation arrow.
    - If shaft rotation is incorrect, consult driver IOM.
13. Priming accomplished and correct shaft rotation established, the pump is ready for continued operation.
14. Securely couple the driver and the pump, and ensure the discharge valve is open to approximately ¼ fully open.
15. Start driver again, and completely open the discharge valve IMMEDIATELY when the operating speed has been reached.
    - DANGER: Do not allow discharge valve to remain closed for any length of time. Pumped fluid temperature will rise excessively causing damage to pump.
16. If the pump fails to reach the correct pressure, perform troubleshooting steps.
17. Once the pump is running, perform operating checks.

Commissioning Checklist

- Check Pump is in place and properly grouted, leveled and anchoring installed as per specification
- Check pump data plate against design requirements and electricity supply
- Check that pump casing and system have been cleaned prior to start-up
- Ensure that pump impeller rotates in the correct direction and pump is installed in correct configuration
- Check for noise and vibration, including evidence of cavitation under system design temperatures (for hot water pumps)
- Check for shaft misalignment
- Check the pump pressure, corresponding flow rate and motor amps.

Commissioning Checklist from IOM

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- Check at regular intervals that the safety equipment is sound and is arranged and fastened according to the regulations, and energized where applicable.
- Check the security of all bolting, piping, and wiring.
- Check all gauges, valves and instruments for proper working order
- Check all equipment for proper lubrication and correct rotation.
- Check the oil level and validate that the correct oil grade is installed.
- Open and look through the oil fill/breather (refer to General Arrangement) to verify that the oil rings are in their grooves (oil ring and purge mist lubrication only) and are picking up oil.
- Check the temperature of the bearing bracket surface. It should not exceed 185 °F (85 °C).
- Check that the pumping unit is running quietly and without vibrating.

ATTENTION

- Unusual or too loud noises point towards a possible fault.

- Monitor the power consumption of the drive motor. Low or excessive power consumption indicates a possible fault.
- Check the sealing system:
  a. Refer to the seal manufacturer for his estimate of maximum acceptable leakage rate, as this will depend on application, design, location and the sealed liquid characteristics
  b. If leakage excessive, switch the pump off as quickly as possible, isolate the pump by closing the discharge and suction valves or using some other approved method designated as safe for your system, and check the rotating seal ring and the stationary seal ring.

Troubleshooting

What is Troubleshooting?

Troubleshooting is a systematic approach to problem solving that is often used to find and correct issues with complex machines, electronics, computers and software systems.

- First step: gather information on the issue, such as an undesired behavior or a lack of expected functionality.
  - Other important info: related symptoms and special circumstances that may be required to reproduce the issue.

- Next step: Eliminate unnecessary components in the system and verify that the issue persists, to rule out incompatibility and third-party causes.

The ***first*** requirement is that no cavitation of the pump occurs throughout the broad operating range and the ***second*** requirement is that a certain minimum continuous stable flow (MCSF) is always maintained during operation.

Unfavorable conditions which may occur below MCSF:

1. Deflection and shearing of shafts
2. Seizure of pump internals
3. Close tolerances erosion
4. Separation cavitation
5. Product quality degradation
6. Excessive hydraulic thrust
7. Premature bearing failures

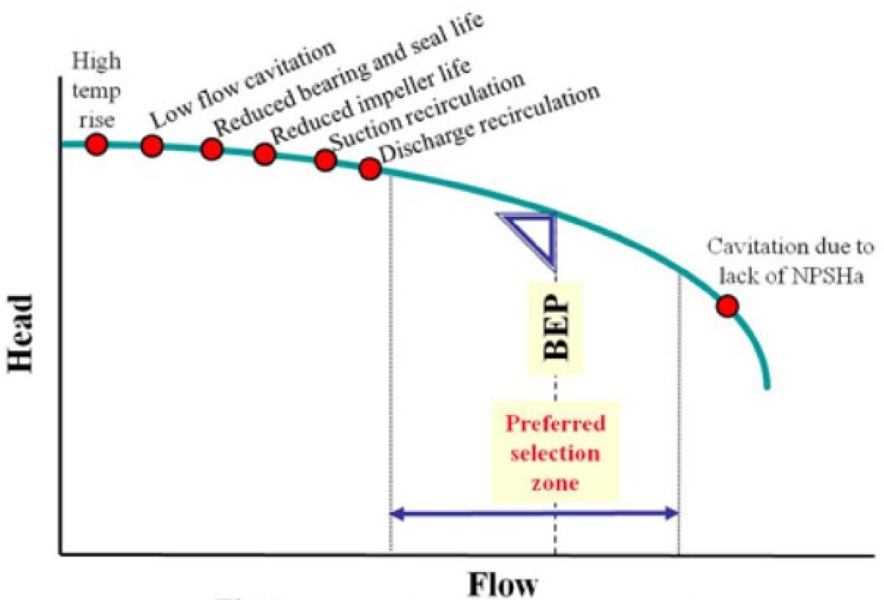


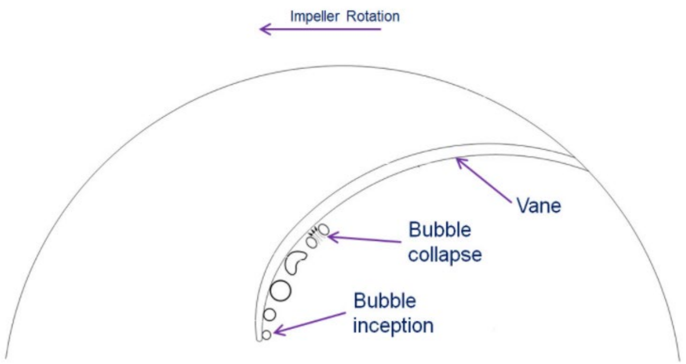
Fig 1 Courtesy PIA Australian Pump Technical Handbook

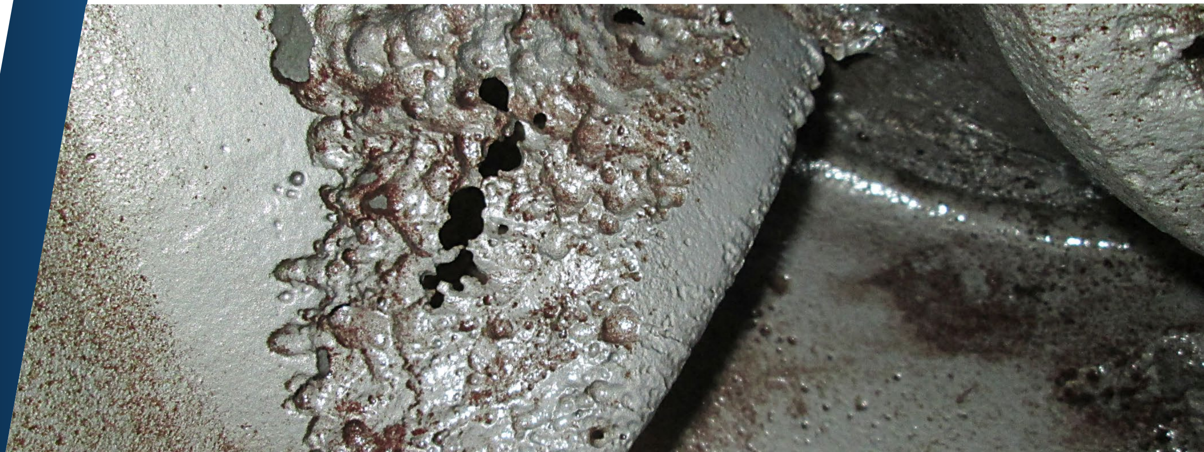
Cavitation

As the suction head value gets closer to the $NPSH_3$ value, vapour bubbles form on the underside of the inlet vanes of the impeller.

The closer you get to the $NPSH_3$ value the more bubbles will form and over a larger area of vane.

As these bubbles are swept into higher pressure areas they collapse with a shock



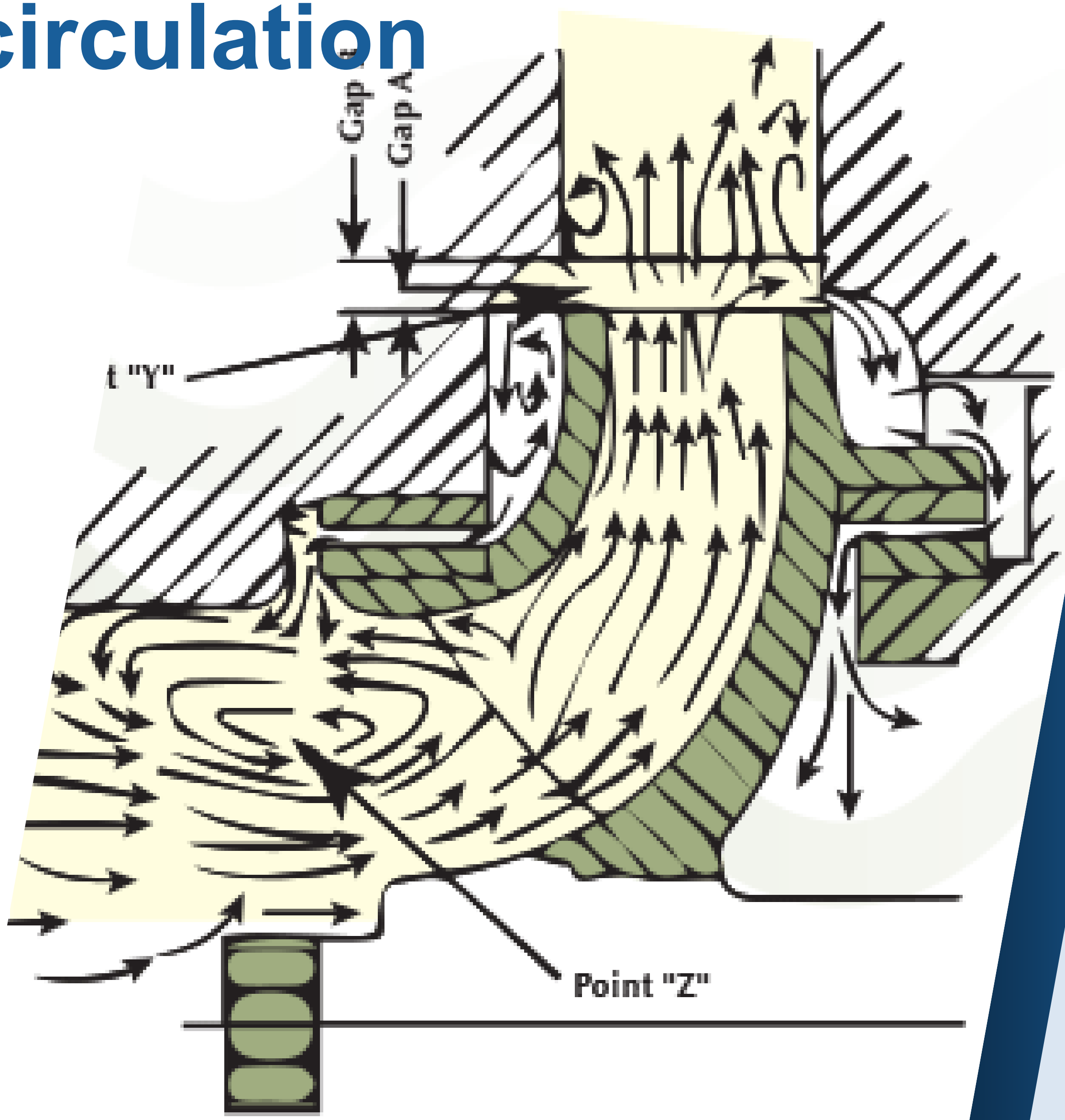


Suction & Discharge Recirculation

A Different kind of Cavitation

Occurs when pumps operate back on the curve from BEP

- When two flow paths within a fluid are moving in opposing directions and in close proximity to each other, vortices form.
- These vortices result in low pressure areas (where bubbles form) and high pressure areas (where they collapse).



Recirculation vortices at impeller suction eye and at vane tips (sourc Handbook, Igor J. Karassik and Joseph P. Messina; ISBN-10 007033

Centrifugal pumps
5 Common Problems

Centrifugal Pumps Common Problems

1. No liquid delivery
2. Low Liquid flow rate
3. Intermittent operation
4. Low Discharge pressure
5. Excessive Power demand

No liquid delivery — Possible cause

- Instrument error
- Not primed
- Cavitation
- Supply tank empty.

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Liquid flow-rate low — Possible cause

- Instrument error
- Cavitation
- Non-condensibles in liquid
- Inlet strainer clogged.

Intermittent operation	Possible cause	Cavitation
		Not primed
		Non-condensibles in liquid.

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Discharge pressure low — Possible cause:

- Instrument error
- Non-condensibles in liquid.
- Speed too low
- Wrong direction of rotation (or impeller in backwards if double suction).

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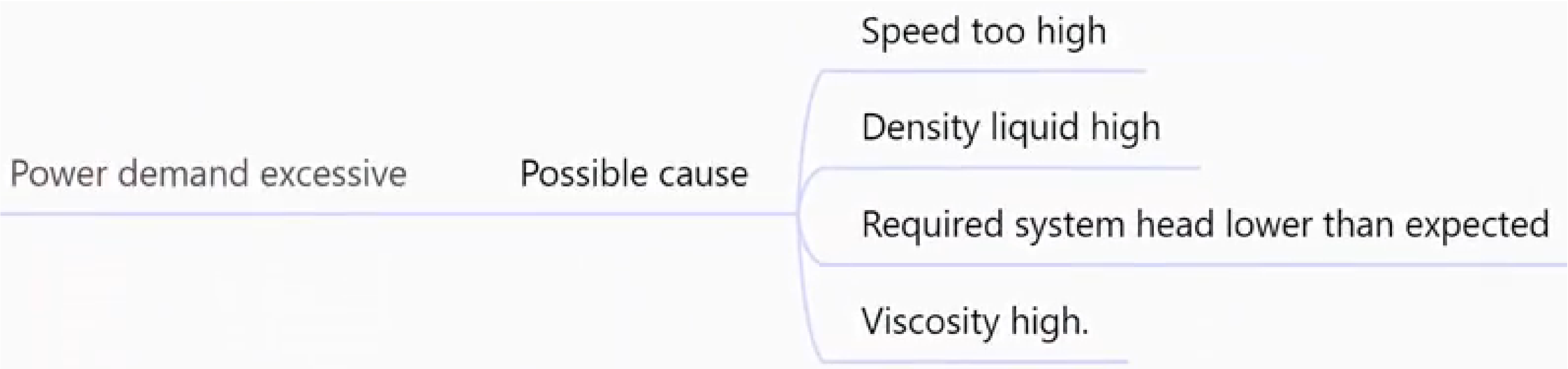

General Troubleshooting Flow Diagram & Charts

General Troubleshooting Flow Diagram 1

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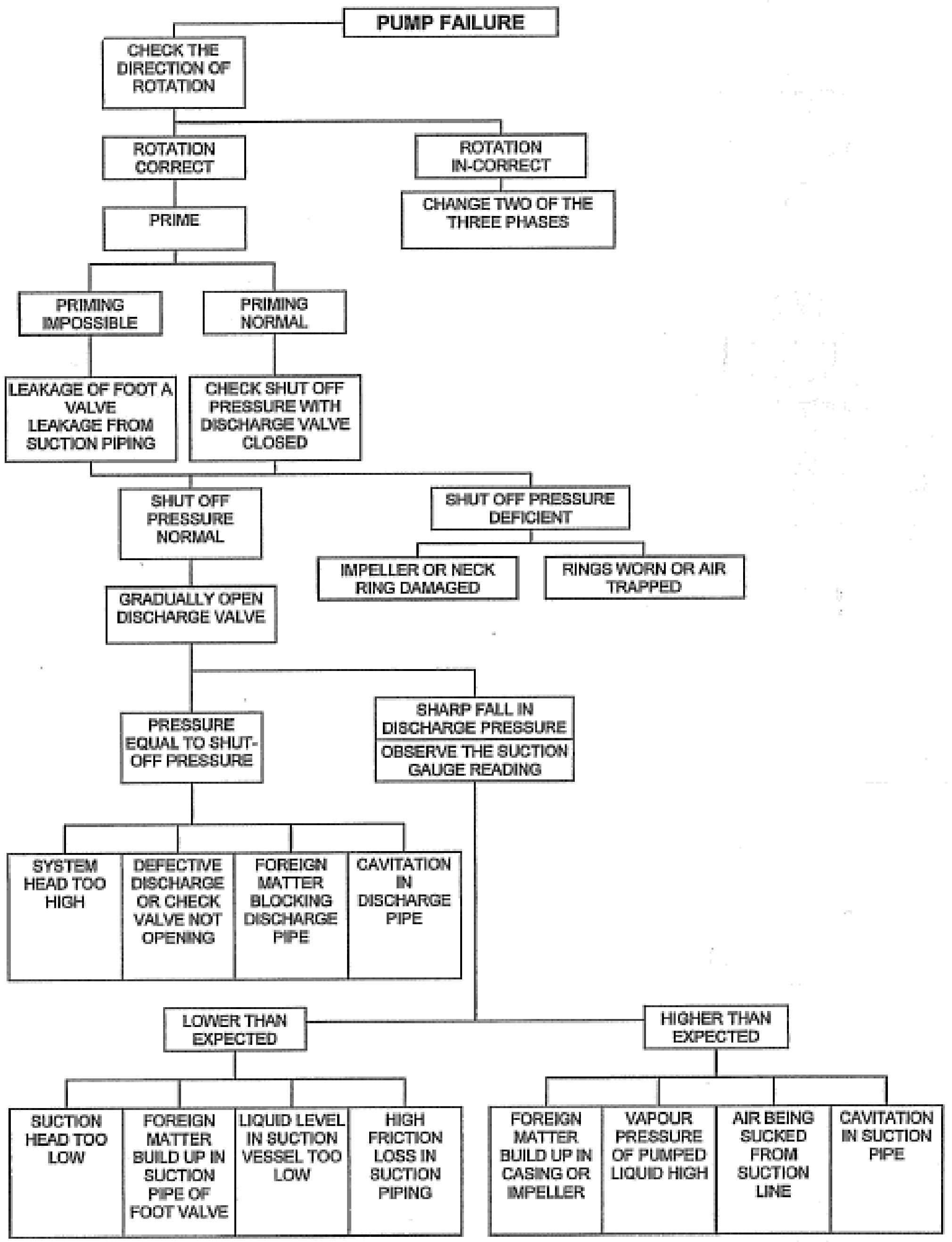
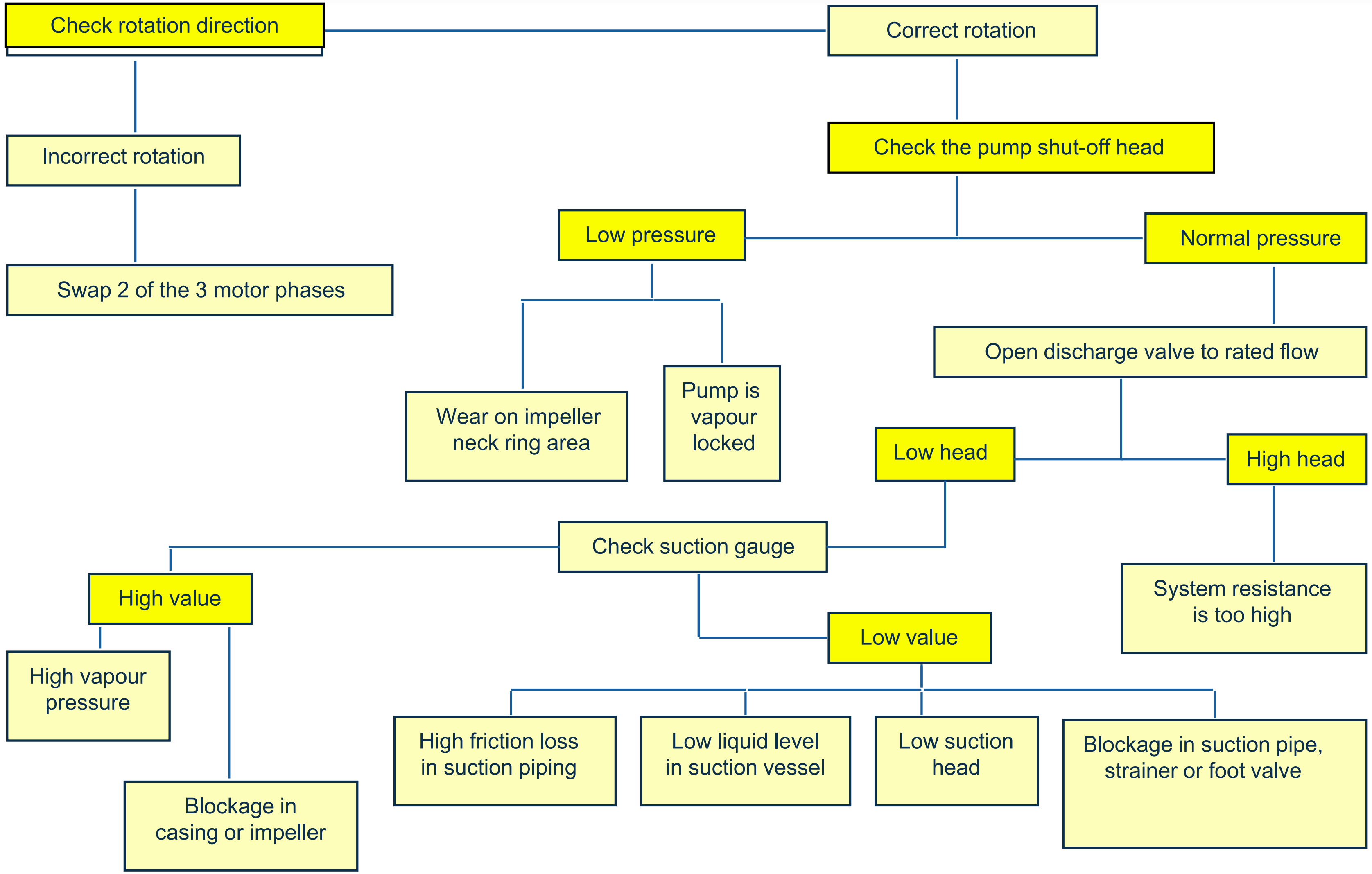
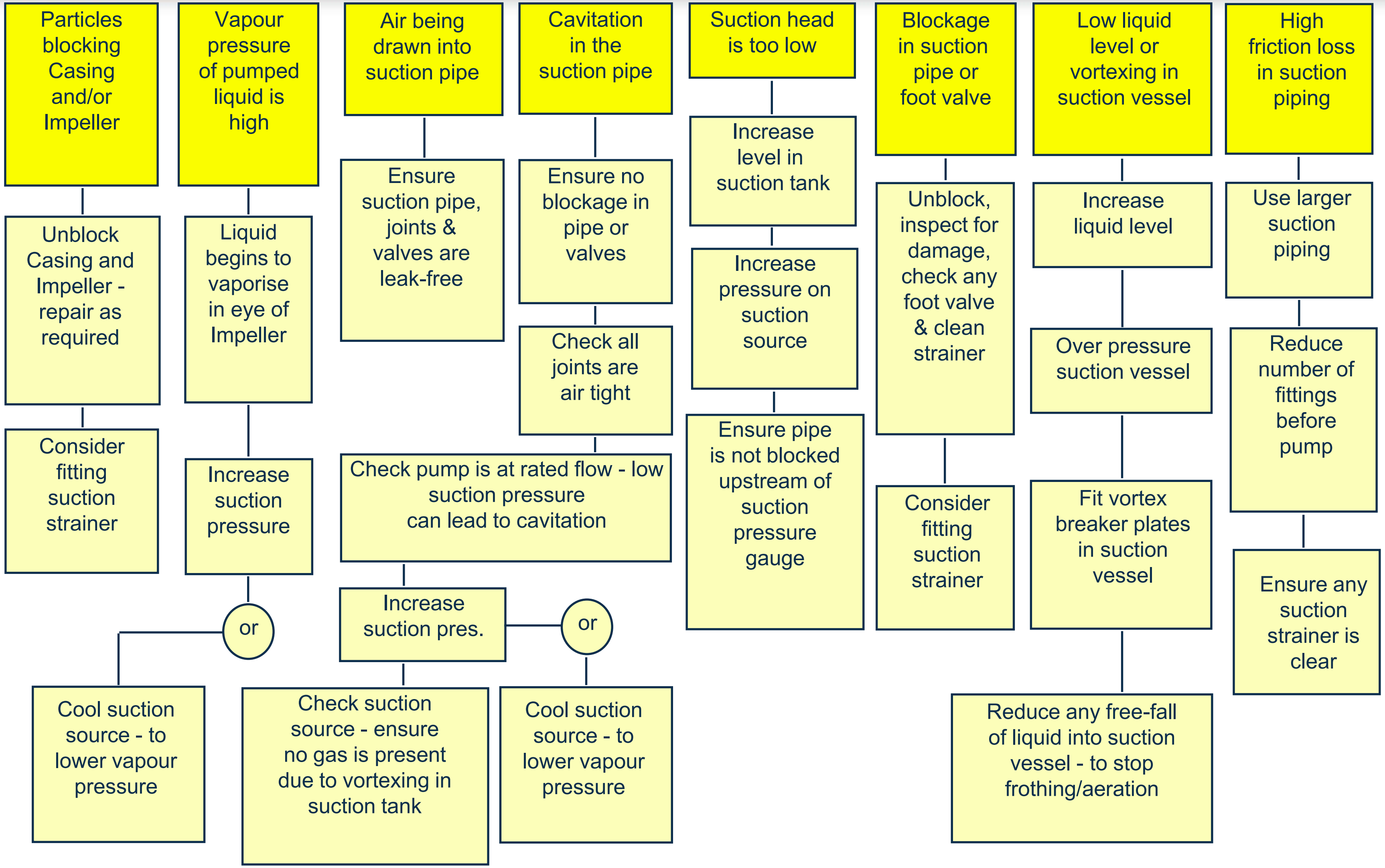


General Troubleshooting Flow Diagram



General Troubleshooting Fault Finding Flow Chart



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TROUBLE	CAUSE	REMEDY
Insufficient capacity and/or pressure	Suction pressure or speed too low	Open suction valve wide. Check power supply for correct voltage to motor.
	Incorrect direction of rotation	Re-connect motor leads
	Excessive amount of air or vapors in the fluid.	Check suction system for air leakage and correct. Vent air. Tighten flange bolts
	Foreign material in impeller.	Dismantle pump and remove any foreign material.
	• Mechanical defects • Wearring rings worn. • Impeller damaged • Sheared impeller key	Dismantle pump and correct.
Pump loses prime after starting.	Insufficient liquid supply	Ensure that suction valve is wide open. Check for proper supply of liquid to be pumped.
	Excessive amount of air or vapors in the liquid.	Check suction system for air leakage and correct.
	Broken or damaged coupling	Inspect and replace same.
	Clogged impeller	Dismantle pump and correct.
	Suction pipe clogged	Remove foreign material.

General Troubleshooting Cause & Remedy Chart

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Pump vibrates	Loose mounting or coupling bolts	Tighten bolts.
	Air or gas in liquid	Vent air and check suction for leaks. Tighten flange bolts.
	Misalignment	Check alignment and correct.
	Foreign material in impeller causing unbalance	Dismantle pump and remove any foreign material.
	Mechanical Defects: • Shaft bent • Bearings worn	Dismantle pump and replace part or parts causing vibration.
Pump overloads driver	Speed too high	Refer to motor instruction manual and check power supply for correct frequency.
	Pump bearing seize or rotating element binds	Dismantle pump and replace part or parts causing seizures or binding.
Pump stops abruptly	Pump binding at running fits	Dismantle pump and correct.

High pump thrust bearing temperature rise	Improper lubrication	Replenish oil with proper grade lubricant.
	Insufficient oil – Contaminated oil	Add oil. Drain and clean bearing housing reservoir. Refill with clean oil.
Mechanical seal gland overheats	Insufficient cooling water to seal	Obstruction in seal water piping. Remove and clean.
Mechanical seal leakage	Checked for cracked rotating face/ stationary face	Remove, dismantle, and inspect seal unit per 'MECHANICAL SEAL' page.
Pump is noisy	Cavitation	Check pump is primed, check for high suction temperature, increase static head, check for obstruction in suction line.
	Loose parts	Tighten or replace defective part.
	Noise in driver	Check driver with stethoscope.

Troubleshooting – Checking 5 Major pump Parameters

Many clues can be obtained by checking all the normal pump parameters:

1. Vibration
2. Power
3. Flow
4. Head
5. Temperatures

Vibration

Check vibration levels with a basic frequency analysis using a portable vibration analyzer.

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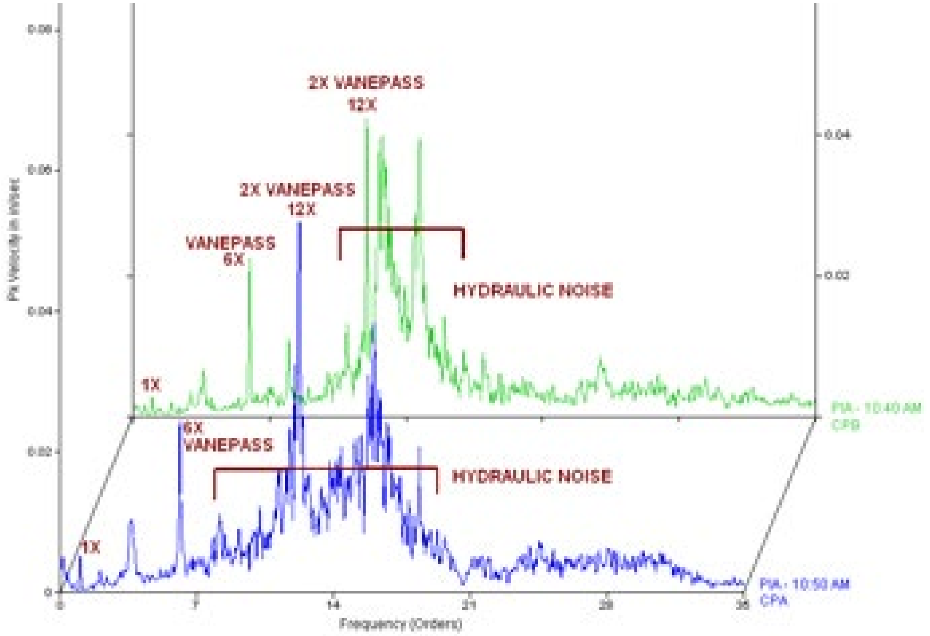
Pump spectral analysis separates the overall vibration level into amplitudes at discrete frequencies and is helpful in determining the cause of the vibration. For example, a peak at the running speed (1X RPM) may indicate rotor imbalance, while a peak at the blade passing frequency (BPF = Z x RPM where Z is the number of impeller vanes) typically indicates a hydraulic issue.



Source – ProPump Services

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FREQUENCY AS % RUN SPEED.	POTENTIAL CAUSES (%)	SOLUTIONS
FREQUENCY OF 0 - 40%	Seal faces dry & rubbing (10%). Also the harmonics of this vibration can be 40%-50%, & 100% & 200%.	Inspect seal faces, no particles & identify the cause. Also check if quench is required, if pumped liquid crystalizes when it contacts atmosphere (eg:- NaOH).
	Wear Rings rubbing (20%).	Inspect wear ring TIR's, clearances, bearings & shaft TIR. Also check Suction & Discharge piping accuracy & loads
	Anti-Friction Radial Bearing damage (20%).	Inspect bearings, check bearing fits, oil qualities & oil levels.
	Anti-Friction Thrust Bearing damage (90%).	Inspect bearings, check bearing fits & bearing locknut.
	Some components Loose:- Bearing inner race mounting (90%). Bearing outer race mounting (90%). Impeller secure bolt (40%). Casing mounting bolts to baseplate (40%).	Check fits, dimensions and bolting tightness.

Vibration Trouble Shooting Chart -2

FREQUENCY AS % RUN SPEED.	POTENTIAL CAUSES (%)	SOLUTIONS
FREQUENCY OF 40 - 50%	Foundation uneven & affecting base level (20%).	Check levelness of foundation & baseplate. Also check foundation & mounting bolt tightness, shims & alignment, & carry out a Soft-Foot check for parallelism of the Pump and Motor mounting pads and Baseplate support pads.
	Seal faces dry & rubbing (10%). Also the harmonics of this vibration can be 40%-50%, & 100% & 200%.	Inspect seal faces, no particles & identify the cause. Also check if quench is required, if pumped liquid crystalizes when it contacts atmosphere (eg:- NaOH).
	Wear Rings rubbing (20%).	Inspect wear ring TIR's, clearances, bearings & shaft TIR. Also check Suction & Discharge piping accuracy & loads
	Anti-Friction Bearing damage (20%).	Inspect bearings, check bearing fits, oil qualities & oil levels.
	Sleeve (Journal) bearing & bush high vibration, possible oil whirl, etc. (70%)	Inspect bearings & clearances. Also perform frequency test of bearing housings. If cause is oil whirl, consider oil whirl resistant oval & grooved sleeve bearings.
	Some components Loose:- Bearing inner race mounting (90%). Bearing outer race mounting (90%). Impeller secure bolt (40%). Casing mounting bolts to baseplate (40%).	Check fits, dimensions and bolting tightness.
	Incorrect flexible coupling alignment & fit (20%).	Inspect coupling alignment, fits and tolerances.

Vibration Trouble Shooting Chart -3

FREQUENCY AS % RUN SPEED.	POTENTIAL CAUSES (%)	SOLUTIONS
FREQUENCY OF 50 - 100%	Seal faces dry & rubbing (10%). Also the harmonics of this vibration can be 40%-50%, & 100% & 200%.	Inspect seal faces, no particles & identify the cause. Also check if quench is required, if pumped liquid crystalizes when it contacts atmosphere (eg:- NaOH).
	Wear Rings rubbing (20%).	Inspect wear ring TIR's, clearances, bearings & shaft TIR. Also check Suction & Discharge piping accuracy & loads
	Anti-Friction Bearing damage (20%).	Inspect bearings, check bearing fits, oil qualities & oil levels.
	Incorrect flexible coupling alignment & fit (20%).	Inspect coupling alignment, fits and tolerances.

Vibration Trouble Shooting Chart -4

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FREQUENCY AS % RUN SPEED.	POTENTIAL CAUSES (%)	SOLUTIONS
FREQUENCY OF 100% (1 x Running Frequency)	Major rotating component Unbalanced (90%).	Rebalance Impeller, Rotor & Coupling.
	Anti-Friction Bearing damage (20%).	Inspect bearings, check bearing fits, oil qualities & oil levels.
	Slightly bent Shaft (90%).	Inspect & TIR check the Shaft & rebalance assembled rotor.
	Slight Casing distortion	Check excessive nozzle loads have not distorted the Casing from the flanges. Also check Shaft & Impeller Wear Rings are concentric with Case Wear Rings & Impeller is inline with volute centerline. Also check foundation & Baseplate alignment
	Seal faces dry & rubbing (10%). Also the harmonics of this vibration can be 40%-50%, & 100% & 200%.	Inspect seal faces, no particles & identify the cause. Also check if quench is required, if pumped liquid crystalizes when it contacts atmosphere (eg:- NaOH).
	Foundation uneven & affecting base level (20%).	Check levelness of foundation & baseplate. Also check foundation & mounting bolt tightness, shims & alignment, & carry out a Soft-Foot check for parallelism of the Pump and Motor mounting pads and Baseplate support pads.
	Wear Rings rubbing (20%).	Inspect wear ring TIR's, clearances, bearings & shaft TIR. Also check Suction & Discharge piping accuracy & loading, to ensure the piping is not excessively overloading the pump suction & discharge flange maximum nozzle loads.
	Misalignment (40%).	Inspect Pump Shaft, Motor Shaft and Coupling alignment.

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FREQUENCY AS % RUN SPEED.	POTENTIAL CAUSES (%)	SOLUTIONS
FREQUENCY OF 150% (1.5 x Running Frequency).	Possible looseness of Impeller or Coupling (20%).	Check the tightness of the Impeller bolt, successfully clamping the Impeller to the Shaft. Also check casing & impeller Wear Ring fits, clearances and TIR. Check the Coupling fit to Shaft. If the coupling hub on the Shaft of a between bearing Pump is a taper fit on the Shaft, then check the fit is perfect using Marking Blue. If it is not a good fit, use grinding paste to match the tapers more than 90% of the contact area. Then re-assemble & check alignment of the Impeller, and the Pump coupling with the Motor Coupling.

Vibration Trouble Shooting Chart -6

FREQUENCY AS % RUN SPEED.	POTENTIAL CAUSES (%)	SOLUTIONS
FREQUENCY OF 200% (2 x Running Frequency)	Seal faces dry & rubbing (10%). Also the harmonics of this vibration can be 40%-50%, & 100% & 200%.	Inspect seal faces, no particles & identify the cause. Also check if quench is required, if pumped liquid crystalizes when it contacts atmosphere (eg:- NaOH).
	Foundation uneven & affecting base level (20%).	Check levelness of foundation & baseplate. Also check foundation & mounting bolt tightness, shims & alignment, & carry out a Soft-Foot check for parallelism of the Pump and Motor mounting pads and Baseplate support pads.
	Misalignment (50%).	Inspect Pump Shaft, Motor Shaft and Coupling alignment.
	Bearing damage (20%).	Inspect bearings, check bearing fits, oil qualities & oil levels.
	Sleeve (Journal) bearing & bush high vibration, possible oil whirl, etc. (70%)	Inspect bearings & clearances. Also perform frequency test of bearing housings. If cause is oil whirl, consider oil whirl resistant oval & grooved sleeve bearings.
	Excessive Suction and Discharge piping forces and moments. (50%)	Check the accuracy of the Suction and Discharge Piping connected to the pump. Also calculate that the piping forces and moments are within the published maximum Pump flanges forces amd moment limits, to ensure that excessive forces would not cause casing distortion.

Vibration Trouble Shooting Chart -7

FREQUENCY AS % RUN SPEED.	POTENTIAL CAUSES (%)	SOLUTIONS
FREQUENCY OF Number of Impeller Vanes x running Frequency (RPS)	This is the Vane passing Frequency. Which is the Frequency the Impeller vanes pass the casing Volute Lips (Cut-Waters). (90%)	This usually occurs with maximum diameter Impellers fitted. To reduce the effect of this frequency vibration, the solution is to cut the Volute Lip at an angle of approximately 20 degrees,and radius the edge. Then cut the Impeller Vanes at an opposite angle of approx 20 degrees. So when each vane passes the Volute Lip it slices and minimises the pressure pulsation.
VERY HIGH FREQUENCY.	Anti-friction Bearing damage (30%).	Examine the Anti-Friction Bearings. The high frequency is due to the large number of balls or rollers causing damage to the Inner or Outer races, and the Bearing Cage. Renew the Anti-Friction Bearings. The damage is likely due to problems with the lubricating oil quality, oil levels being inaccurate and the oil cleanliness. So clean the Bearing Housings, and renew the correct oil grade and levels. Also, if the Pump is VFD driven, check that the pump speed is correct, and not over-speed. Because if it was over-speed for any reason, the increased loads could damage the bearings.

Vibration Trouble Shooting Chart -8

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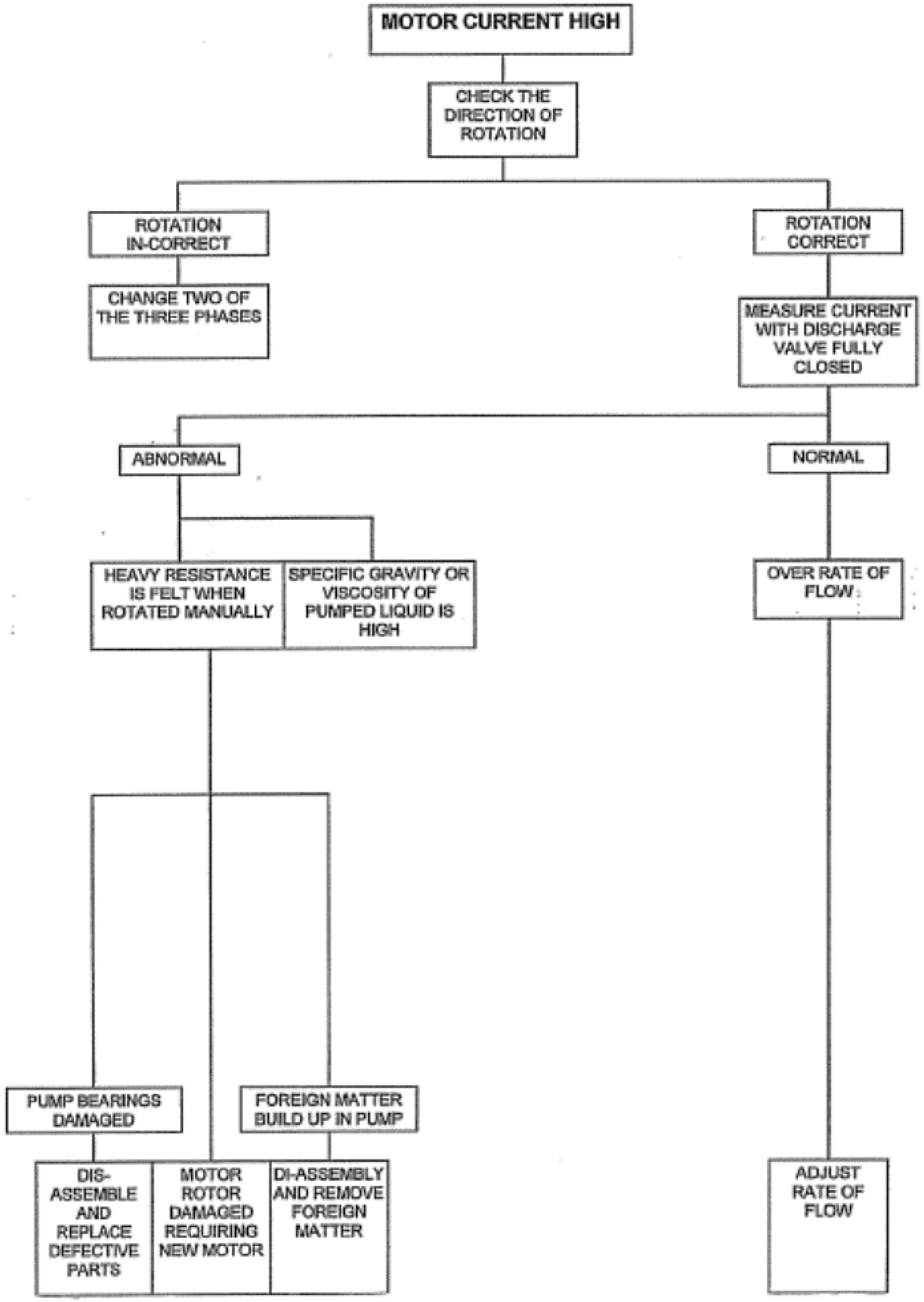
FREQUENCY AS % RUN SPEED.	POTENTIAL CAUSES (%)	SOLUTIONS
VERY HIGH FREQUENCY- BUT, also with the HIGH FREQUENCIES and the PEAKS VARYING FREQUENTLY.	The cause will be Cavitation. (90%)	CHECK ALL THE POTENTIAL CAUSES OF CAVITATION BELOW:- 1. If there is a Suction Filter fitted, ensure the pressures on both upstream and downstream sides of the Filter are monitored. To ensure the Filter is never progressively blocking, which would cause a Suction Pressure drop & turbulence. Which would result in Cavitation. 2. Check the Casing & Impeller Wear Ring clearances and TIR. Because the higher the Clearances become, the greater is the Wear Ring recirculation into the suction Eye of the Impeller, which can result in Cavitation, & reduced Efficiencies. 3. Check that the Pump flowrate is not lower or higher than recommended. As this could result in Discharge or Suction Recirculation vortices, that can result in Cavitation & damage. 4. Check there are never any upset conditions that could reduce the NPSHA, by reducing the Suction Pressure. 5. If the Pump is VFD driven, ensure the Pump is never running at a speed higher than stated to the pump supplier, as this would result in a much higher NPSHR value. Which would reduce or eliminate the NPSH Margin, resulting in Cavitation.

High Motor Current:



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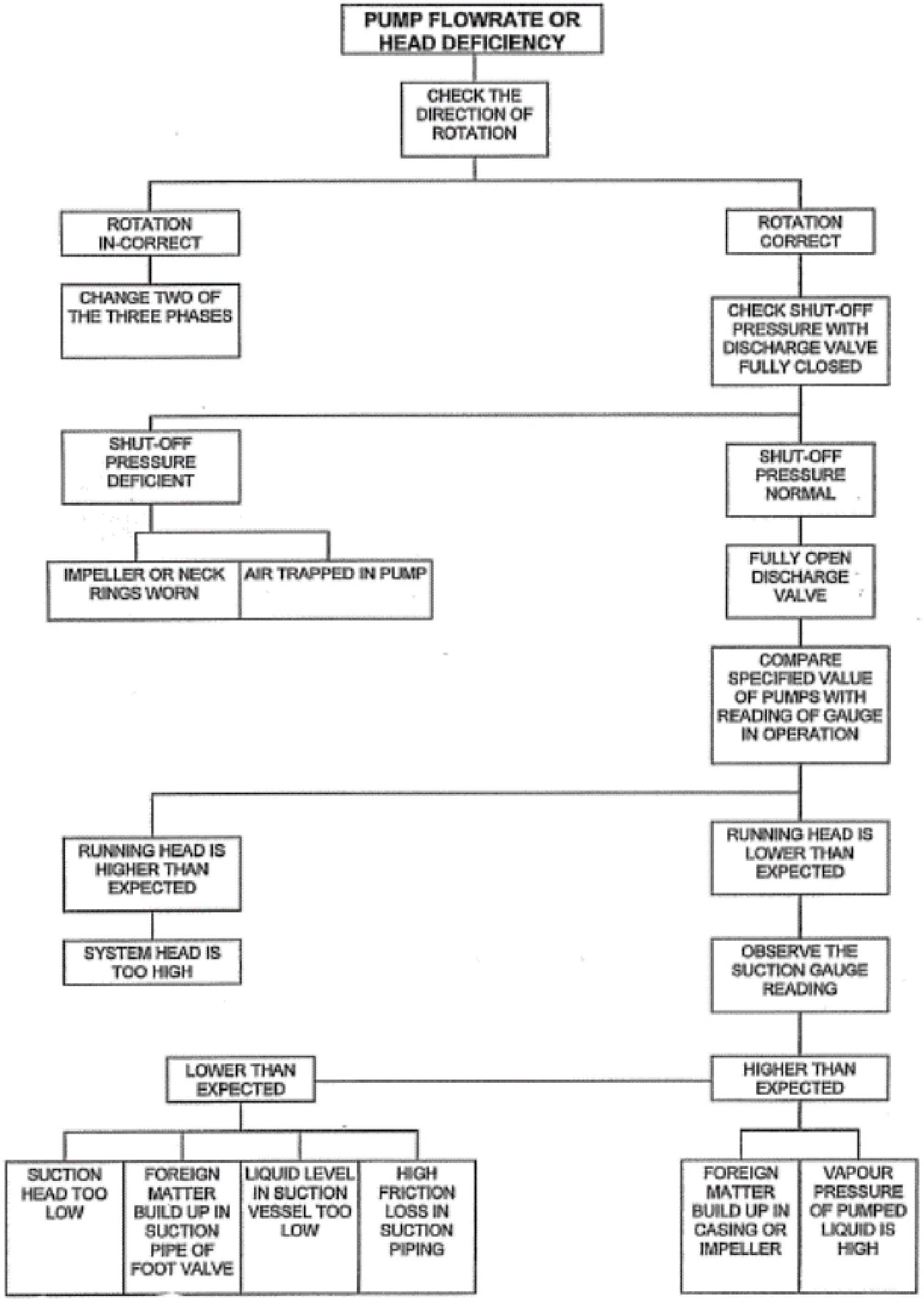
Unexpected Power increase:

- Piping strain, if excessive, could be causing impeller wear ring to touch case wear ring.
- Change in system resistance- Flow has increased.
- A Bypass loop may have opened, again increasing the flow.
- Check the antifriction bearings- is the Oil mist still being supplied. If not bearings may be being damaged.
- Could be mechanical seal problems- Check mechanical seal systems are operating correctly & contain correct liquid level.

Unexpected Power decrease:

- Cavitation taking place- Good indication if Head is reducing, & vibration increasing.
- Check if an In-Line filter is blocking, causing cavitation and lower flows.
- Increase in system resistance-Flow has decreased.

Low Flow or Low Head:



Unexpected Changes in Flow & Head

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- Changes in system resistance - Lower resistance = higher flows, higher resistance = lower flows.
- Has a bypass line opened or closed?
- Is cavitation causing low head and so low flows…. If so there will usually be increases in vibration and possibly noise.

Unexpected Changes in Bearing Temperature:

- Check the Oil mist is connected and running OK.

- Increased wear ring clearance can cause increased axial thrust. This will lead to higher thrust bearing temperatures.

- Is cavitation causing low head and so low flows…. If so there will usually be increases in vibration and possibly noise.

- Check alignment is correct.

Common Reasons Why Seals Fail

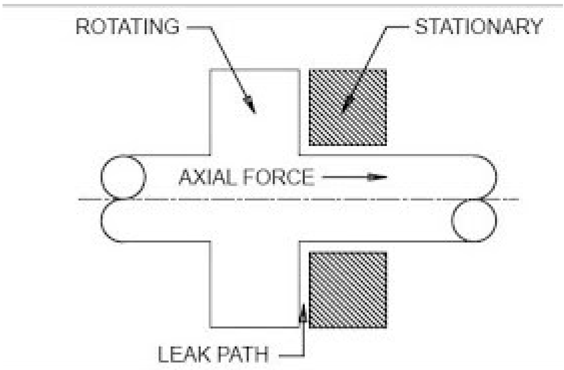
"90% of pump problems show up as mechanical seal problems. 90% of seal problems are actually pump problems"

Peter Hickman – Flowserve Seals

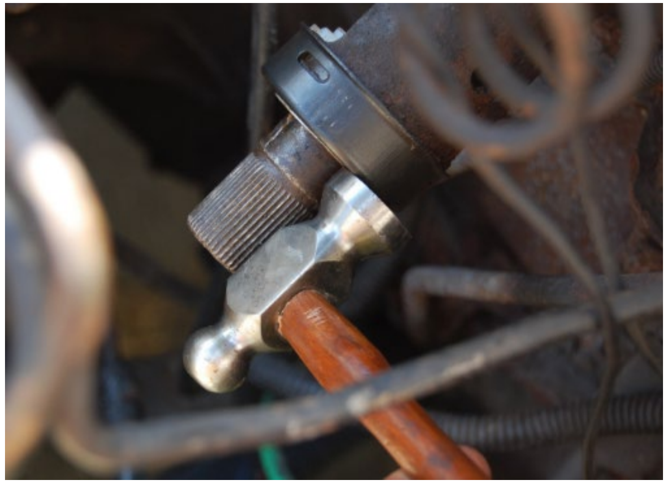
- Allowing the pump to run dry

Thermal cracks in seal face caused by poor lubrication

- Vibration
  - Rotating components are out of balance
    1. Seal faces can separate
    2. Seal faces become damaged



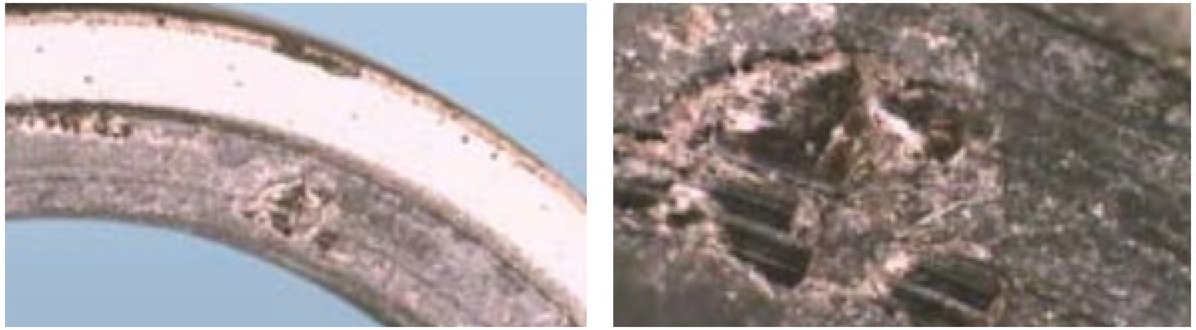
- Hammering coupling onto the shaft



- Operator Error

- Seal flush plan improper use or lack thereof

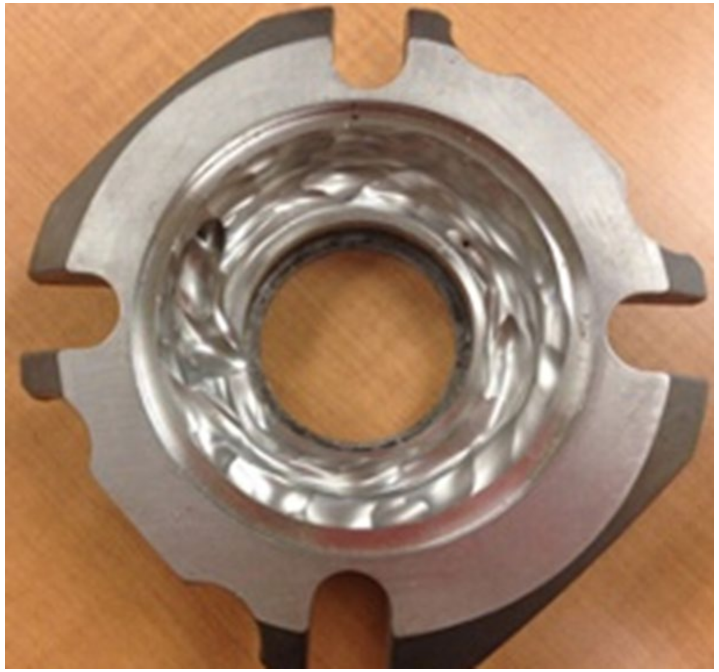
Surface damage due to high temperature on EPDM and FKM secondary seals



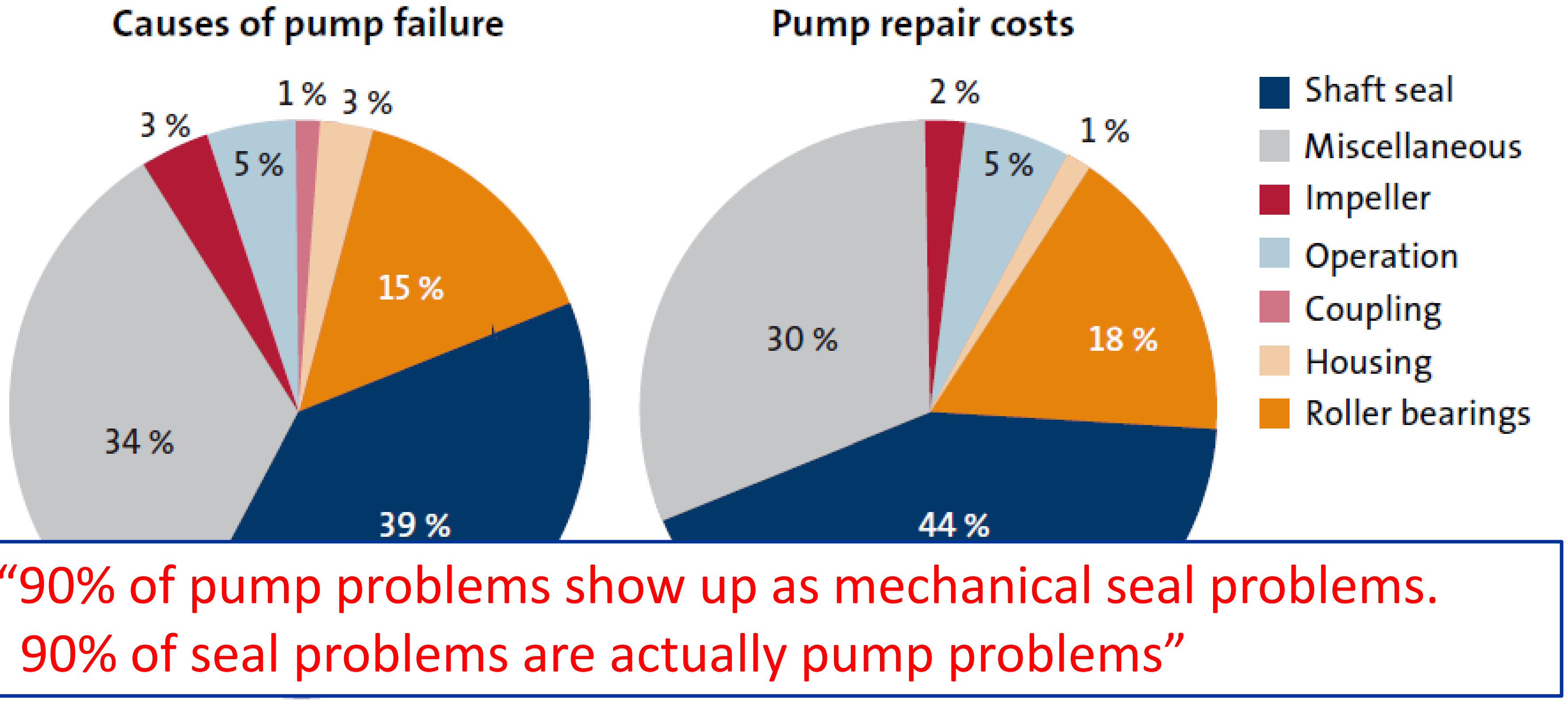
Deposits on carbon graphite seal face

- Selecting the wrong seal or materials

A fresh EPDM O-ring (left) and a swollen EPDM O-ring (right) exposed to water containing mineral oil



5 Types of Sealing Failures



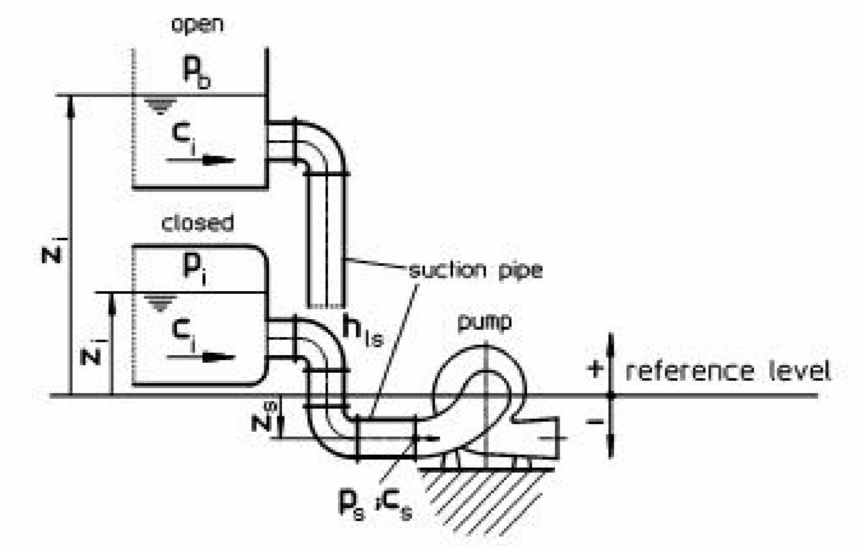
"90% of pump problems show up as mechanical seal problems.
90% of seal problems are actually pump problems"

Fig. 5.1: Analysis of pump failure. Mechanical seals account for 39 % of pump failures. [1]

Fig. 5.2: Analysis of pump repair costs. Mechanical seals account for 44 % of pump repair costs. [1]

1. Operational Failures – About 40% of all sealing device failures are due to operational errors

   - Insufficient Net Positive Suction Head (NPSH)
   - Operating Dead-Headed
   - Dry Running & Improper Venting of Seal
   - Low Vapor Margin



Sealing Failures

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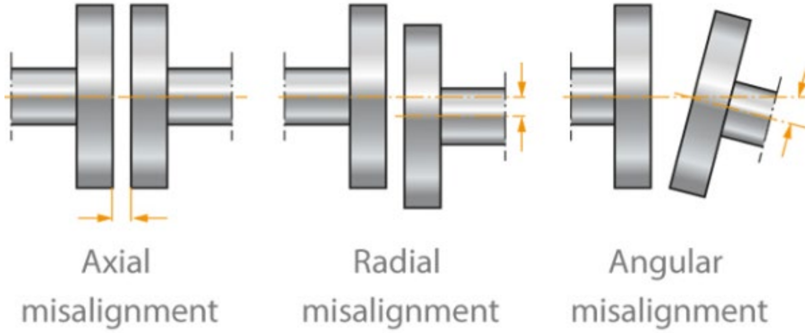
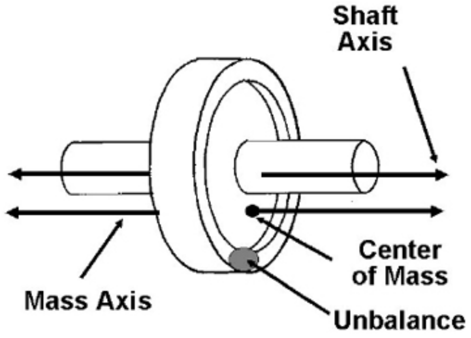
2. Mechanical Failures – Contribute to about 24% of all failures

- Shaft misalignment
- Coupling imbalance
- Impeller imbalance
- Additionally:
  - Misaligned pipes bolted to pump
  - Avoid a bad base
  - Check the bearings



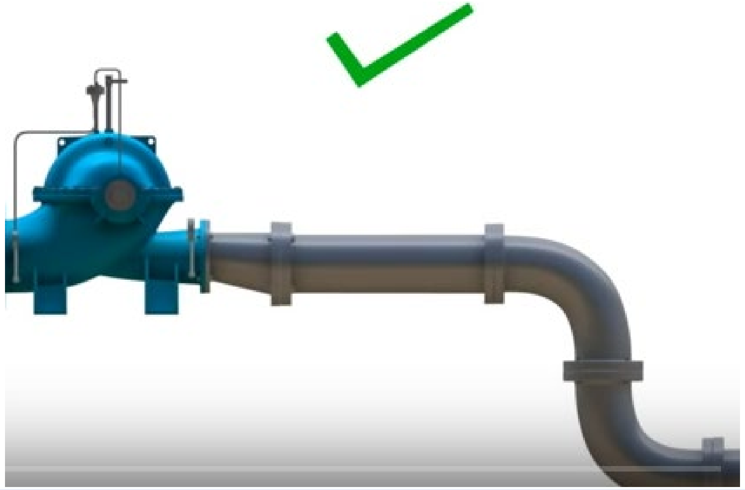


3. Seal Component Failures – Comprise 9% of seal failures

- Have you chosen the correct facing combinations?
- What about the seal face material quality?
- Are your materials appropriate for your specific application?
- Have you selected the proper secondary seals, such as gaskets and o-rings, that are prepared for chemical and heat attacks?
- Your springs should not be clogged or your bellows corroded.
- Look out for face distortions from pressure or heat.

4. System Design Failures – About 19% of mechanical seal failures are due to a poor system design.

- Proper seal flush arrangement, along with sufficient cooling.
- Dual systems have barrier fluids; the auxiliary seal pot needs to be in the right location, with the correct instrumentation and piping.
- Length of Straight Pipe at Suction
- All the suction/discharge and bypass piping needs to be engineered correctly



5. Everything Else - Other miscellaneous factors account for only about 8% of all failures

- For example, auxiliary systems are sometimes required to provide an acceptable operating environment for a mechanical seal.

- Conclusion:
  - Mechanical seals are a major factor in rotating equipment reliability
  - Responsible for leaks and failures of the system
  - But also indicate problems
  - Seal reliability is greatly affected by seal design and operating environment

Seal Troubleshooting

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- Collect Entire Seal
  - Do not try to troubleshoot a seal by using only the parts that look important. You must have both rotating and stationary parts.
  - Tie mating ring and primary ring parts together.
- Examine Seal Faces
  - Look for wear track in circular pattern on matting ring face.
  - A proper wear track is the same dia. & width as the primary ring face dia. & width.
    - This important sign, tells you pump is in good alignment and face leakage is probably not cause if any seal problem.
  - A wide wear track indicates that there is serious misalignment of pump.
- Check for chipping of seal faces
  - Chipping at the OD is most often associated with fluids that flash
  - Severe cavitation of the pump coupled with a hung-up seal may cause the seal face ID to chip.
- Check the Drive Mechanisms
  - Worn drive lugs or drive slots are usually caused by high face friction and loss of face lubrication (slip-stick).
    - Lack of lubrication can be caused by: installing seal with too much spring compression, to much pressure on the faces, poor lubricating properties of the fluid, bad face combinations, pump cavitation, a gas bubble trapped in the seal chamber at the face.

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- Check the Spring or Bellows
  - Springs and metal bellows usually break from chemical attack at time devise is being stressed.
    - Possibility of chloride and sulfide stress corrosion.
  - Metal bellows seal will clog or fail if pumped product hardens, or particles become stuck inside of the bellows
    - This occurs when excessive product leakage past faces of the seal
- Check the Elastomers and Secondary Seals
  - Swollen, sticky or disintegrating elastomer is normally sign of chemical attack.
  - Excessive face heat can cause hardening, charring, cracking, burned appearance, or shape changes on elastomers
- Check for Rubbing
  - Look for worn spots or signs of discoloration on the seal from rubbing
  - Some causes of rubbing:
    - flush lines to far into the lantern connection
    - primary rings rubbing the shaft
    - scale build-up in seal chamber
    - shaft whip caused by impeller imbalance
    - shaft deflection
    - set screws backed out of the seal
    - worn bearings

Metal bellows seal clogged by lime scale build-up

Coming Attractions ☺

"An Introduction to Positive Displacement Pumps"

Thurs 21st April – 08.00 (UK BST (GMT+1)) (Eastern Hemisphere) &

17.00 (UK BST (GMT+1)) (Western Hemisphere)

Aimed at Process and Mechanical Engineers, and Consultant Engineers who specify pumping equipment as well as Applications & Sales Engineers selecting and quoting them.

Pump engineers are generally knowledgeable about centrifugal pumps, but are less familiar with positive displacement pumps. This session will look at PD pumps in general but with particular focus on reciprocating plunger pumps.

Future sessions : TBA

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Q & A

RUHRPUMPEN AT A GLANCE

VERTICAL INTEGRATION

SALES OFFICES IN +35 COUNTRIES

MANUFACTURING **FACILITIES** IN 10 COUNTRIES

+70 YEARS OF EXPERIENCE

+2,000 EMPLOYEES

15 **SERVICE CENTERS**

+70,000 PUMPING SOLUTIONS INSTALLED WORLDWIDE

A GLOBAL COMPANY

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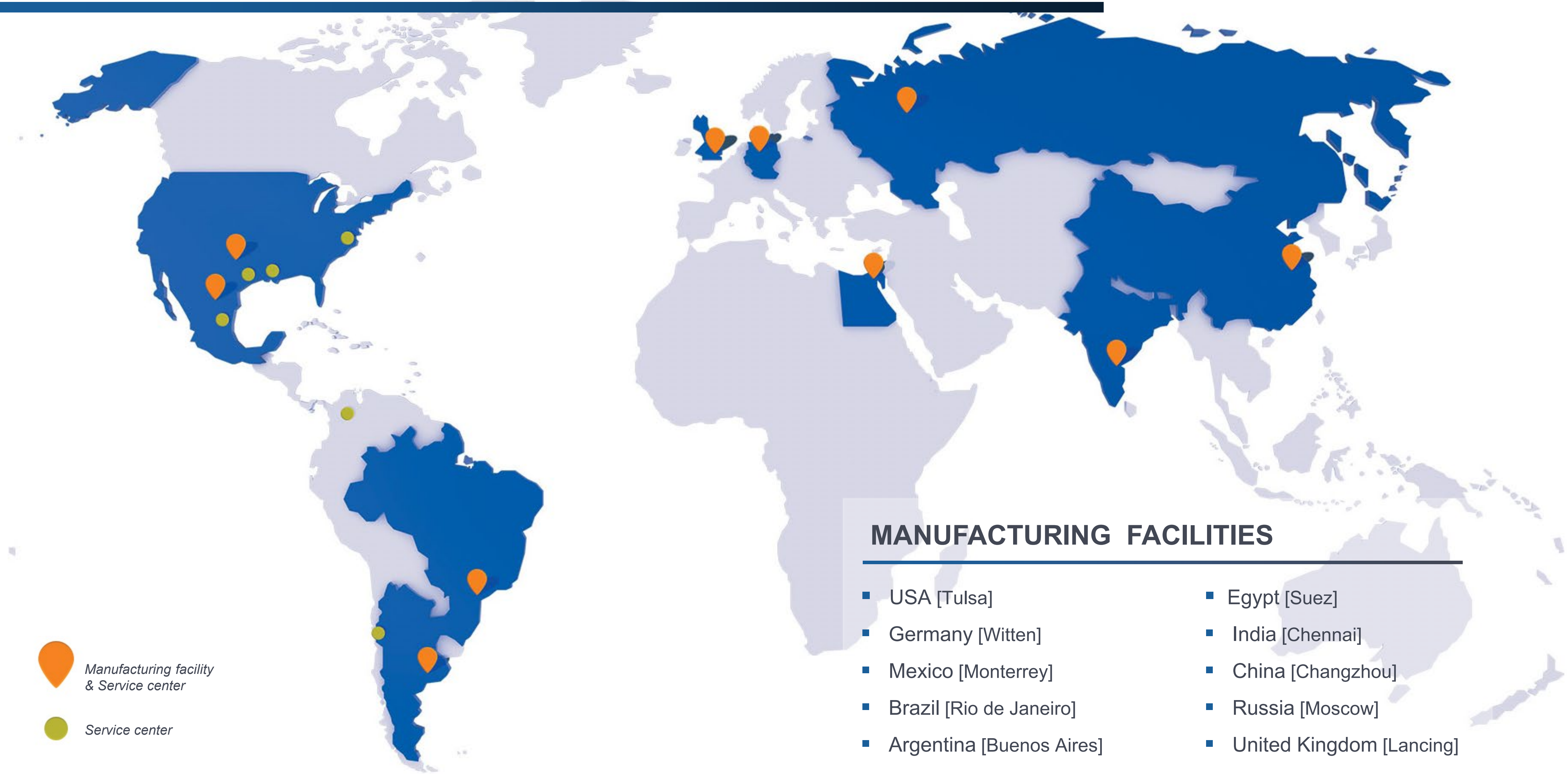
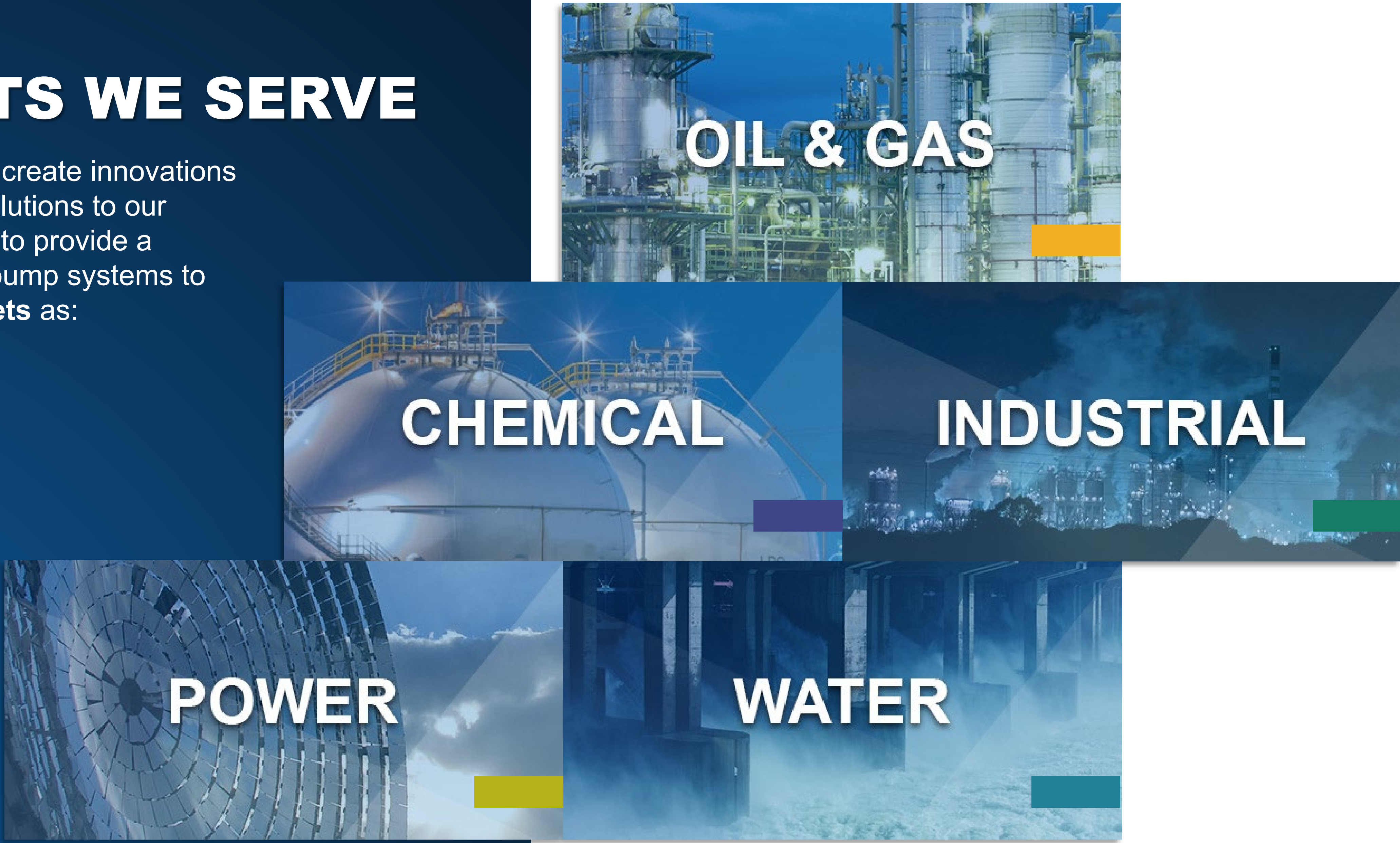


MANUFACTURING FACILITIES

- USA [Tulsa]
- Germany [Witten]
- Mexico [Monterrey]
- Brazil [Rio de Janeiro]
- Argentina [Buenos Aires]
- Egypt [Suez]
- India [Chennai]
- China [Changzhou]
- Russia [Moscow]
- United Kingdom [Lancing]

MARKETS WE SERVE

Our commitment to create innovations that offer reliable solutions to our customers allow us to provide a complete range of pump systems to support **core markets** as:



RUHRPUMPEN

OUR PUMP LINES

Ruhrpumpen offers a broad range of highly engineered and standard pumping products that meet and exceed the requirements of the most demanding quality specifications and industry standards.

Our pumps can handle head requirements as high as 13,000 ft (4,000 m) and capacities up to 300,000 gpm (68,000 m^3/hr). Moreover, our pump designs cover temperatures from cryogenic temperatures of -310 °F (-196 °C) up to 752 °F (400 °C).

Products include:

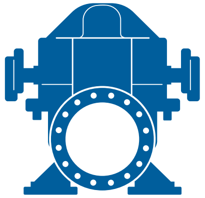
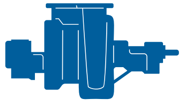
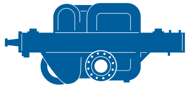
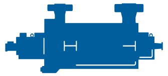
- Single Stage Overhung Pumps
- Between Bearings Pumps
- Horizontal Multi-Stage Pumps
- Vertical Multi-Stage Pumps
- Vertical Mixed Flow & Axial Flow Pumps
- Positive Displacement Pumps
- Full Range of Industrial Pumps
- Submersible Pumps
- Magnetic Drive Pumps
- Decoking Systems
- Packaged Systems
- Fire Systems

OVERHUNG PUMPS

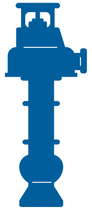
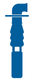
CATEGORY	RP MODEL	DESIGN STANDARD
Sealless Magnetic Drive Pumps	CRP-M / CRP-M-CC	ISO 2858 & 15783 HI design (OH11)
	SCE-M	API 685
Foot Mounted OH1 and General End Suction Pumps	IPP	HI design (OH1)
	CPP / CPP-L	HI design (OH1) ANSI B73.1
	CPO / CPO-L	HI design (OH1) ANSI B73.1
	CRP	HI design (OH1) ISO 2858 & 5199
	GSD	HI design (OH0)
	SHD / ESK / SK / SKO SKV / ST / STV	HI design (OH1)
	SWP	HI design (OH3A)
Centerline Mounted	SCE	API 610 (OH2)
Vertical In-Line Pumps	SPI	API 610 (OH3)
	IVP / IVP-CC	HI design (OH4 / OH5)
	IIL	HI design (OH5) Dimensionally compliant with ANSI B73.2
	SPN	API 610 (OH5)

OUR PUMPS

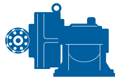
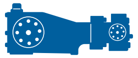
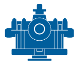
BETWEEN BEARING PUMPS

CATEGORY		RP MODEL	DESIGN STANDARD	
1 and 2 stage	Axially split	HSC / HSD / HSL HSR / ZW	HI design (BB1)	
		HSM	HI design (BB3)	
		ZM / ZMS ZLM / ZME	API design (BB1)	
	Radially split	HVN / J	API design (BB2)	
		RON / RON-D	API design (BB2)	
Multi-stage	Axially split	SM / SM-I	API design (BB3)	
		JTN	API design (BB3)	
	Radially split *single casing*	GP	API design (BB4)	
	Radially split *double casing*	A LINE	API design (BB5)	

VERTICAL PUMPS

CATEGORY		RP MODEL	DESIGN STANDARD	
Single casing	Diffuser	**VTP**	HI & API 610 (VS1)	
		VCT	HI & API 610 (VS1)	
		HQ	HI & API 610 (VS1)	
		VLT	HI & API 610 (VS1)	
	Volute	**DSV / DX**	HI & API 610 (VS2)	
	Discharge through column – Axial flow	**VAF**	HI & API 610 (VS3)	
	Separate discharge line	**VSP / VSP-Chem**	HI & API 610 (VS4)	
Double casing	Diffuser	**VLT / VMT**	HI & API 610 (VS6)	
	Volute	**DSV / DX**	HI & API 610 (VS7)	
Submersible pumps		**SMF**	HI design (OH8A)	
		VLT-Sub / VTP-Sub	HI design (VS0)	

SPECIAL SERVICE PUMPS

CATEGORY	RP MODEL	DESIGN STANDARD	
Pitot tube pumps	**COMBITUBE**	HI design	
Reciprocating pumps	**RDP**	API 674 ISO 13710	
Vertical turbine generator	**VTG**	HI design (VS6)	
Barge	**LS BARGE**	HI design	
Floating dock pumps	**ZVZ**	HI design	
	LVZ	HI design	
Cryogenic pumps	**SVNV**	-	
	VTG Cryogenic	-	
	VLT Cryogenic VLTV	-	
Pre-packaged fire pump systems	Fire systems incorporate pumps, drivers, control systems and pipework in a single container. They can be skid mounted, with or without enclosure and supplied with electric motor or diesel engine.	**NFPA-20-850** UL and FM approved components