RUHRPUMPEN

Specialist for Pumping Technology

Session 32 –

Understanding Pump Instrumentation (2)

Simon Smith April 2024

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 43 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.

RUHRPUMPEN

RuhRPumpen Short Courses

Here is a listing of all the previous courses.

- No 1 – API610 12th v 11th editions
- No 2 - Curve Shape (1)
- No 3 – The Importance of System Curves (1)
- No 4 - Selecting the Right Pump for the Application
- No 5 - NPSH & Nss
- No 6 - Mechanical Seals & Systems (1)
- 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
- No 15 – Start-Up, Commissioning & Troubleshooting Centrifugal Pumps
- No 16 – Introduction to Positive Displacement (Plunger) Pumps
- No 17 – Refresher Session
- No 18 – Overhung Process Pumps OH1 & OH2

Continued next slide

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RuhRPumpen Short Courses

Here is a listing of all the previous courses. Contd

- No 19 – Vertical Overhung Process Pumps OH3-OH6
- No 20 – New Developments in the VS6 Market
- No 21 – BB4 Multistage Pumps for the Power Industry
- No 22 – Coking Process and Hydraulic Decoking Equipment
- No 23 – Pumps for the Desalination Market
- No 24 – Cryogenic Pumps
- No 25 – Magnetic Drive Pumps
- No 26 – Mechanical Seals & Systems (2)
- No 27 – The Importance of System Curves (2)
- No 28 – NPSH & Nss Made Simple (2)
- No 29 – Curve Shape, Head Rise & Allowable Tolerances (2)
- No 30 – Selecting the Right Pump for the Application (2)
- No 31 Comparison of API610 12th & 11th Editions (2)

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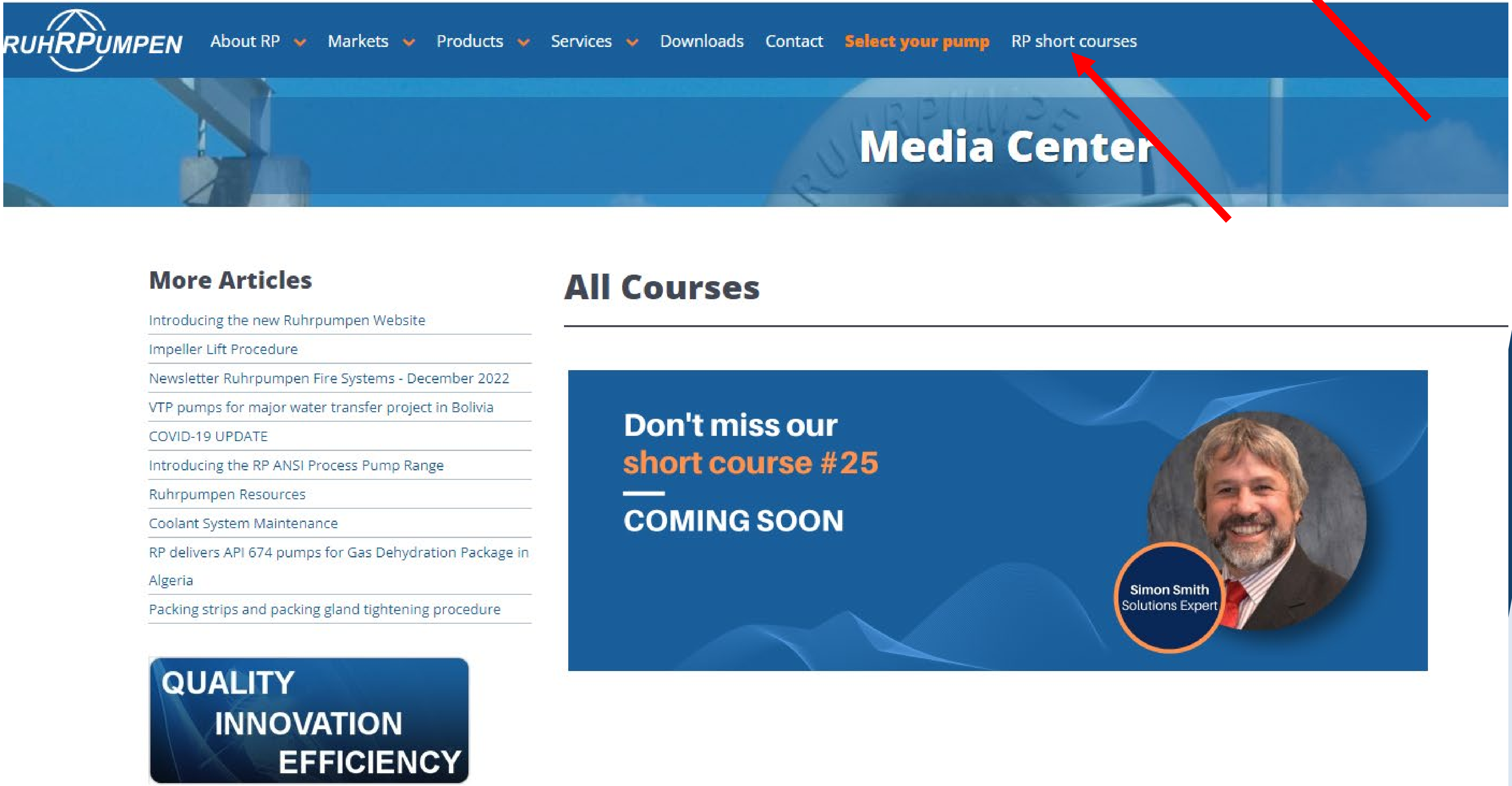

RuhRPumpen Short Courses

SHORT COURSE 12

Vertical Pumps (VS4/5, VS6, VS7)

Full session.

Downloads. (14.73 MB)

SHORT COURSE 13

Performance Testing and Inspection of API 610 Pumps

Full session.

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SHORT COURSE 14

Performance Testing and Inspection of API 610 Pumps

Full session.

Downloads. (7.30 MB)

RuhRPumpen Short Courses

SHORT COURSE 14

Performance Testing and Inspection of API 610 Pumps

Full session.

Downloads. (7.30 MB)

SHORT COURSE 15

Start-Up, Commissioning & Troubleshooting Centrifugal Pumps

Full session.

Downloads. (6.14 MB)

SHORT COURSE 16

Introduction to Positive Displacement (Plunger) Pumps

Session part 1.

Session Part 2.

Downloads. (10.50 MB)

Session 32 –
"Understanding Pump Instrumentation"

Aimed at Process and Mechanical Engineers, Consultant Engineers and possibly even Instrumentation Engineers who specify pumping equipment as well as Applications & Sales Engineers selecting and quoting them.
This course will look at commonly supplied pump instrumentation (especially vibration monitoring) and understanding what the readings obtained tell you about your pump installation.

Identifying Pump Vibration Problems by Analysing the Vibration Frequencies

Knowing how to identify the many potential pump vibration causes will lead to identifying the potential cause and solution.

These slides are intended to give guidance as to the likely cause.

THERE ARE 2 GENERAL PHYSICAL CAUSES OF VIBRATION:-

1. Mechanical Causes:- Such as Balancing, Mis-alignment & Bearing problems, and others as shown later.

2. Hydraulic Causes:- Such as Liquid Turbulence, Cavitation & low flow Suction & Discharge recirculation, and other Causes as shown later.

Understanding Pump Vibration

There Are 3 Different Vibration Measurement Devices That Are Used On Pumpsets:-

1. Velometers (also called Velocimeters):- Which measure the Velocity of the Vibration levels in units of Inches/Second or mm / second
2. Accelerometers:- Which measure the rate of change of Velocity over time. So the units of Acceleration of the Vibration levels is in Inches/Second^2 (or mm/second^2)
3. Displacement Vibration Proximity Probes:- Which are used on pumps with Journal (Sleeve) Radial Bearings, and on pumps with Tilting Pad Thrust Bearings. These Probes measure the displacement (slight movement), of a rotating component (usually just the Shaft) in Mils (thousandths of an inch (0.001 inch)) Peak-to-Peak or microns (µm (10^{-6} m).

- Many Vibration devices can measure Vibration units either in RMS (Root Mean Square) or Peak-to-Peak.

Understanding Pump Vibration

RMS:- But, if you ever need to manually convert several Peak-to-Peak values to RMS values manually, here is the mathematical method of converting :-

RMS stands for ROOT…MEAN…SQUARE…….

- Which means you SQUARE all of the individual Peak to Peak values…
- Then calculate the MEAN value by Averaging the Sum of the squared Peak-to-Peak values…
- Then calculate the Square ROOT of that Total, which is the RMS of all the evaluated Peak-to-Peak values.

EXAMPLE OF CONVERTING PEAK-TO-PEAK TO RMS MANUALLY:-

- Peaks= 0.12, 0.09, 0.14.
- Square= 0.0144, 0.0081, 0.0196.
- Mean (Average)= (0.0144+0.0081+0.0196)/3 = 0.01403.
- Square ROOT of 0.01403 = RMS = 0.118.

Understanding Pump Vibration

PUMP STANDARDS SPECIFY THAT THE VIBRATION MEASUREMENTS MUST BE IN 3 PLANES, EACH AT 90 DEGREES TO THE OTHER, WHICH ARE:-

H = Horizontally, at the side of each Bearing Housing.

V = Vertically, at the top of each Bearing Housing.

A = Axially, at the end of each Bearing Housing or their flange.

This is shown on the next slide as an extract from API610- 11th Edition.

Location of Vibration Readings

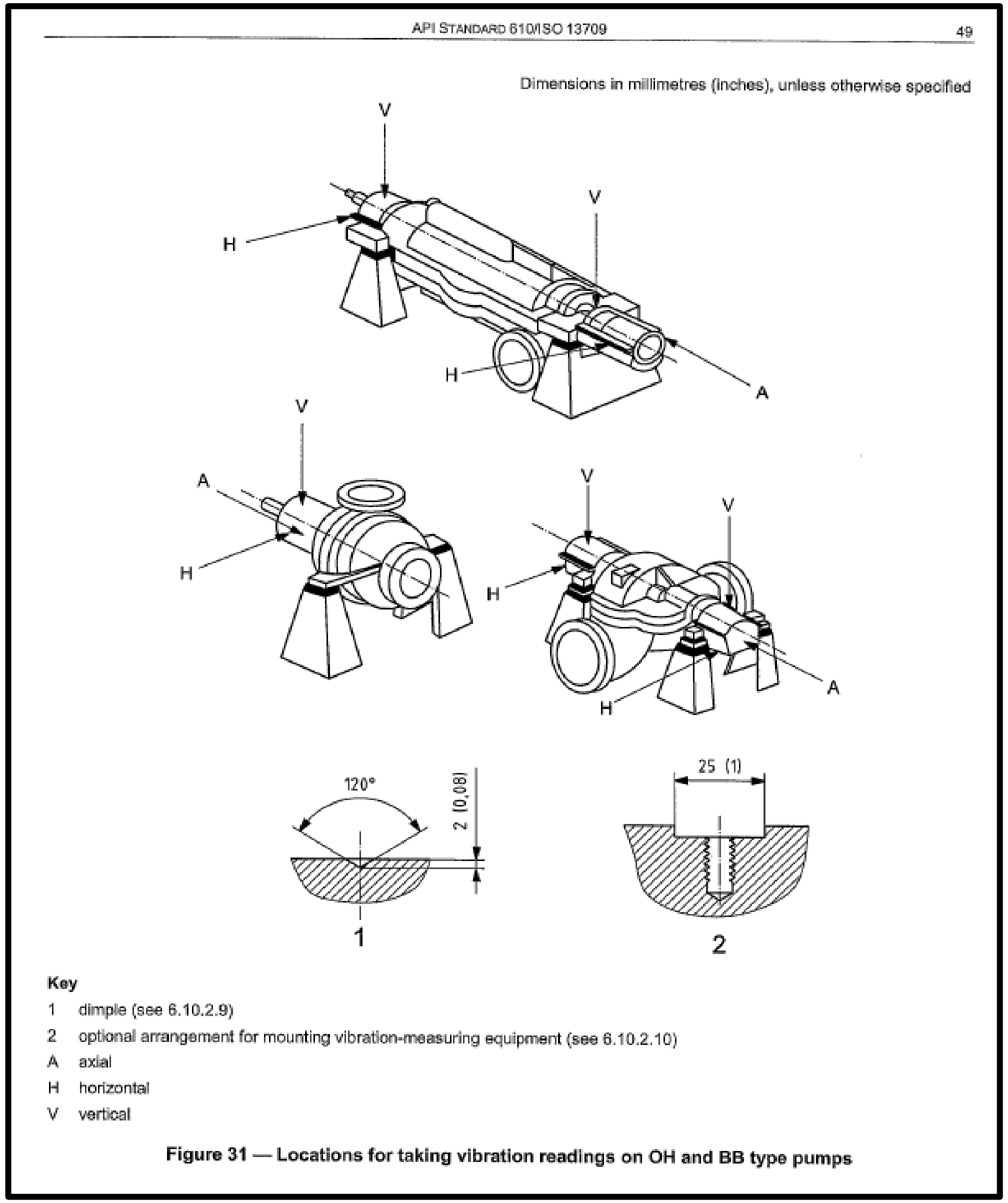
<u>This sketch from API610- 11th Edition, shows the location of the 3 Vibration Axis to be measured:-</u>

The Accelerometer & Velometer vibration devices used, can be hand-held, always using the same Dimpled areas. Or screwed into the Bearing Housings.

Hand-held:

Screwed device:

These devices are usually only used on Pumps with anti-friction bearings.


API STANDARD 610/ISO 13709 49

Dimensions in millimetres (inches), unless otherwise specified

Key

1 dimple (see 6.10.2.9)

2 optional arrangement for mounting vibration-measuring equipment (see 6.10.2.10)

A axial

H horizontal

V vertical

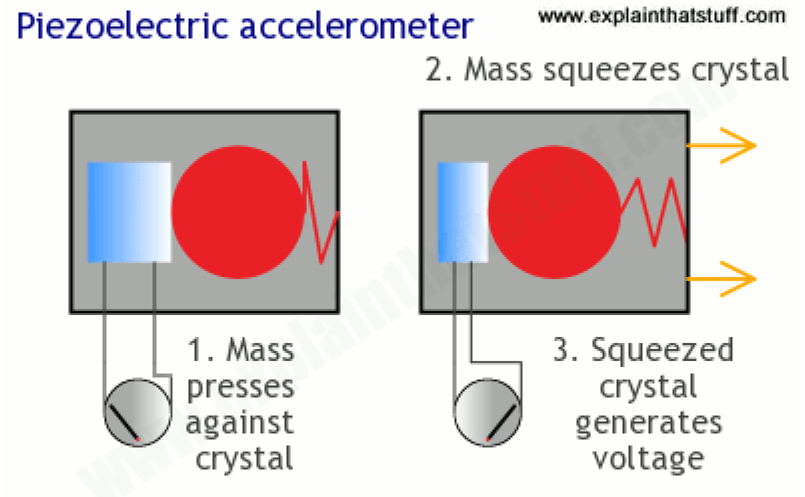
Figure 31 — Locations for taking vibration readings on OH and BB type pumps

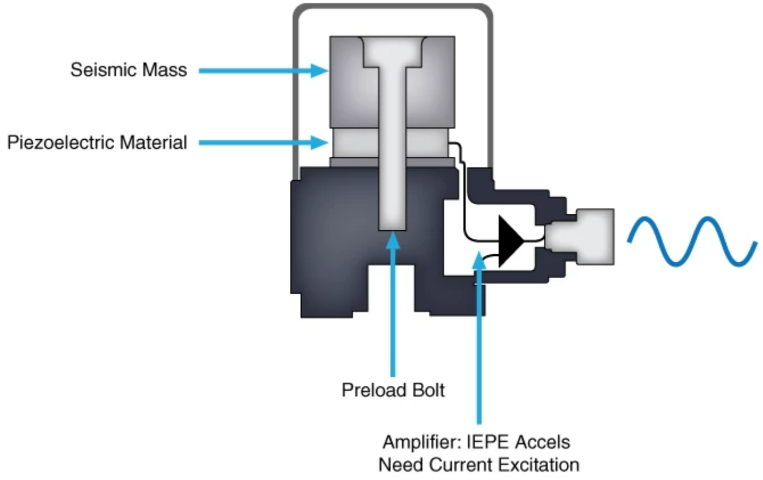
Understanding Pump Vibration

HOW THE VIBRATION MEASUREMENT DEVICES OPERATE-

ACCELEROMETER:-

An accelerometer is a device that measures the vibration, or acceleration of motion of a structure. The force caused by vibration or a change in motion (acceleration) causes the mass to "squeeze" the piezoelectric material which produces an electrical charge that is proportional to the force exerted upon it. The millivolts are amplified which, on the separate monitoring device, allows the Acceleration to be plotted.





Understanding Pump Vibration

HOW THE VIBRATION MEASUREMENT DEVICES OPERATE-

VELOMETER:-

Most Velometers are constructed in a similar manner to Accelerometers.

Except they contain integration circuitry, which converts Acceleration values to Velocity.

API610 specifies vibration limits in Velocity units.

Understanding Pump Vibration

Table 8 — Vibration limits for overhung and between-bearings pumps

Antifriction Bearings

Criteria	Location of vibration measurement	
	Bearing housing (see Figures 31 and 33)	Pump shaft (adjacent to bearing)
	Pump bearing type	
	All	Hydrodynamic journal bearings
	Vibration at any flowrate within the pump's preferred operating region	
Overall	For pumps running at up to 3 600 r/min and absorbing up to 300 kW (400 hp) per stage: $v_u < 3{,}0$ mm/s RMS (0,12 in/s RMS) For pumps running above 3 600 r/min or absorbing more than 300 kW (400 hp) per stage: see Figure 34	$A_u < (5{,}2 \cdot 10^6/n)^{0{,}5}$ µm peak-to-peak $[(8\ 000/n)^{0{,}5}$ mils peak-to-peak] Not to exceed: $A_u < 50$ µm peak-to-peak (2,0 mils peak-to-peak)
Discrete frequencies	$v_f < 2{,}0$ mm/s RMS (0,08 in/s RMS)	for $f < n$: $A_f < 0{,}33 A_u$
Allowable increase in vibration at flows outside the preferred operating region but within the allowable operating region	30 %	30 %

DISPLACEMENT VIBRATION PROXIMITY PROBES

Understanding Pump Vibration

<u>DISPLACEMENT VIBRATION PROXIMITY PROBES</u>:- The 2 radial probes are shown below. They are powered by a Proximitor which provides an alternating, high frequency voltage from a minus 24 Volts DC supply to the coils within the Proximity Probes. Which causes an alternating electro-magnetic field at the probe tip. The effect of which is to induce alternating eddy-currents in the Shaft. These eddy-currents then generate a magnetic field emanating from the Shaft, which opposes the field from the Probe.

Then as the gap between the Probe and the Shaft varies, the magnetic field interaction changes as well. The Probe electronics measure these field changes, and generate an output voltage which is proportional to the change in the gap. The Probes then accurately measure the radial movement of the Shaft in mils (0.001”) or µm (10^{-6}m)

<u>Proximity Probes are calibrated to match the Resistivity of AISI-4140 shaft material:-</u>

So Different Shaft metallurgies, with different Resistivity, need to be told to the Probe supplier so they will Re-Calibrate the Probes to suit that material.

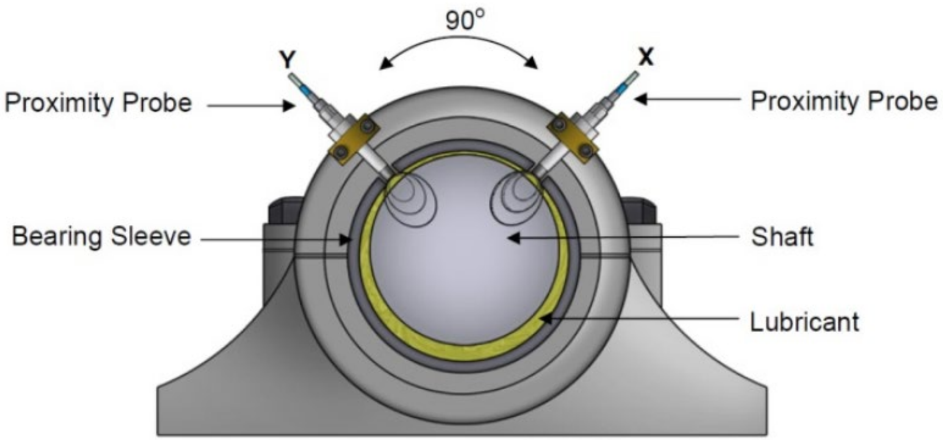


Figure #2 – X and Y Radial Proximity Probes

Understanding Pump Vibration

Table 8 — Vibration limits for overhung and between-bearings pumps

Hydrodynamic Bearings

Criteria	Location of vibration measurement	
	Bearing housing (see Figures 31 and 33)	Pump shaft (adjacent to bearing)
	Pump bearing type	
	All	Hydrodynamic journal bearings
	Vibration at any flowrate within the pump's preferred operating region	
Overall	For pumps running at up to 3 600 r/min) ... n	$A_u < (5,2 \cdot 10^6/n)^{0,5}$ µm peak-to-peak $[(8\ 000/n)^{0,5}$ mils peak-to-peak] Not to exceed: $A_u < 50$ µm peak-to-peak (2,0 mils peak-to-peak)
Discrete frequencies	$v_f < 2,0$ mm/s RMS (0,08 in/s RMS)	for $f < n$: $A_f < 0,33A_u$
Allowable increase in vibration at flows outside the preferred operating region but within the allowable operating region	30 %	30 %

v_u is the measured overall velocity;

v_f is the discrete frequency velocity, measured with a FFT spectrum using a Hanning window and a minimum frequency resolution of 400 lines;

A_u is the amplitude of measured overall displacement;

A_f is the amplitude of displacement at discrete frequencies, measured with a FFT spectrum using a Hanning window and a minimum frequency resolution of 400 lines;

f is the frequency;

n is the rotational speed, expressed in revolutions per minute.

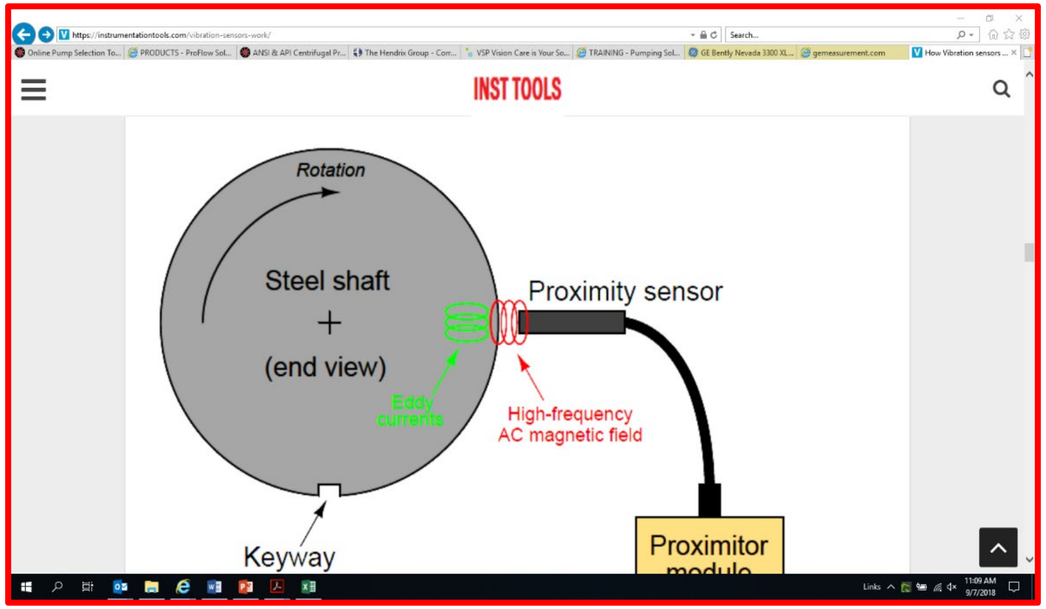
Key Phasor Proximity Probes

Understanding Pump Vibration

<u>KEYPHASOR PROXIMITY PROBES</u>:- The 2 radial Probes shown on the previous slide, would identify all Shaft vibration orbits through the 360 Degrees of the Shaft rotation.

A REFERENCE POINT IS REQUIRED TO SHOW WHERE, WITHIN 360 DEGREES, THE SHAFT IS DISPLACING. To identify the displacement location, this extra Proximity Probe, as shown below. Which is located above a Shaft Keyway and is called the KEYPHASOR PROBE. Whose signal is combined with the radial Probe signals.

The KeyPhasor Probe (sketch below) then identifies how many degrees from the key location the shaft is displacing. The KeyPhasor can be used as a tachometer to accurately determine the pump RPM.



Understanding Pump Vibration

Trouble Shooting - 1

Centrifugal pumps generally operate for years trouble free and have a great reputation for reliability.

If there are problems, then there may be early indications that can help provide a solution.

Many clues can be obtained by checking all the normal pump parameters, such as sudden Power variations. As shown on the next two slides.

Trouble Shooting – Checklist 1

Trouble Shooting - 1

EXPLAINING THE POTENTIAL CAUSES OF A SUDDEN PUMP POWER INCREASE:-

1. If Piping Loads are excessive, this could be causing wear ring contacts. If the impeller wear ring is touching the case wear ring. Therefore damaging friction would cause higher Power.
2. Extreme Wear Ring wear, can double the clearances. Which would allow greater re-circulation, which would reduce the Efficiency, and so would increase Power.
3. Reduction in the System Resistance, such as a By-Pass Valve faulty be fixed open. Which would cause the Pump Discharge flow to increase, and so the Power would increase.
4. Check the antifriction bearings, & check the oil level, oil quality and oil grade is correct.
5. If the bearings are Oil-Mist lubricated, then verify the oil mist system is operating correctly. If not, bearings may be being damaged, and absorbing more Power.
6. If the Power increase is due to Mechanical Seal problems, just prior to seal leakage. Check the seal piping system is operating correctly, and that the seal faces are clean and not eroded due to liquid crystallization. Which could occur if pumping for example Sodium Hydroxide (NaOH), which forms crystals as vapor reaches atmosphere across the seal faces:-
(Which is why, when pumping NaOH, a Plan-62 liquid Quench system is used to prevent formation of crystals, on the atmospheric side of the seal faces).

Trouble Shooting – Checklist 1

7. Bearing Oil Temperature. The hotter the oil the lower the oil viscosity becomes. And the Bearing manufacturers, advise that when the oil gets down to 11cSt or lower it would cause the Bearings to start skidding against their inner & outer races. This causes bearing damage & Bearing Vibrations.

EXPLAINING THE POTENTIAL CAUSES OF SUDDEN PUMP POWER DECREASE:-

1. If Cavitation occurs. This would result in the Pump Flow, Head & the Power Reducing.
2. If there is an In-Line Suction Filter whose pressure upstream and downstream of the filter is not being monitored; check for blockage due to solid particles. When the filter is being blocked, the pressure drop across the blocking filter can cause Cavitation. Which would cause Lower Flows, Head & Lower Power.
3. An Increase in System Resistance, due to any System Upset condition. Means that the Flow would be Lower. So the pump Power would decrease.
4. If the Pump has a Minimum Flow Bypass line controlled by an Automatic Bypass Valve to ensure the Pump will never run at a flow below its Minimum Continuous Stable Flowrate. If the Automatic Bypass Valve is jammed Closed this would cause the Pump to run at too low a Flowrate. Which would result in the pump Power being very low.

Understanding Pump Vibration

Trouble Shooting - 2

Centrifugal pumps generally operate for years trouble free and have a great reputation for reliability.

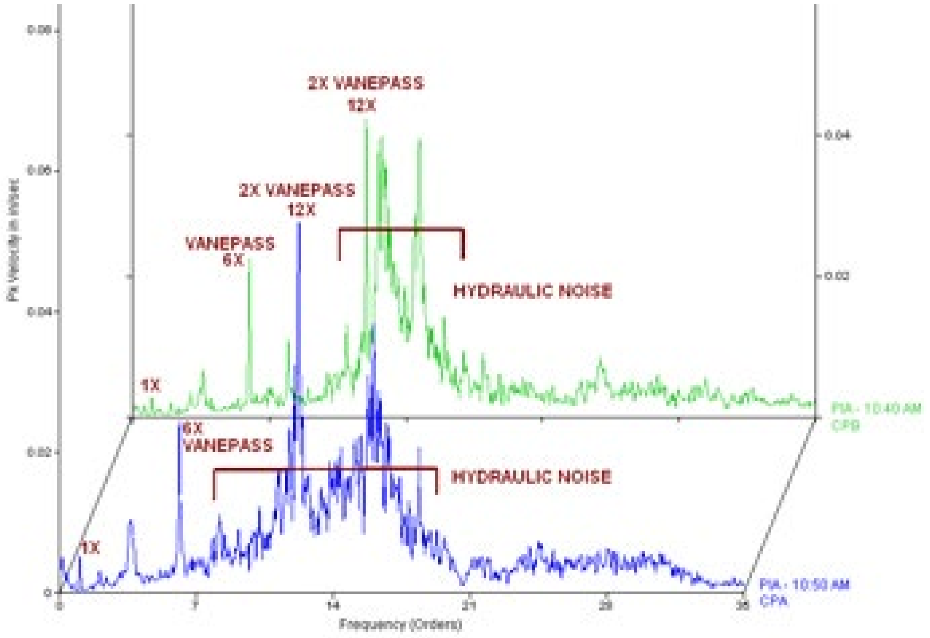
If there are problems, then there may be early indications that can help provide a solution.

Many clues can be obtained by checking all the normal pump parameters, such as sudden Power variations. As shown on the next two slides.

There are actually more methods of identifying problem causes, by checking the Pump Vibration frequencies as a % of the Running Speed, as shown on the following slides.

Understanding Pump Vibration

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

Trouble Shooting – Checklist 2 - 1

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.

Trouble Shooting – Checklist 2 - 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.

Trouble Shooting – Checklist 2 - 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.

Trouble Shooting – Checklist 2 - 4

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.

Trouble Shooting – Checklist 2 - 5

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.

Trouble Shooting – Checklist 2 - 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.

Trouble Shooting – Checklist 2 - 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.

Trouble Shooting – Checklist 2 - 8

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.

API Compliance

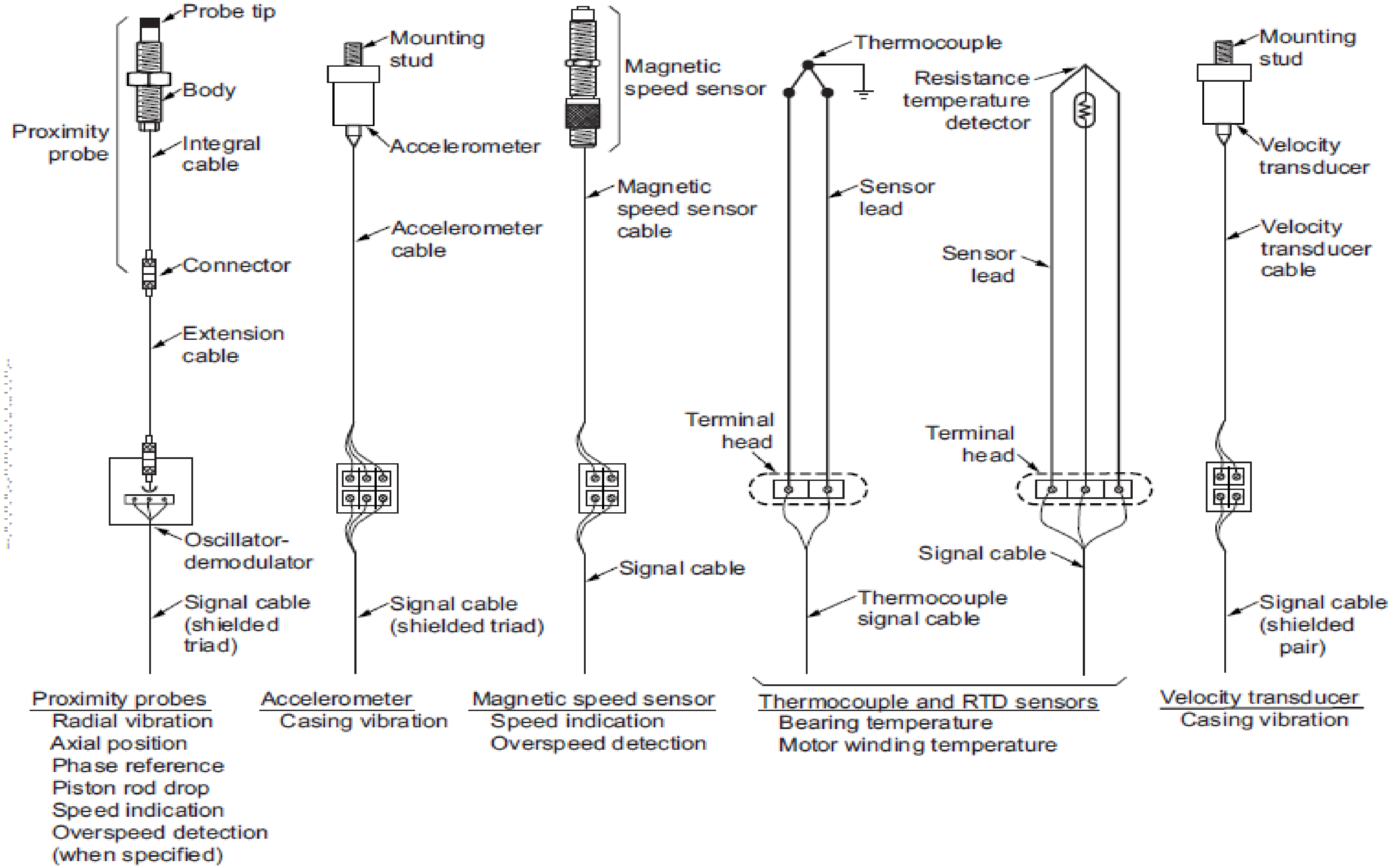
API 670 5th Edition

Defines the selection, installation and best practices rules for the following instrumentation:

Vibration:	Accelerometer and Proximity Probe.
Temperature:	RTD and Thermocouples.
Synchrony detection:	Keyphasor "Proximity Probe Arrangement"
Speed :	Magnetic sensor.

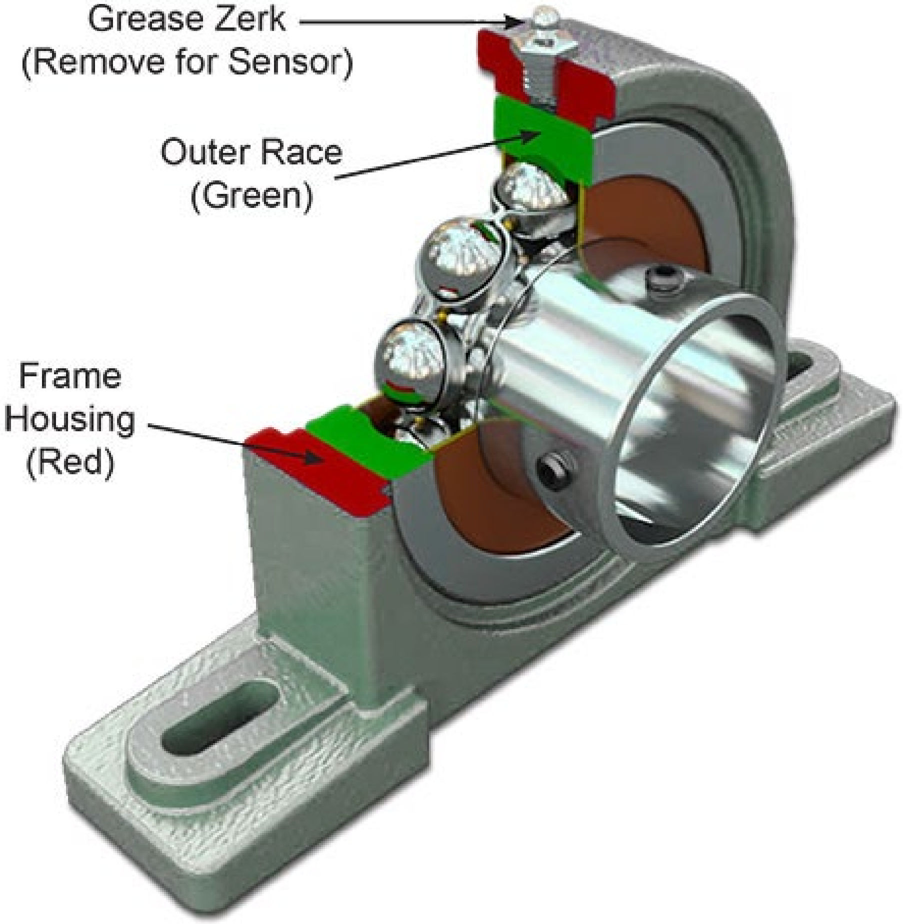
API Compliance

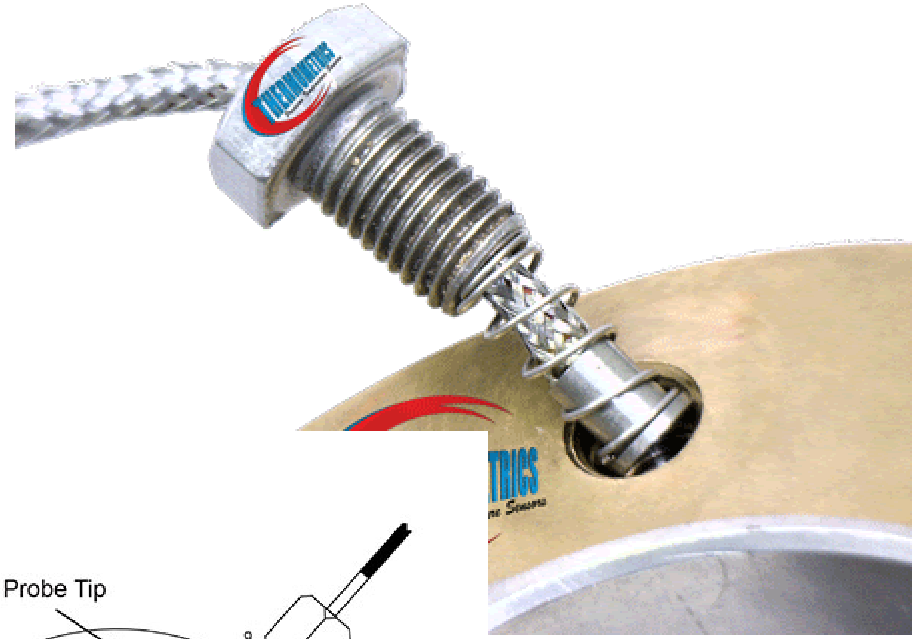
API 670 5th Edition

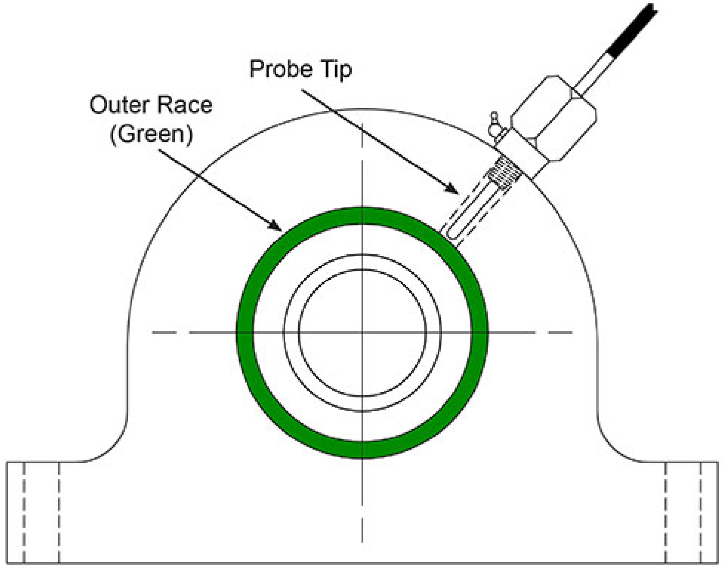


Bearing Temperature Measurement

RTDs for A/F Bearings





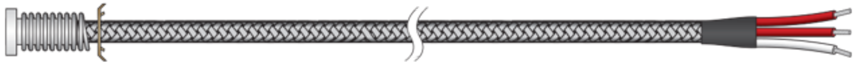


Bearing Temperature Measurement

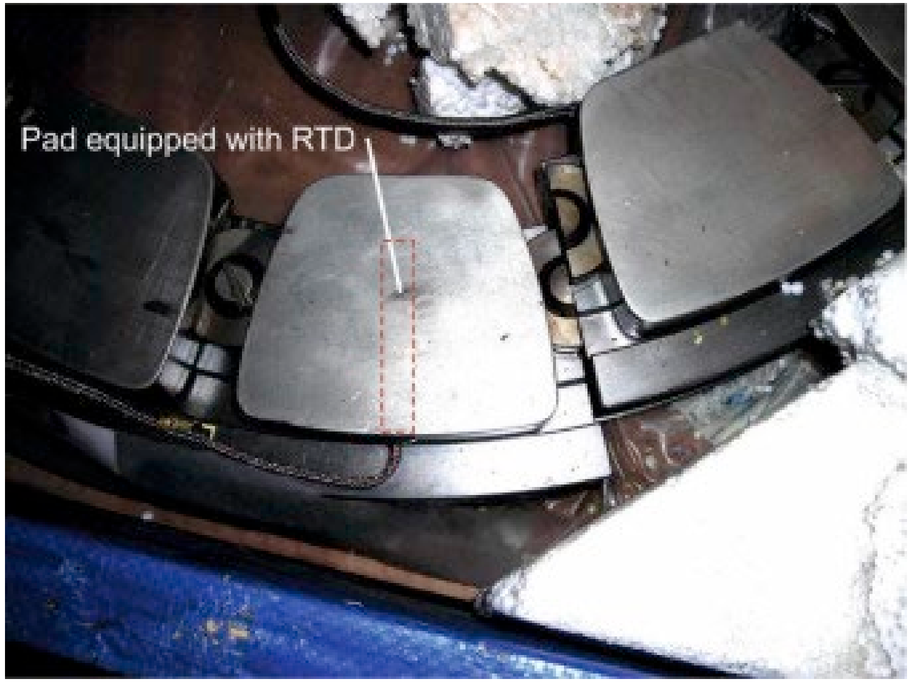
RTDs for Hydrodynamic Bearings

66T style illustrated with Phosphor Bronze Tip

66T style with oil seal barrier illustrated



66TH 'Top Hat' style illustrated



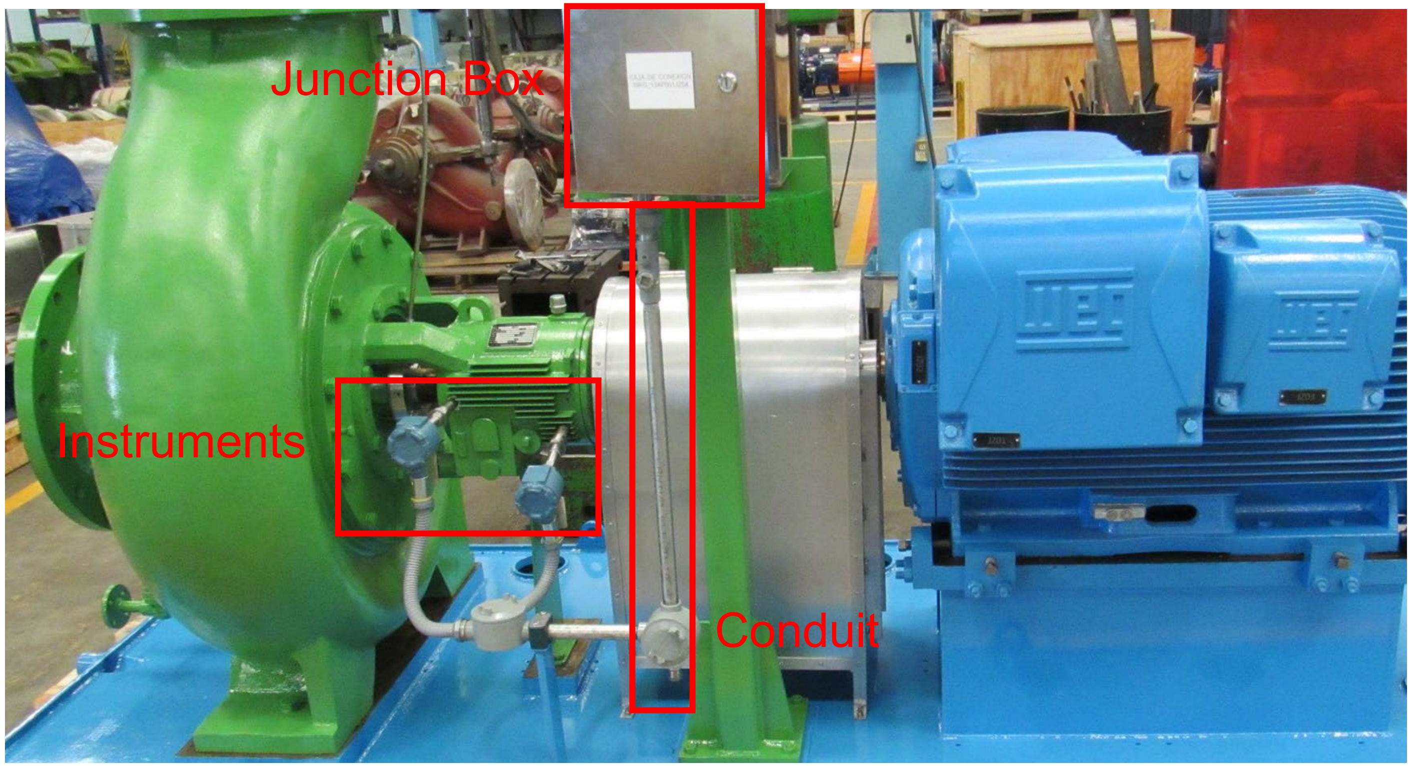
Bearing Temperature Measurement

RTDs for Sleeve (Journal) Bearings

Pump Instrumentation

Typical Supply - OH1 or OH2 Pump

- 1 Accelerometer Location: Bearing Housing.
- 1 RTD (3-Wire/1xPt100) Location: Bearing Housing on the Thrust bearing.

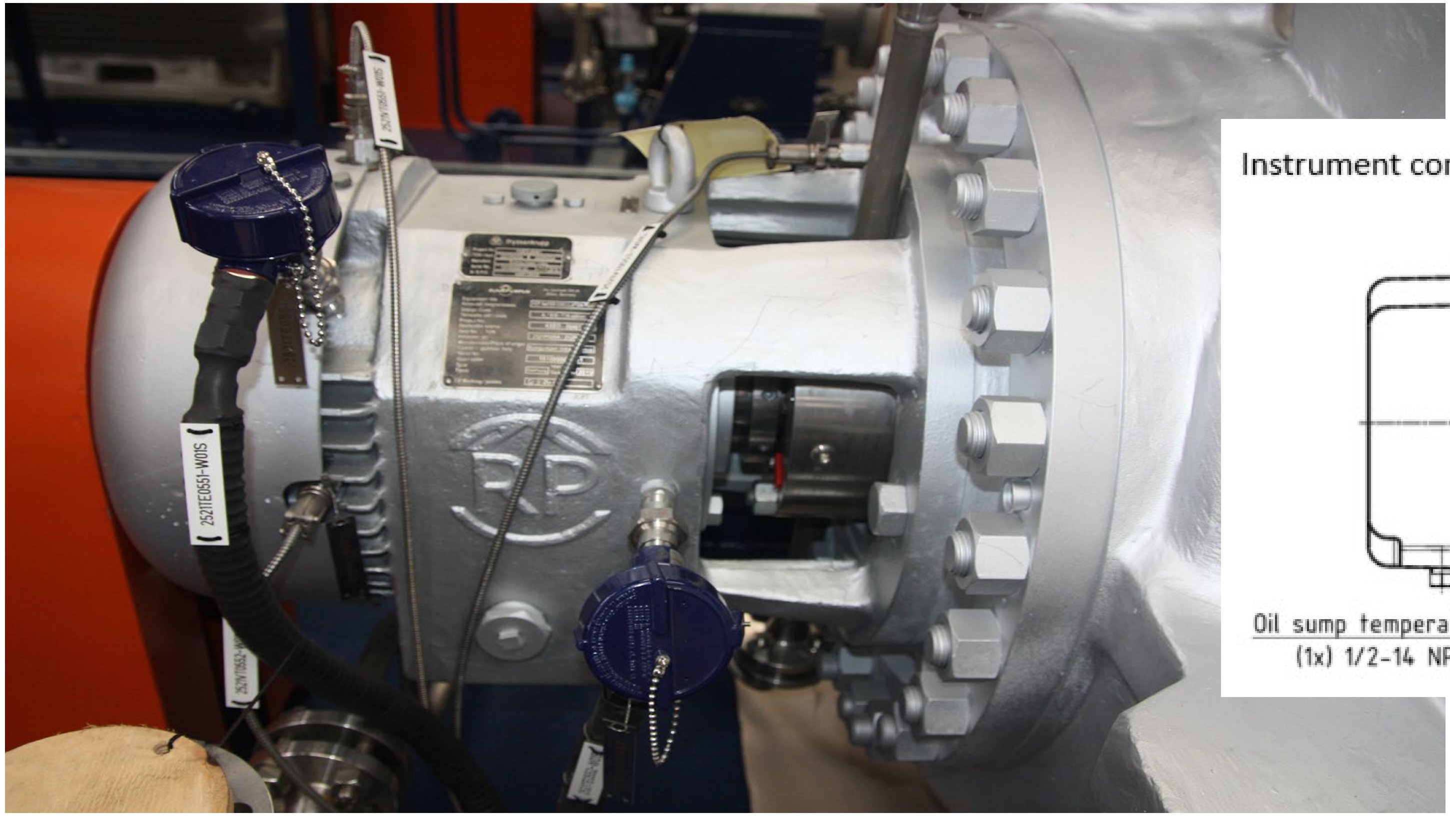


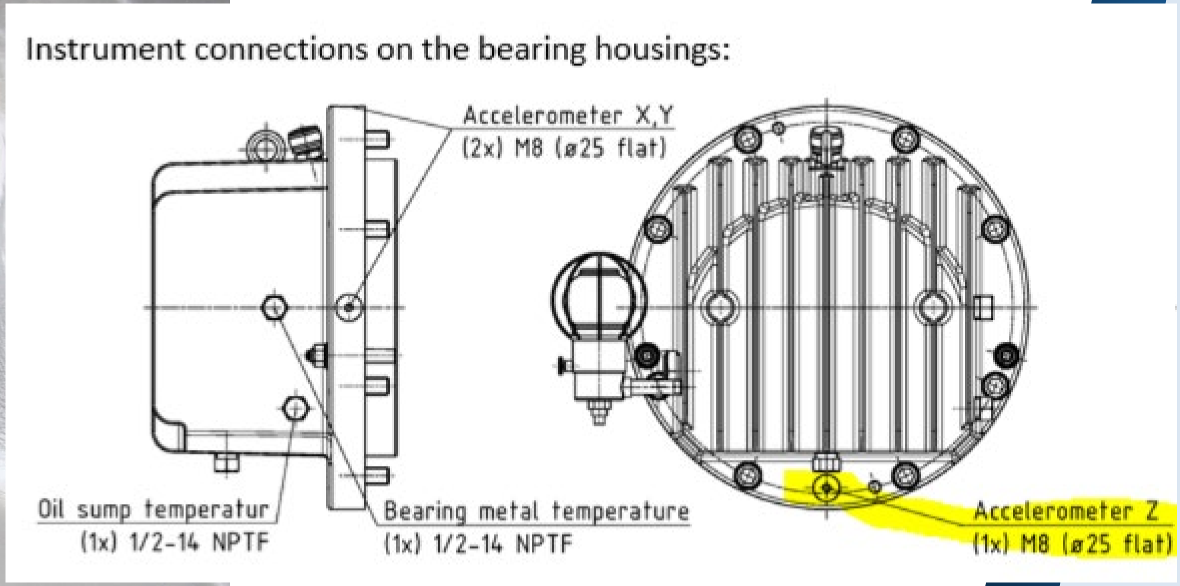
- Instrumentation installation with conduit and junction box installed at “Skid edge”.
- Normally for USA the most used cable protector is conduit vs EU/Asia the cable protector used is a Cable tray.

Pump Instrumentation

Non-Typical Supply - OH1 or OH2 Pump

- 3 Accelerometers Location: Bearing Housing (2) – (X,Y), Cover (1) – (Z)
- 2 RTD (3-Wire/1xPt100) Location: Bearing Housing on each bearing.

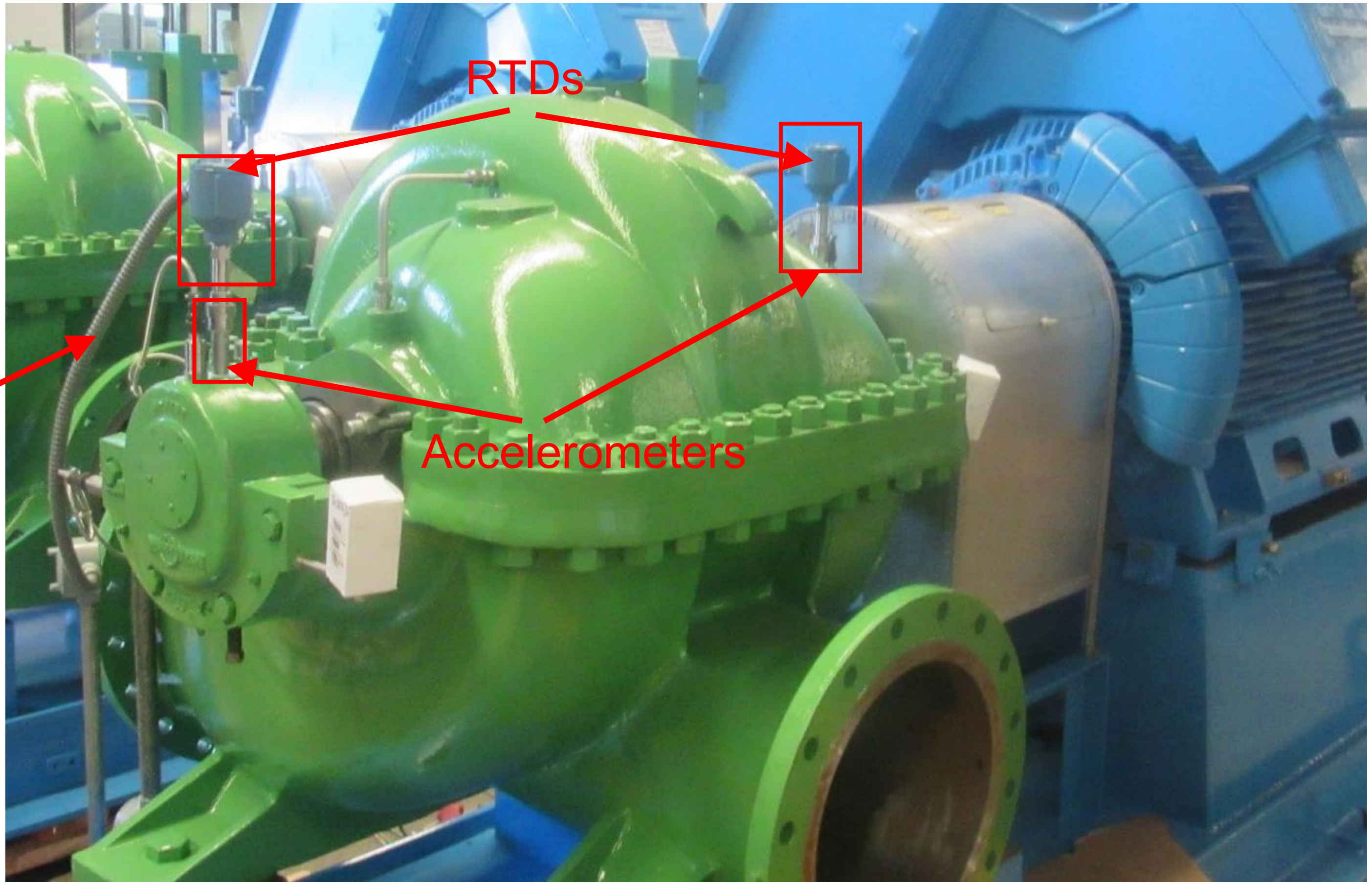




Pump Instrumentation

Typical Supply BB Pump - Antifriction Bearing Configuration

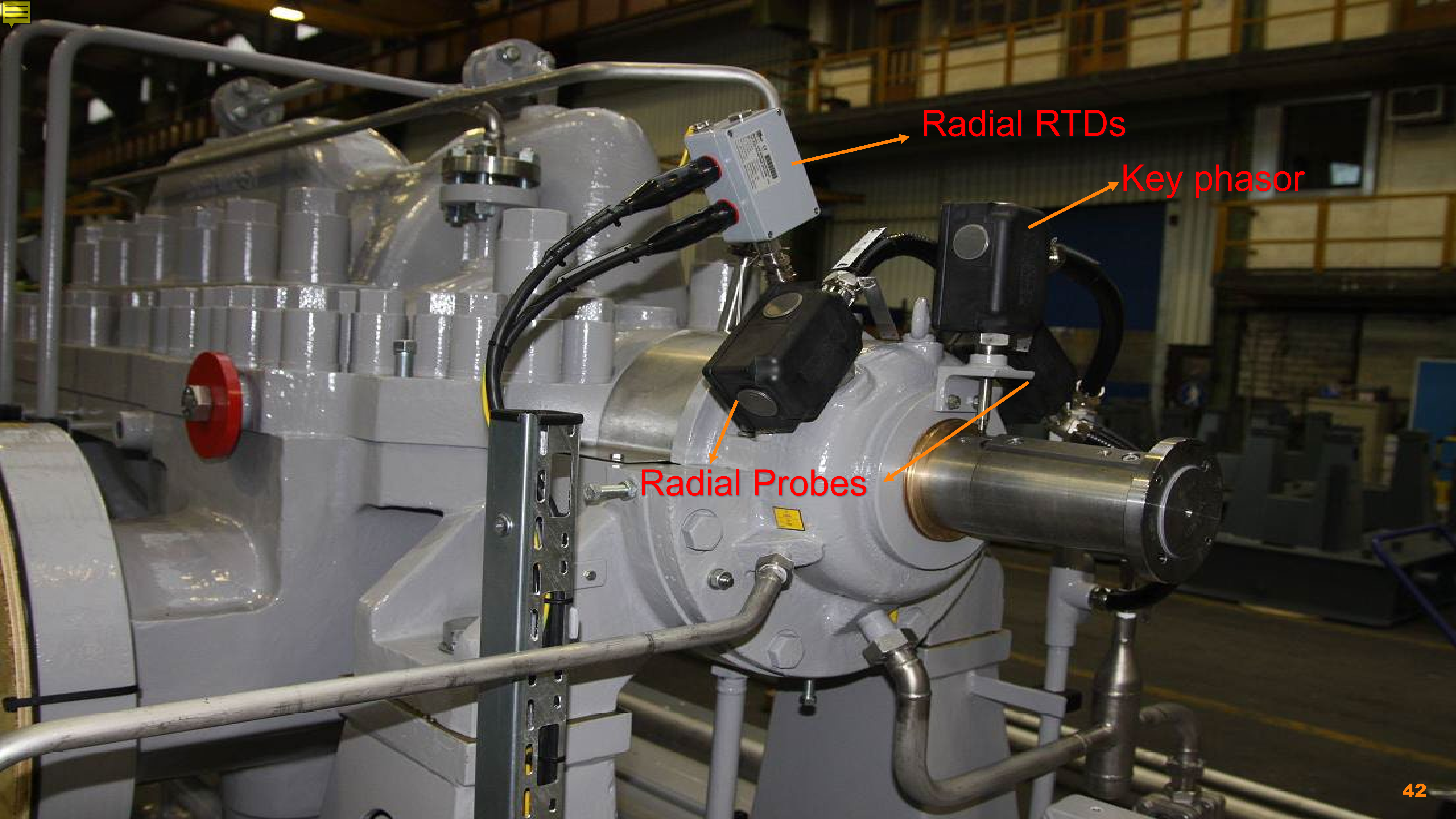
- 2 Accelerometers Location: 1 on each bearing housing.
- 2 RTDs (3-Wire / 1xPt100) Location: 1 on each bearing housing.
- Conduit and J-Box



Pump Instrumentation

Typical Supply BB Pump - Hydrodynamic Bearing Configuration

- 4 Proximity Systems "X-Y" Location: Radial Bearing 2 per bearing housing.
- 2 Proximity Systems "Z" Location: Thrust bearing.
- 1 Key phasor Location: in the end of the shaft on the NDE side.
- 8 micro RTDs (3-wire / 1xPt100) Location: 4 in radial bearings and 4 in thrust bearing


Radial RTDs
Key phasor
Radial Probes

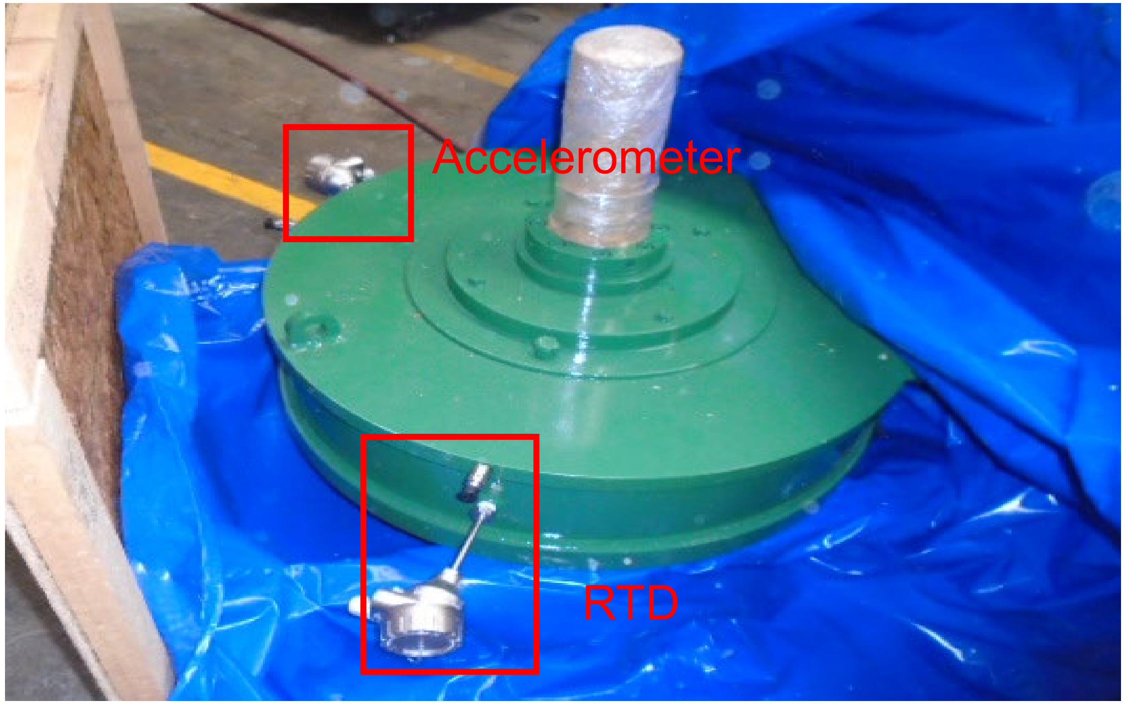

Radial RTDs
Radial Vibration
Axial RTDs
Axial Vibration
ZE-02

Pump Instrumentation

Typical Supply VS1 / VS6 Pump

Vertical Pump Thrust pot configuration:

- 1 Accelerometer Location: Thrust Pot .
- 1 RTD (3-Wire / Pt100) Location: Thrust Pot



Pump Instrumentation

Cable Management

On simple pumps (OH1, OH2) instruments are frequently close enough to skid edge to need no cable runs and J-boxes (but these are commonly specified and supplied).

On more complicated pumps instruments must be cabled to one or more J-Boxes at the skid edge

Cable protection:

There are mainly two options to protect and manage the cable runs :-

Conduit or Cable Tray

Both have their own advantages, but normally the selection between the two is determined by the normal practice in the country of installation.

Pump Instrumentation

Cable Management

Cable Tray(EU):

Easy rearrangement of the cables.

Conduit(US):

Compact size.

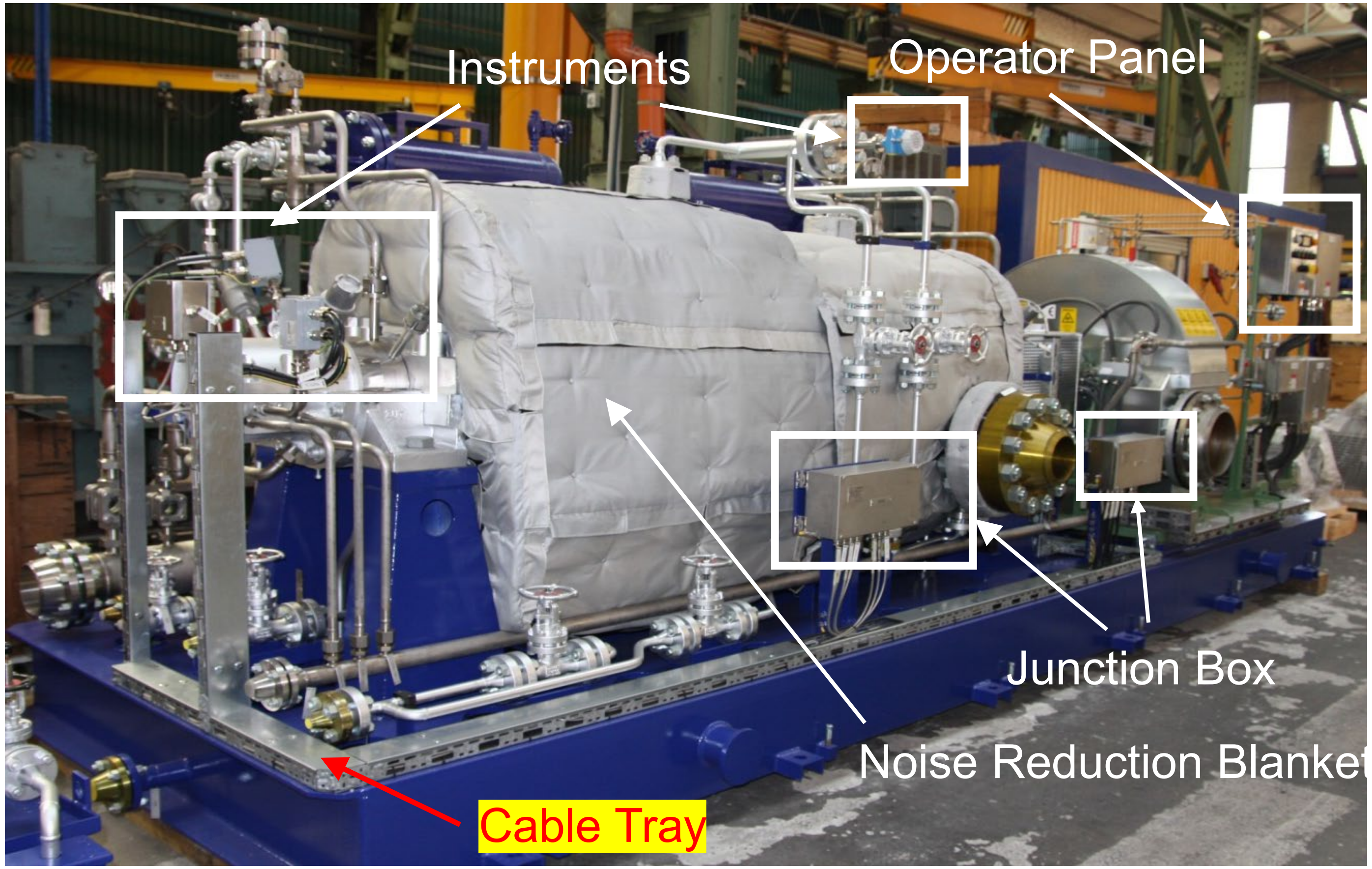
Easy installation across the Skid pump.

Hermicity.

No need for armoured cables

Pump Instrumentation

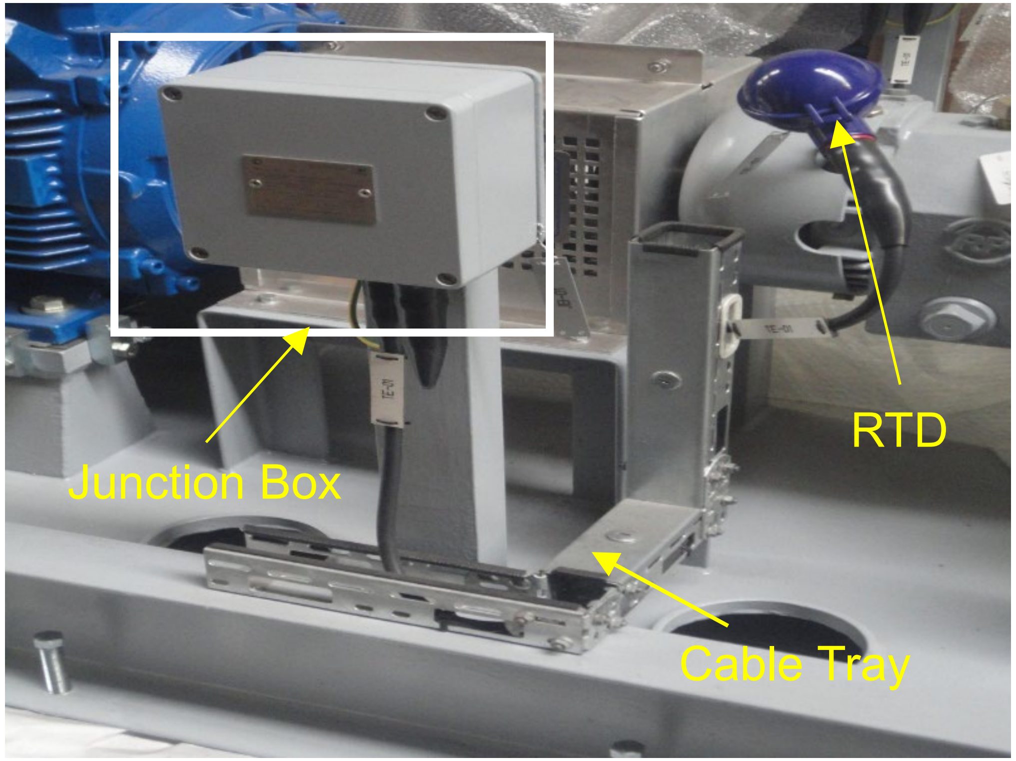
Cable Management – Cable Trays



Pump Instrumentation

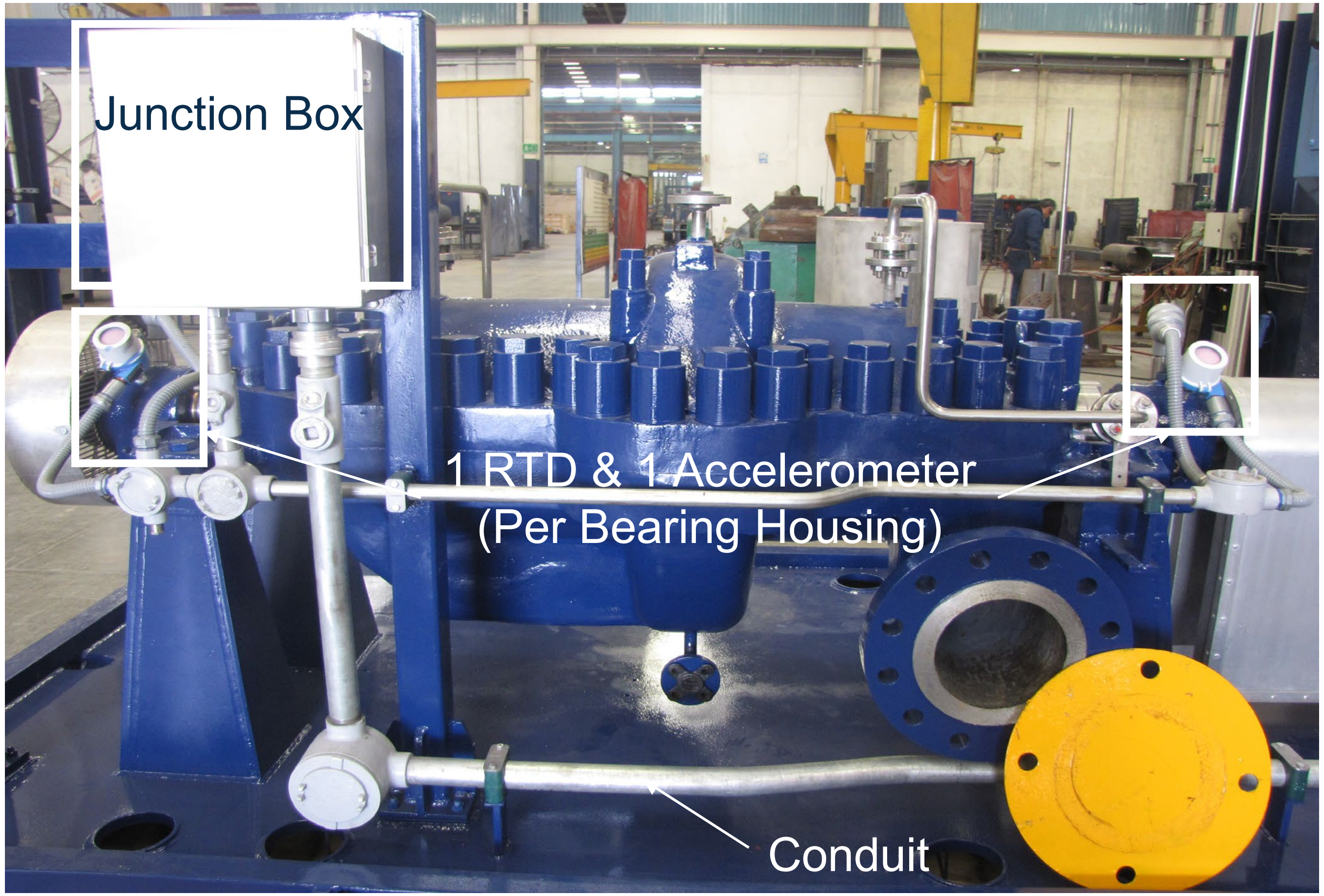
Cable Management

- OH2 Pump
- One instrument



Pump Instrumentation

Cable Management - Conduit

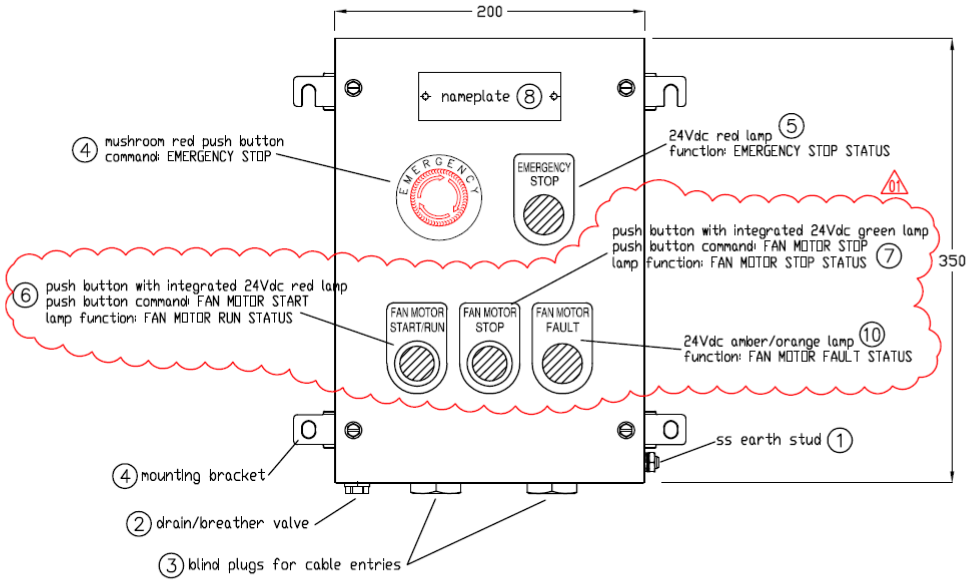


Pump Installations

Local Pushbutton Station

Interface between the operator/user and the control room, the intention is to have it nearby the pump to give visual contact on the equipment before starting it.

It’s a dummy box because all the control and logic is made by a superior system located away , as a remote commander.



Machinery Monitoring System (MMS)

Vibration Analysis is used to detect early precursors to machine failure, allowing machinery to be repaired or replaced before an expensive failure occurs, this solution is base in a machinery monitoring system there are several monitoring racks that fulfill the API670 but the well-known brands are Bently Nevada (BN 3500) and Metrix (SetPoint).

Input:

- Accelerometers, Proximity probes, RTDs and Speed sensors.

Outputs:

- Relays outputs for safety (Stop motor/process) but most important output from a monitoring system is the complete report of trending and mechanical malfunction.

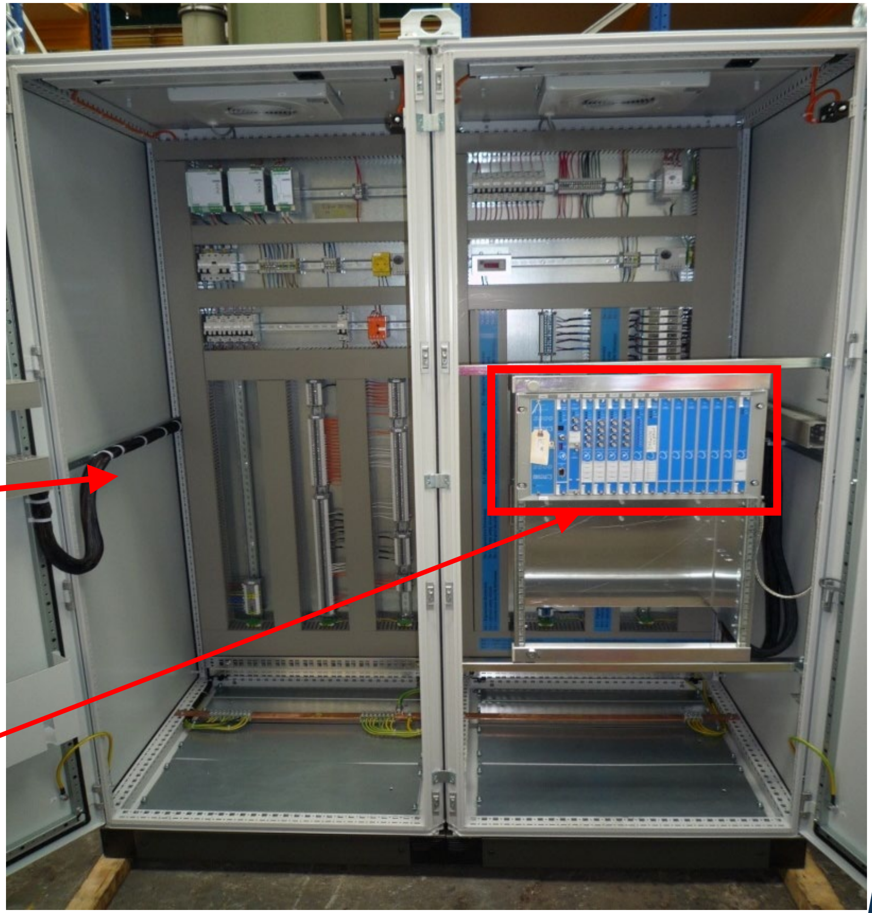
Machinery Monitoring System (MMS)

Pump suppliers can supply either:-

- Pump mounted instruments only (terminating at J-Boxes at skid edge; (EPC supplies the MMS))
- The Rack Mounted System (control room cabinet supplied by the EPC)
- Complete system of instruments, racks and cabinets

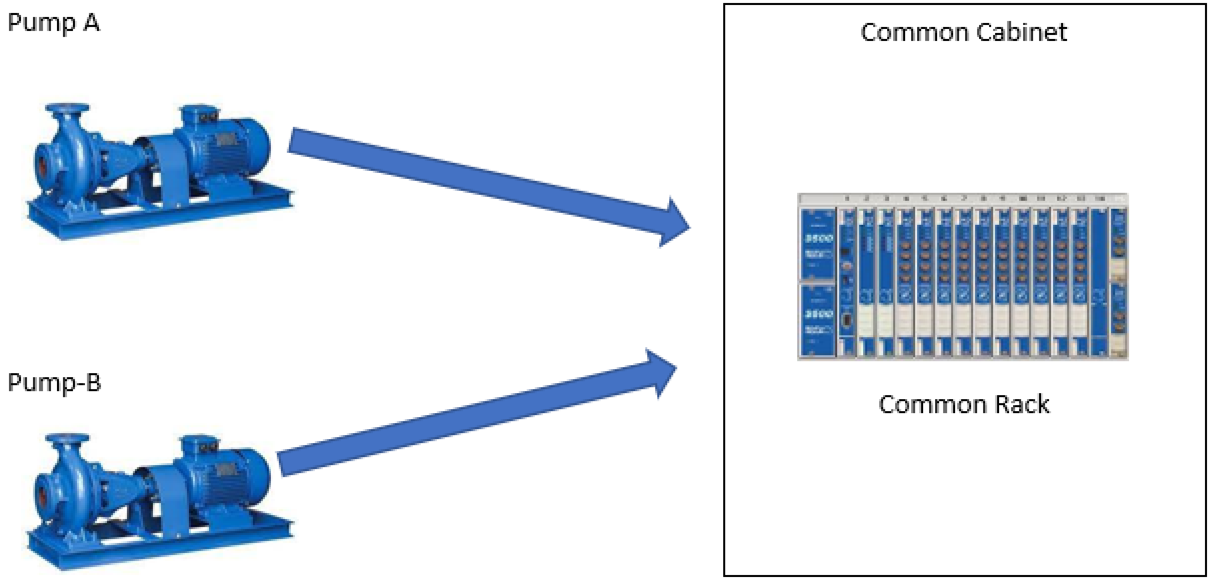
Cabinet

BN 3500 MMS Rack



Machinery Monitoring System (MMS)

Define Your Requirements!



Simplest system

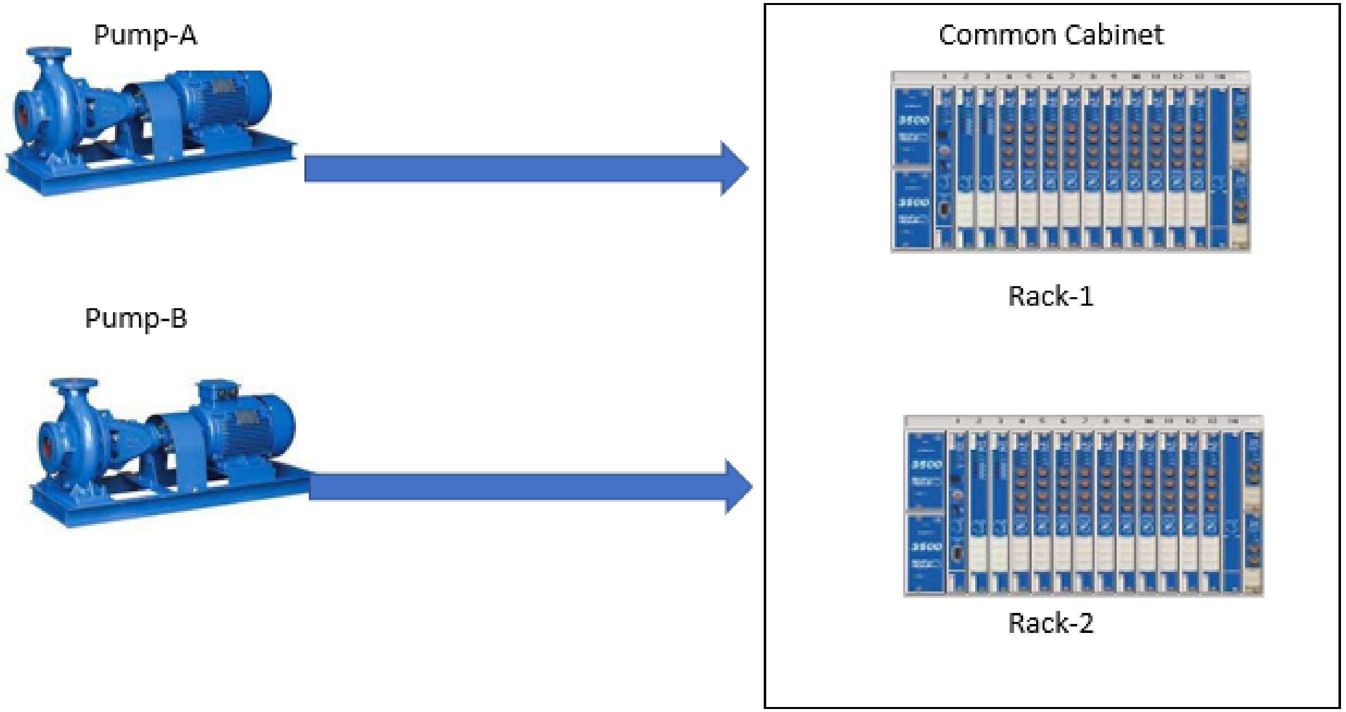
Lowest Cost System

One common cabinet for all pumps

One common rack for all pumps

Machinery Monitoring System (MMS)

Define Your Requirements!



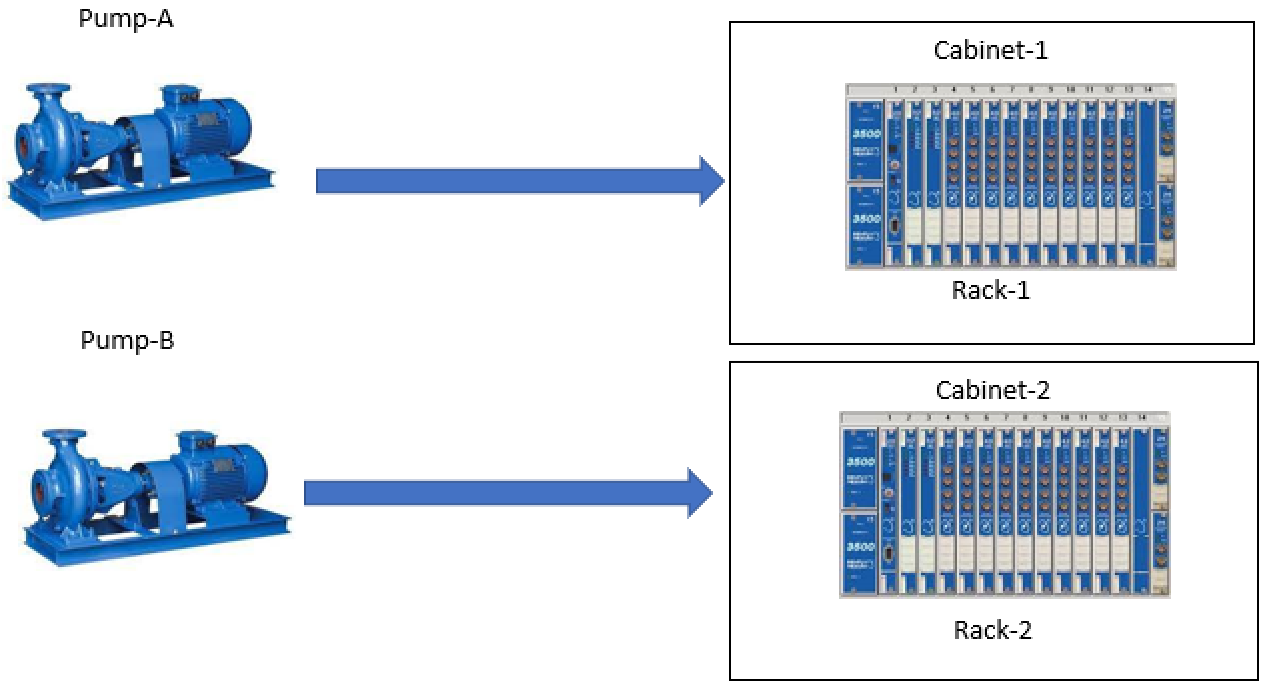
<u>Intermediate system</u>

One common cabinet for all pumps

One rack for each pump

Machinery Monitoring System (MMS)

Define Your Requirements!



Most Expensive System

One cabinet for each pump

One rack for each pump

Usually required when pumps are installed in different locations or pumping stations with separate control rooms.

Machinery Monitoring System (MMS)

Define Your Requirements!

Define whether you want temperature monitoring in the MMS

As per API 670, the Bearing & Winding RTD monitoring shall be also part of the MMS. But there are instances where a different solution is preferred. It is important we know what our customer wants.

- Case-1: Bearing RTD (Pump & motor) + Winding RTD (Motor) shall be connected to the Monitoring system.
- Case-2: Only Bearing RTD (Pump & motor) shall be connected to the Monitoring system.
- Case-3: NO need of connecting the Temp Probes to the monitoring system. Only Vibration monitoring is sufficient. Sometimes the RTDs shall be connected directly to the customer PLC/DCS. In such cases we do not need any Temp monitoring feature to be provided with the system.

Machinery Monitoring System (MMS)

Define Your Requirements!

Define whether you need a Touch Screen Display (HMI) in the MMS

The MMS cabinet may require a local touch screen display for operation & viewing some trends etc. Often, the customer spec is silent on the HMI requirement.

In some cases the operation shall be directly via the SCADA (Supervisory control and Data Acquisition) system and the customer may not ask for a local display.

Smart Pump Monitors

Most pump companies now have one of these.

This one illustrated is the “KSB Guard”, Flowserve has “LoRaWAN”, Sulzer has “Sense”.

Either your plant engineers or the supplier service engineers can monitor and give advice

More monitoring, less maintenance

How does this work? Very easily:

- A sensor unit attached to the pump records temperature and vibration data regularly and alerts you to any deviations.
- It notifies you when a bearing needs to be re-lubricated or replaced.
- All data recorded is analysed and transferred directly via a gateway to secure storage in the KSB Cloud.
- You can access your data at any time using your smartphone or another device.

Coming Attractions ☺

"Handling Viscous Fluids in Centrifugal Pumps, & Handling Slurries in Centrifugal Pumps"

Thur 9th May – 08.00 (UK GMT+1) (Eastern Hemisphere) & 17.00 (UK GMT+1) (Western Hemisphere)

Aimed at Process and Mechanical Engineers, Consultant Engineers who specify pumping equipment as well as Applications & Sales Engineers selecting and quoting them.
This course will look at how to correct standard (water) performance curves for handling viscous fluids and the considerations to be taken into account in selecting & specifying them.

Also - correcting standard curves for handling slurries and the considerations to be taken into account in selecting & specifying them.

Future subjects in preparation include:

- Pump Testing & Inspection
- Double Case Pumps (Barrel Pumps – BB5)
- Fire Pump Systems & Packages
- Sump Pumps
- Wastewater Pumps

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15 **SERVICE CENTERS**

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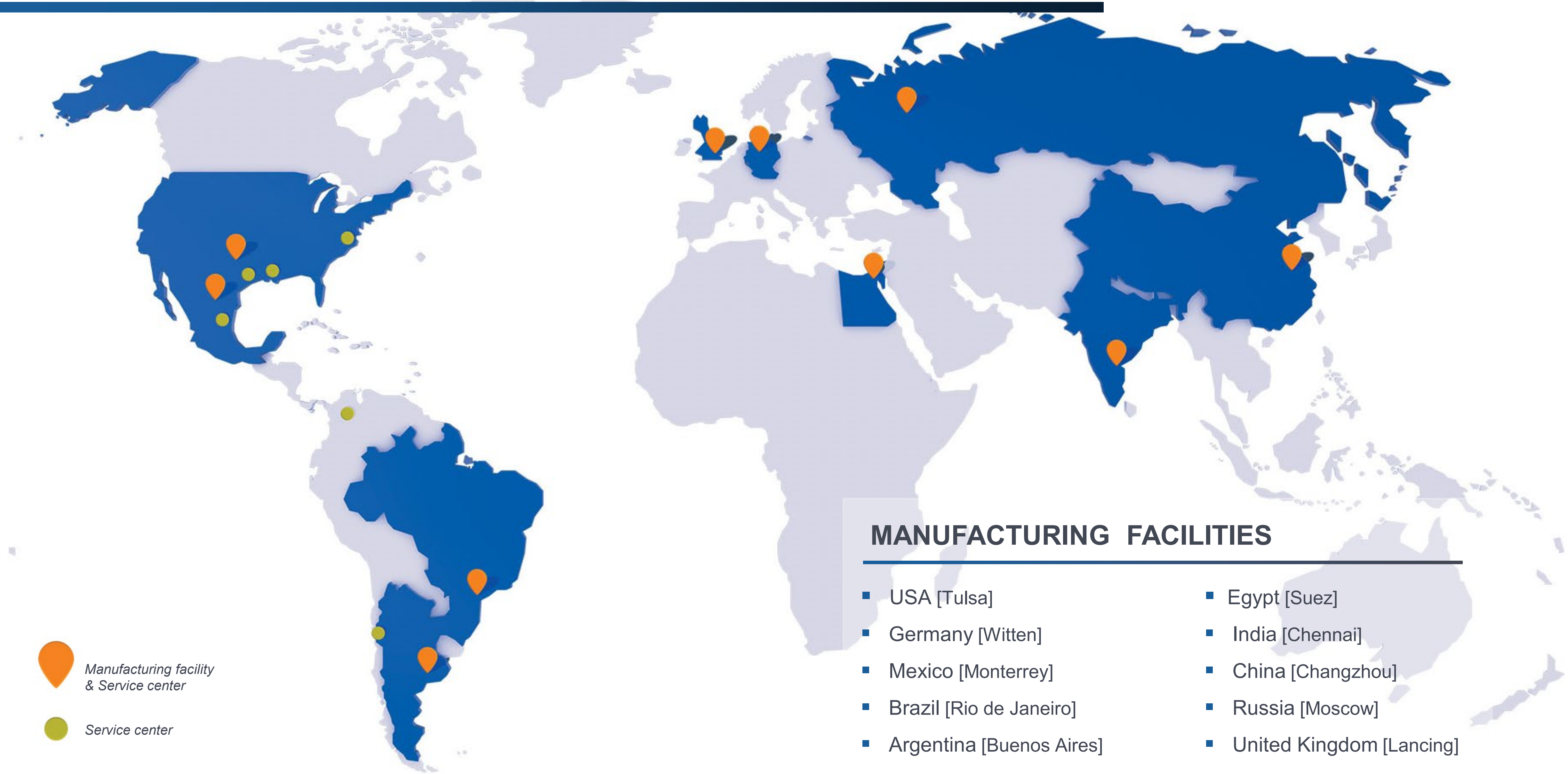

MANUFACTURING FACILITIES

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- 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).

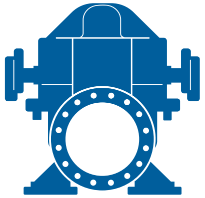
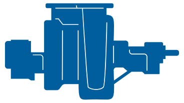
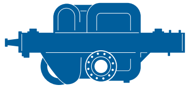
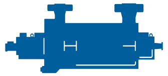
Products include:

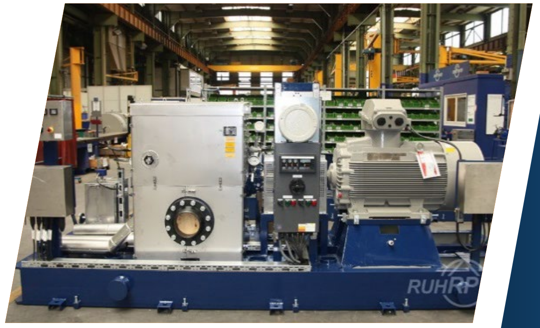
- Single Stage Overhung Pumps
- Between Bearings Pumps
- Horizontal Multi-Stage Pumps
- Vertical Multi-Stage Pumps
- Vertical Mixed Flow & Axial Flow Pumps
- Positive Displacement Pumps
- Full Range of Industrial Pumps
- Submersible Pumps
- Magnetic Drive Pumps
- Decoking Systems
- Packaged Systems
-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

OVERHUNG PUMPS

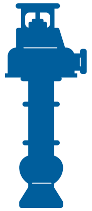
CATEGORY	RP MODEL	DESIGN STANDARD
Sealless Magnetic Drive Pumps	CRP-M / CRP-M-CC	ISO 2858 & 15783 HI design (OH11)
	SCE-M	API 685
Foot Mounted OH1 and General End Suction Pumps	IPP	HI design (OH1)
	CPP / CPP-L	HI design (OH1) ANSI B73.1
	CPO / CPO-L	HI design (OH1) ANSI B73.1
	CRP	HI design (OH1) ISO 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)

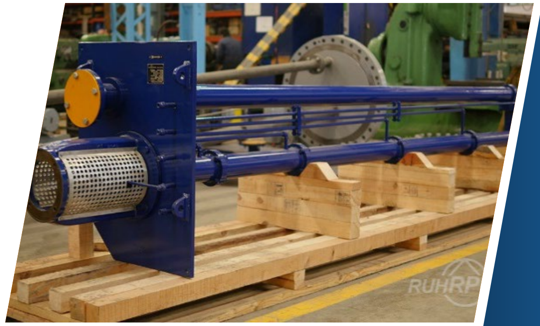
BETWEEN BEARING PUMPS

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)	

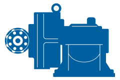
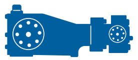
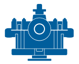


VERTICAL PUMPS

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