Contents.

1. Definition of Vibration

The oscillating, reciprocating, or other periodic motion of a **rigid or elastic** body forced from a position or state of equilibrium.

2. Introduction of Predictive Maintenance;

Recent days, **focus** in the industry is shifting from **scheduled maintenance** to the new technology of constantly observing machine condition and predicting the condition in advance, is called **predictive maintenance.**

The use of vibration analysis as one of the fundamental tools for condition monitoring – for last 35 years in Marine & other industries.

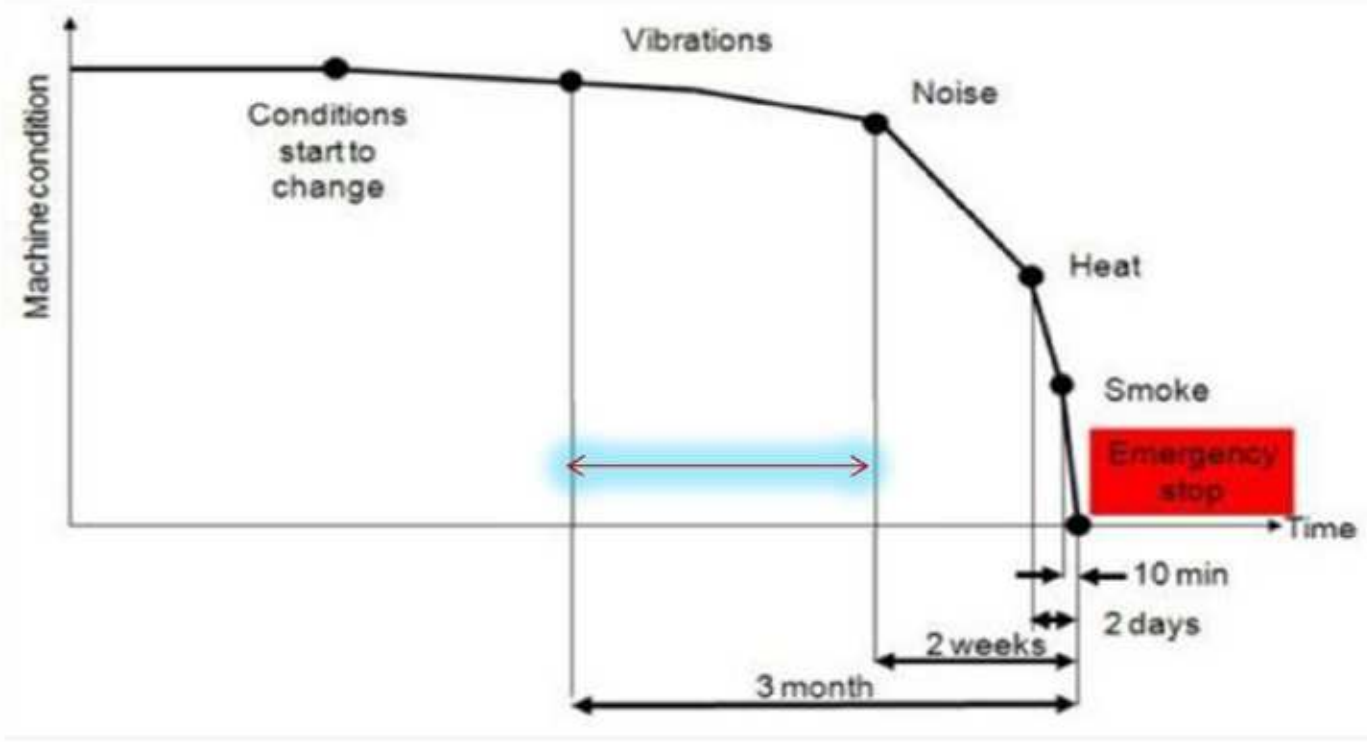
From 1960 to the mid 1970s simple practical methods were used, along with careful watch on the machine's behavior, Elementary instruments were ***sometimes*** used to concluded maintenance decisions. This required highly skilled and experienced maintenance staff to ensure efficient operation and to avoid catastrophic failures.

The 1990s - Development of instrumentation which were simpler to operate, and problems can be analyzed faster.

2. Advantage of Vibration monitoring instrument.

- It's a kind of condition monitoring system which provides information about the health of a machine.
- You can use this information to detect warning signs early,
- It Helps to stop the unscheduled outages & optimize machine performance.
- It reduces repair time, down time & maintenance costs.
- increasing the life of your machinery & the efficiency of your plant.

Figure shows a typical machine failure example and the warning signs.



Types of Vibration monitoring instruments.

1. Portable type.
2. Fixed attached type
   continuous monitoring.
3. Remote / wireless type.

1. Portable type - Viber-A

TECHNICAL SPECIFICATIONS
VIBER-A

- **INPUT SENSITIVITY:** 100mV/g calibrated at 156,15 Hz.
- **MEASURING RANGE:** Velocity: 0-200 mm/s RMS
- **FREQUENCY RANGE:** Total level 10-3200Hz, 3000~20000Hz
- The measurement mainly follows ISO 2954.
- **BATTERY TYPE:** 9V 6F22 or similar
- **VIBRATION TRANSDUCER**
- The accelerometer IMI608A11 has a sensitivity 100mV/g +/-10%.
- **MAGNET SUPPORT**
- Length: 20mm, Diameter: 15mm, Magnet force: about 14kg.
- **EXTENSION TIP**
- Length: 65mm

Operating Procedure

Battery check

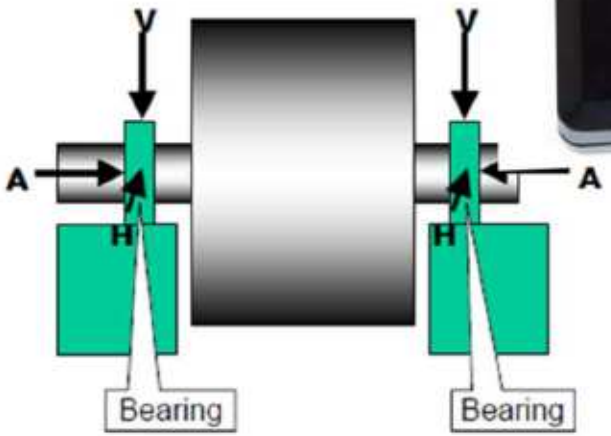
Press this symbol key and keep it pressed and the instrument shows the battery voltage.
Change the battery when the voltage is below 7 volts.
The battery capacity of an ordinary type is enough for
approximately 20 hours of constant operation or 350 measurement.

Start of the instrument

Press this symbol key and the instrument starts to measure.
The instrument will be shut off automatically after
approximately 2,5 minutes.

Bearing condition

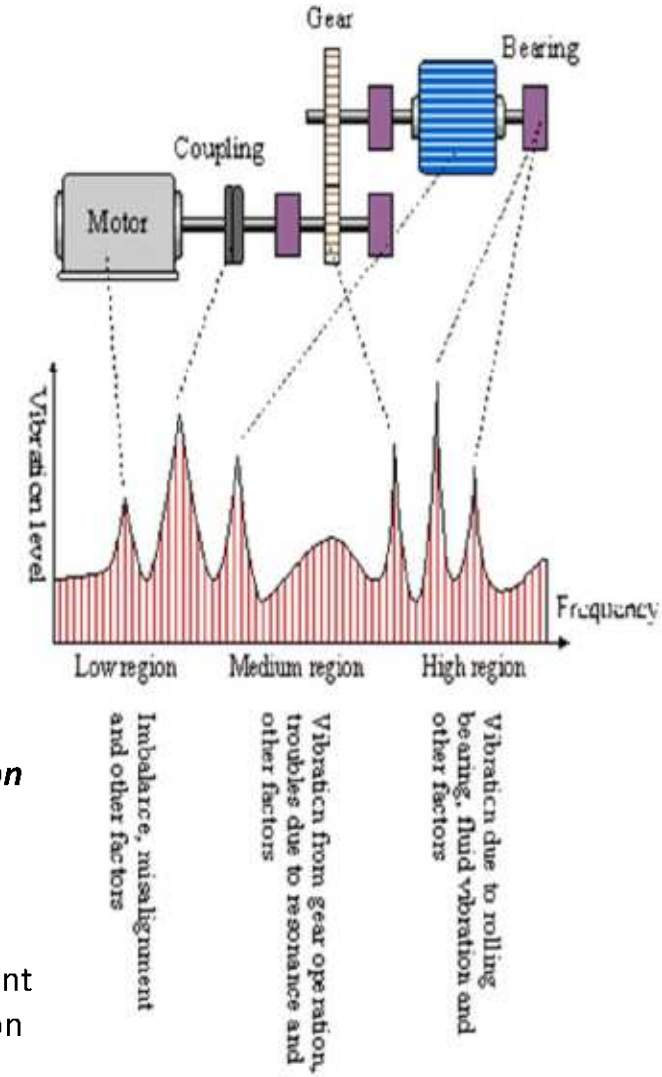
Press this symbol key and keep it pressed. The instrument measures instantaneously a bearing condition value in the range between 3.200Hz to 20.000Hz.



General description of VIBER A

- It's a fully portable instrument used in preventive maintenance work on rotating machinery.
- It comprises an ***instrument***, a ***vibration transducer*** with ***magnet support.***
- Used for measuring the effective velocity (mm/s RMS)
- In the frequency range between 10 and 3200 Hz.
- This range covers most of the frequencies that will occur for the majority of ***mechanical malfunctions and imperfections***.

Examples are ;
unbalance,
misalignment of shafts and gears,
cavitation
and **other fluid generated** vibrations.



- The judgment of the measured levels is greatly supported by ***several vibration standards.***

- EXAMPLE calculation:
- If the simultaneous vibration caused by unbalance is (4mm/s), by misalignment (2 mm/s) and by the gear mesh (5 mm/s) then the total vibration measured on the VIBER-A is 6.7 mm/s.
- Total vibration = $\sqrt{4*4+2*2+5*5} = 6.7 mm/s$

Recommended vibration levels in mm/s - common findings.

- Take as a good housekeeping rule to ***investigate the reason for any machine that vibrates above 3 mm/s RMS.***

- Do not leave them above **7mm/s** since very few machines are capable for sustaining this vibration level.

- **0-3 mm/s** Small vibrations very low noise level – safe to operate with in this level

- **3-7 mm/s** Noticeable vibration , **Keep under observation**. Plan action during next r regular stop / maintenance. **Try to investigate the reason.** Keep the machine under observation. **Compare with previous readings.**

- **7-18 mm/s** Large vibration / High noise level, Bearings running hot.
  Plan action at the earliest. Seals wear out, leakage of all kinds evident.
  Screws and bolts are loosening. High noise level. Plan action soonest. Do your best to reveal the reason. You are wearing down investments quickly.

- **>18 mm/s** Very large vibration Stop machine as soon as possible to rectify cause.
  No known machine will withstand this level without internal or external damage.

Suggested measuring intervals; Daily measurement for Purifiers / critical Motors (Aux blower motors / Boiler blower motors etc) and once a week for the remaining motors / Pumps.

Most Importantly the monthly or weekly readings to be compared for any increase in vibration.

Measuring points for Purifiers

PURIFIER VIBRATION MEASURING POINTS **MOL ENCORE**

Vibration Points as shown are drived from Vibration monitor manual and Westfalia service engineer suggestions During vessel visit

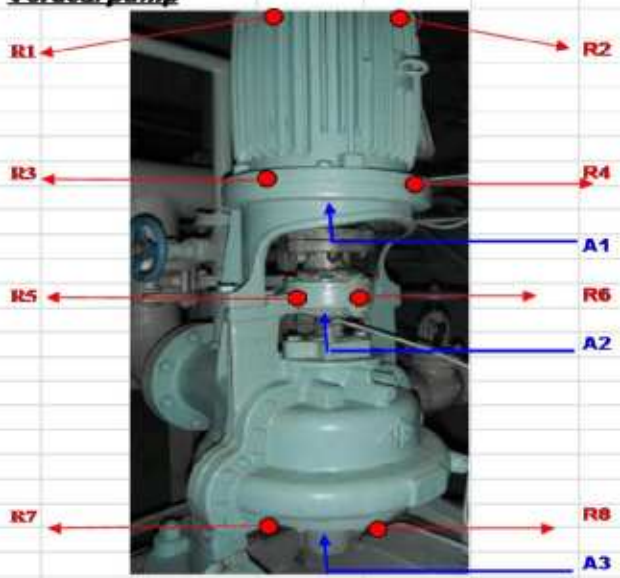
Following points were gathered as per Purifier maker service engineer reccomendations

1. Readings are to be taken as close to bearing as possible
2. In the radial direction for each position Two readings are to be taken 90degrees apart
3. Good Axial readings are not possible as it is difficult to access bearing in axial direction

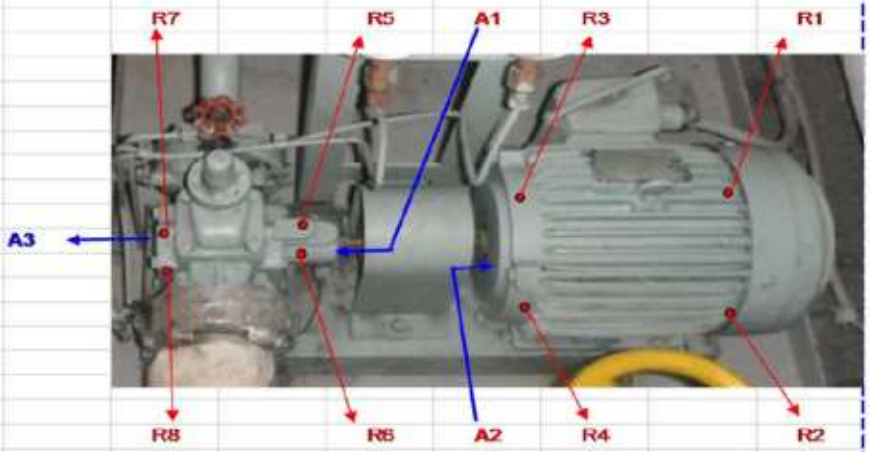
Measuring points for Motors & Pumps

Position of vibration monitoring According to vibration monitor manual

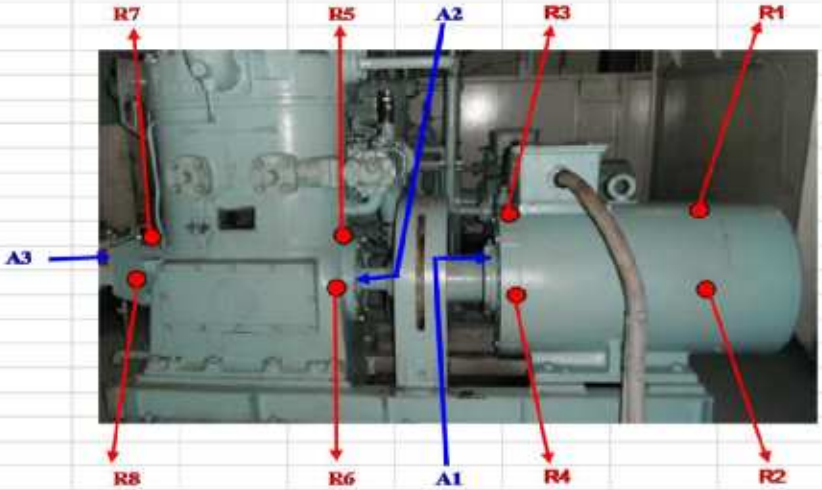
Vertical pump



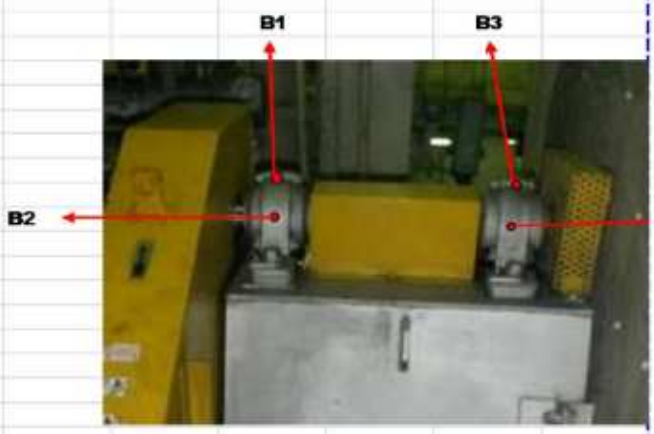
Horizontal pump



Main Air Compressor



Bearing housings



MOL ENCORE | PURIFIER VIBRATION MONITORING SHEET | Month : Sep-12

Date	M/E RPM	HFO PURIFIER NO.1									HFO PURIFIER NO.2									HFO PURIFIER NO.3								
		Operating Parameters				Vibration(mm/s)				FO1 BASE	Operating Parameters				Vibration(mm/s)				FO2 BASE	Operating Parameters				Vibration(mm/s)				FO3 BASE
		Flow rate (kl/hr)	Temp deg C	Outlet back pr	Motor Current (A)	A1/A2	B1/B2	C1/C2	D1/D2		Flow rate (kl/hr)	Temp deg C	Outlet back pr	Motor Current (A)	A1/A2	B1/B2	C1/C2	D1/D2		Flow rate (kl/hr)	Temp deg C	Outlet back pr	Motor Current (A)	A1/A2	B1/B2	C1/C2	D1/D2	
1	77.0	5.7	98	3	24	1.2/1.3	1.8/1.7	2.0/1.7	1.5/1.7	0.8										5.7	98	3	23	1.5/1.4	1.3/1.4	0.9/0.7	0.7/0.6	0.9
2	79.0	5.5	97	3	24	2.2/2.7	1.5/2.4	1.4/1.3	1.4/1.5	0.9										5.5	97	3	23	1.3/1.4	1.8/2.7	1.7/1.8	1.5/1.8	0.7
3	80.0	5.5	98	3	23	1.5/1.4	1.3/1.4	0.9/0.7	0.7/0.6	0.7										5.5	98	3	23	1.2/1.3	1.0/1.1	1.3/1.4	1.2/1.0	0.7
4	82.0	5.5	97	3.2	22	2.5/3.0	1.9/2.5	1.5/1.7	1.4/1.7	0.8										5.5	97	3.2	22	1.9/2.5	0.9/1.0	1.9/2.5	1.0/1.2	0.8
5	81.0	6.0	96	3.2	23	2.4/2.9	1.7/2.8	1.7/1.6	1.5/1.6	0.9										6.0	96	3	23	1.7/1.6	1.1/1.0	0.9/1.0	1.4/1.2	0.5
6	83.0	5.5	97	3.2	22	2.2/2.7	1.5/2.4	1.4/1.3	1.4/1.5	0.9										5.5	97	3	22	1.3/1.4	1.9/2.5	1.0/1.1	1.3/1.2	0.6
7	78.0	5.5	98	3	23	2.7/3.0	2.1/2.9	1.8/1.9	1.7/1.6	0.9										5.5	98	3	23	1.1/1.1	1.2/1.1	1.3/1.0	1.2/1.1	0.8
8	61.0			3.2	23	1.5/1.4	1.3/1.4	0.9/0.7	0.7/0.6	0.8	5.5	95	3	23	1.8/1.9	0.9/0.9	1.2/1.0	0.9/1.0	0.8									0.9
9	80.0			3.1	23	1.3/1.4	1.8/2.7	1.7/1.8	1.5/1.8	0.8	5.5	96	3.2	24	1.8/1.9	2.1/1.9	1.7/1.8	1.4/1.2	0.8									0.9
10	82.0			3	23	1.2/1.3	1.0/1.1	1.3/1.4	1.2/1.0	0.7	5	96	3.2	24	1.8/1.7	0.9/1.0	1.2/1.0	0.9/1.0	0.5									0.8
11	82.0			3.1	24	1.9/2.5	0.9/1.0	1.9/2.5	1.0/1.2	0.7	5	95	3.2	24	1.8/1.9	0.9/0.9	1.2/1.0	0.9/1.0	0.6									0.9
12	75.0			3.2	23	1.7/1.6	1.1/1.0	0.9/1.0	1.4/1.2	0.8	5	95	3.2	23	1.9/1.8	2.1/2.0	1.8/1.4	1.3/1.6	0.8									0.8
13	78.0			3.2	24	1.3/1.4	1.9/2.5	1.0/1.1	1.3/1.2	0.7	6	95	3.2	23	2.1/2.0	2.1/2.0	1.8/1.4	1.3/1.6	0.5									0.7
14	75.0			3.2	23	1.1/1.1	1.2/1.1	1.3/1.0	1.2/1.1	0.8	5.5	96	3	23	1.8/1.7	0.9/1.0	1.2/1.0	0.9/1.0	0.8									0.6
15	80.0			3.1	23	1.2/1.0	1.3/1.4	1.5/1.4	1.3/1.2	0.7	5.5	96	3.2	24	1.3/1.4	1.8/2.7	1.7/1.8	1.5/1.8	0.8									0.6
16	70.0			3.2	24	1.1/1.3	1.6/1.7	1.3/1.4	1.5/1.6	0.7	5.6	95	3	24	1.8/1.9	0.9/0.9	1.2/1.0	0.9/1.0	0.5									0.5
17	70.0			3.2	24	1.0/1.1	1.2/1.3	1.1/1.0	1.0/1.1	0.7	6	95	3	24	1.9/1.8	2.1/2.0	1.8/1.4	1.3/1.6	0.6									0.6
18	71.0			3.1	24	1.0/1.1	1.0/1.1	1.9/2.5	1.2/1.3	0.7	6	95	3	24	2.1/2.0	2.1/2.0	1.8/1.4	1.3/1.6	0.8									0.6
19	80.0			3.2	24	1.1/1.0	1.3/0.9	1.1/1.2	0.9/0.8	0.8	6	95	3	23	1.8/1.9	2.1/1.9	1.7/1.8	1.4/1.2	0.6									0.5
19	80.0			3.2	24	0.9/0.8	1.0/1.1	0.9/0.9	0.9/1.0	0.8	6	95	3	23	1.7/1.6	1.1/1.0	0.9/1.0	1.4/1.2	0.7									
20	80.0			3.2	23	1.6/1.7	1.9/2.5	1.0/1.1	1.3/1.4	0.8	5.5	96	3.2	24	2.1/1.8	1.2/1.3	2.0/1.8	1.3/1.6	0.7									0.6
21	80.0			3.2	23	1.3/1.4	1.5/1.8	1.3/1.1	1.2/1.1	0.7	6	95	3	24	1.5/1.6	2.1/2.0	0.9/1.1	1.3/1.6	0.7									0.7
22	70.0			3.2	23	1.1/1.0	1.2/1.0	1.3/1.4	1.6/1.7	0.5	5.5	95	3	23	1.9/1.8	1.2/1.3	1.8/1.4	1.3/1.6	0.6									0.7
23	67.0			3.2	23	1.3/1.1	1.5/2.4	1.4/1.3	1.4/1.4	0.6	5.5	95	3.2	24	1.8/1.9	0.9/0.9	1.2/1.0	0.9/1.0	0.8									0.7
24	66.0			3.2	24	1.0/1.2	1.0/1.1	1.3/1.4	0.9/0.8	0.6	5.7	95	3.2	24	1.9/1.8	2.1/2.0	1.8/1.4	1.3/1.6	0.8									0.7
25	66.0			3.2	23	0.9/1.0	1.1/1.2	1.3/1.3	1.0/0.9	0.9	5.5	95	3.2	24	2.1/2.0	2.1/2.0	1.8/1.4	1.3/1.6	0.7									0.7
26	67.0			3.2	23	1.2/1.3	1.0/1.1	1.4/1.2	1.0/1.1	0.7	5.5	95	3	24	1.4/1.0	1.1/1.3	1.4/1.0	0.8/0.9	0.8									0.8
27	67.0			3.2	23	1.4/1.5	1.6/1.7	1.7/1.5	1.4/1.3	0.5	5.5	95	3.2	24	1.4/1.0	1.1/1.3	1.5/1.0	0.8/1.2	0.7									0.9
28	66.0			3.2	24	1.5/1.2	1.6/1.7	1.3/1.0	1.6/1.7	0.8	5	95	3.1	24	1.4/1.1	1.2/1.3	1.4/1.0	0.7/1.1	0.6									0.8
30	63.0			3.2	23	1.5/1.6	2.1/2.0	1.9/1.8	1.7/1.6	0.7	5	95	3.2	23	1.4/1.1	1.1/1.2	1.7/1.2	0.5/1.0	0.6									

Note :

1) Readings A1/A2 , B1/B2 , C1/C2 & D1/D2 are radial readings outside the casing 90 degrees apart Ref Fig

2) Readings are to be taken as close to bearing housing as possible

3) As per vibration monitor manual:

0-3 mm/s	Small vibrations very low noise level
3-7 mm/s	Noticeable vibration , Keep under observation. Plan action during next regular maintenance
7-18 mm/s	Large vibration , causes rapid wear , Plan action at the earliest
>18 mm/s	Very large vibration Stop machine as soon as possible to rectify cause.

4) Bowl speed ,n= 6500 RPM

5) Centripetal pump ,Output = 8000-35000 l/h

6) BASE is reading taken at the base of the purifier

MOL ENCORE **PURIFIER VIBRATION MONITORING SHEET** **Month : Sep-12**

Date	RPM M/E	LO PURIFIER NO.1								LO1 BASE	LO PURIFIER NO.2								LO2 BASE	LO PURIFIER NO.3								LO2 BASE
		Operating Parameters				Vibration(mm/s)					Operating Parameters				Vibration(mm/s)					Operating Parameters				Vibration(mm/s)				
		Flow rate (kl/hr)	Temp deg C	Outlet back pr	Motor Current (A)	A1/A2	B1/B2	C1/C2	D1/D2		Flow rate (kl/hr)	Temp deg C	Outlet back pr	Motor Current (A)	A1/A2	B1/B2	C1/C2	D1/D2		Flow rate (kl/hr)	Temp deg C	Outlet back pr	Motor Current (A)	A1/A2	B1/B2	C1/C2	D1/D2	
1	77.0									1.1	5.5	93	3	19	2.9/2.7	2.7/2.7	2.1/1.9	2.0/1.7	1.3	5.5	95	3	20	2.6/2.4	2.5/2.6	2.1/2.4	1.9/1.7	
2	79.0									1.1	5.5	93	3	18	2.8/2.6	2.3/2.3	1.9/1.8	1.8/1.8	1.2	5.5	95	3	19	2.1/2.7	3.1/2.9	2.7/2.4	2.2/1.9	
3	80.0									1.1	5.5	93	3	19	2.6/2.7	2.5/2.9	2.6/2.7	2.1/3.0	1.3	5.5	95	3	20	2.9/2.8	2.5/2.7	2.3/2.0	1.7/2.0	1.5
4	82.0									1.1	5.5	93	3	18	1.9/2.1	2.0/2.1	1.6/1.8	1.5/1.3	1.2	5.5	95	3	19	2.0/2.6	2.5/2.6	2.3/2.4	2.5/2.7	1.3
5	81.0									1.2	5.5	95	3	19	2.1/2.7	3.1/2.9	2.7/2.4	2.2/1.9	1.4	5.5	95	3	19	2.6/2.4	2.5/2.6	2.1/2.4	1.9/1.7	1.2
6	83.0									1.3	5.5	93	3	19	2.7/2.8	3.0/2.8	2.5/2.4	1.9/2.5	1.4	5.5	95	3	19	2.1/2.7	3.1/2.9	2.7/2.4	2.2/1.9	1.2
7	78.0									1.1	5.5	94	3	19	2.2/2.1	2.9/2.6/	3.0/2.7	2.3/2.1	1.3	5.5	95	3	19	2.7/2.8	2.8/2.8	2.1/1.8	1.5/1.3	1.3
8	61.0									1	5.5	95	3	18	1.9/2.2	2.3/2.1	2.2/2.0	1.8/2.1	1.3	5.5	95	3	19	2.2/2.1	2.9/2.6	3.0/2.7	2.3/2.1	1.2
9	80.0									1.1	5.5	95	3	18	2.0/2.6	2.5/2.6	2.3/2.4	2.5/2.7	1.4	5.5	95	3	19	2.9/2.7	2.8/2.8	2.0/2.3	1.9/2.0	1.3
10	82.0									1.1	5.5	95	3	19	2.8/2.9	2.6/2.8	1.9/1.8	1.8/1.8	1.5	5.5	95	3	19	2.5/2.3	2.7/2.4	1.9/1.7	1.5/1.5	1.6
11	82.0									1.2	5.5	96	3	18	2.4/2.3	2.3/2.3	1.7/1.6	1.7/1.8	1.5	5.5	95	3	19	2.5/2.3	2.3/2.1	2.5/2.7	2.3/2.0	1.5
12	75.0									1.3	5.5	94	3	19	2.4/2.2	2.5/2.0	1.7/1.5	1.5/1.5	1.5	5.5	95	3	19	2.6/2.7	2.5/2.9	2.6/2.7	2.1/3.0	1.4
13	78.0									1	5.5	94	3	18	2.7/2.8	2.8/2.9	1.9/2.3	1.5/1.7	1.6	5.5	95	3	19	1.9/2.1	2.0/2.1	1.6/1.8	1.5/1.3	1.5
14	75.0									1.2	5.5	92	3	19	2.7/2.6	2.5/2.7	1.5/1.6	1.7/1.7	1.7	5.5	95	3	19	2.1/2.7	3.1/2.9	2.7/2.4	2.2/1.9	1.6
15	80.0									1.1	5.5	93	3	19	2.7/2.8	2.8/2.9	1.9/2.3	1.5/1.7	1.8	5.5	95	3	19	3.0/2.8	2.7/2.4	2.2/1.9	2.3/2.1	1.7
16	70.0									1	5.5	93	3	19	3.1/2.9	2.7/2.4	2.2/1.9	2.3/2.1	1.5	5.5	95	3	19	2.2/2.1	2.9/2.6	3.0/2.7	2.3/2.1	1.7
17	70.0									1.1	5.5	92	3	19	2.5/2.9	2.3/2.4	2.1/2.2	2.1/1.9	1.5	5.5	95	3	19	2.9/2.7	2.7/2.7	2.1/1.9	2.0/1.7	1.7
18	71.0									1.5	5.5	94	3	19	3.1/2.9	1.9/1.8	1.9/1.8	1.9/1.9	1.5	5.5	95	3	19	2.8/2.6	2.3/2.3	1.9/1.8	1.8/1.8	1.6
19	80.0									1.6	5.5	94	3	19	3.0/2.8	1.7/1.6	2.0/1.9	2.0/2.1	1.6	5.5	95	3	19	2.6/2.7	2.5/2.9	2.6/2.7	2.1/3.0	1.5
19	80.0									1.6	5.5	94	3	19	3.0/2.9	1.7/1.7	2.0/1.1	2.0/2.2	1.6	5.5	95	3	19	2.6/2.8	2.5/2.1	2.6/2.8	2.1/3.1	1.3
20	80.0									1.4	5.5	94	3	19	2.9/2.6/	1.7/1.5	2.5/2.6	2.2/2.3	1.5	5.5	95	3	19	2.2/2.1	2.9/2.6	3.0/2.7	2.3/2.1	1.6
21	80.0									1.3	5.5	92	3	19	2.6/2.7	2.5/2.9	2.6/2.7	2.1/3.0	1.6	5.5	95	3	19	2.5/2.9	2.3/2.4	2.1/2.2	2.1/1.9	1.5
22	70.0									1.5	5.5	93	3	19	2.5/2.3	2.3/2.1	2.5/2.7	2.3/2.0	1.5	5.5	95	3	19	2.2/2.1	2.9/2.6/	3.0/2.7	2.3/2.1	1.6
23	67.0									1.2	5.5	94	3	19	2.6/2.7	2.5/2.9	2.6/2.7	2.1/3.0	1.5	5.5	95	3	19	1.9/2.2	2.3/2.1	2.2/2.0	1.8/2.1	1.6
24	66.0									1.2	5.5	94	3	19	2.2/2.1	2.9/2.6	3.0/2.7	2.3/2.1	1.5	5.5	95	3	19	2.5/2.3	2.7/2.4	1.9/1.7	1.5/1.5	1.5
25	66.0									1.2	5.5	94	3	19	2.8/2.6	2.3/2.3	1.9/1.8	1.8/1.8	1.4	5.5	95	3	19	2.2/2.1	2.9/2.6	3.0/2.7	2.3/2.1	1.5
26	67.0									1.3	5.5	93	3	19	2.9/2.9	2.3/2.1	2.3/2.2	1.9/1.8	1.5	5.5	95	3	19	2.8/2.6	2.3/2.3	1.9/1.8	1.8/1.8	1.5
27	67.0									1.3	5.5	93	3	19	2.5/2.3	2.3/2.1	2.5/2.7	2.3/2.0	1.5	5.5	95	3	19	2.2/2.4	2.5/2.4	2.0/1.8	1.5/1.3	1.5
28	66.0									1.4	5.5	93	3	19	2.6/2.7	2.5/2.9	2.6/2.7	2.1/3.0	1.5	5.5	95	3	19	2.6/2.7	2.5/2.9	2.6/2.7	2.1/3.0	1.4
29	63.0																											
30	61.0									1.5	5.5	93	3	19	2.5/2.4	2.3/2.2	1.9/1.8	1.8/1.8	1.5	5.5	95	3	19	2.5/2.4	2.3/2.2	1.9/1.8	1.8/1.8	1.5
31																												

Note :

1) Readings A1/A2 , B1/B2 , C1/C2 & D1/D2 are radial readings outside the casing 90 degrees apart Ref Fig

2) Readings are to be taken as close to bearing housing as possible

3) As per vibration monitor manual:

0-3 mm/s	Small vibrations very low noise level
3-7 mm/s	Noticeable vibration , Keep under observation. Plan action during next regular maintenance
7-18 mm/s	Large vibration , causes rapid wear , Plan action at the earliest

4) Bowl speed ,n= 6500 RPM

5) Centripetal pump ,Output = 8000-35000 l/h

6) BASE is reading taken at the base of the purifier

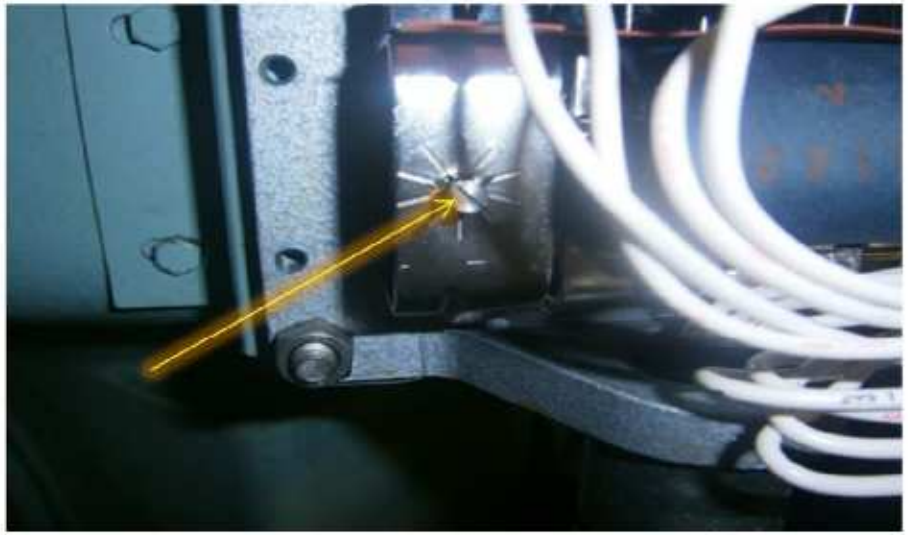
Pump / Motor Vibration measurement Record.

M.V MOL ENCORE VIBRATION MONITORING — September-12

Readings taken on the 27th of September 2012 at a Main Engine R.P.M. of 67.2

S.No	Engine casing	Motor			Pump			
		Free side	Coupling side		Coupling side		Free side	
		Radial	Radial	axial	Radial	axial	Radial	axial
	Pumps	R1/R2	R3/R4	A1	R5/R6	A2	R7/R8	A3
		mm/s			mm/s		mm/s	
	2ND DECK							
1	Sludge Sepa Disc Pump	0.7/0.8	0.4/0.4	NA	0.8/1.0	NA	0.9/1.0	NA
2	Sludge Sepa Feed Pump	0.5/0.7	0.80.7	NA	1.1/1.2	NA	1.2/1.0	NA
3	Hot Water Circ Pump	2.5/1.8	3.2/2.3	2.4	2.8/1.8	NA	NA	NA
	3RD DECK							
4	Aux Boiler Do Pump	0.4/0.8	0.6/0.9	NA	1.2/1.4	NA	1.5/1.2	0.8
5	Aux Boiler Fo Pump No. 01	S/B						
6	Aux Boiler Fo Pump No. 02	6.5/5.4	3.8/4.7	5.6	5.9/3.4	3.1	1.8/2.5	3.2
7	Jacket Cool F.W. Pump No. 1	S/B					NA	NA
8	Jacket Cool F.W. Pump No. 2	5.0/3.8	3.4/1.8	2.4	1.7/1.8	2.6	NA	NA
9	Fwg. Distil Water Pump	3.5/2.6	2.4/1.4	NA	1.9/1.7	NA	NA	NA
10	Fwg. Ejector Pump	4.7/3.4	3.2/1.8	3.2	1.7/2.1	3.0	NA	NA
11	Me Warm Up Pump	2.7/2.2	1.4/1.1	1.5	2.3/0.9	1.0	1.7/1.4	1.0

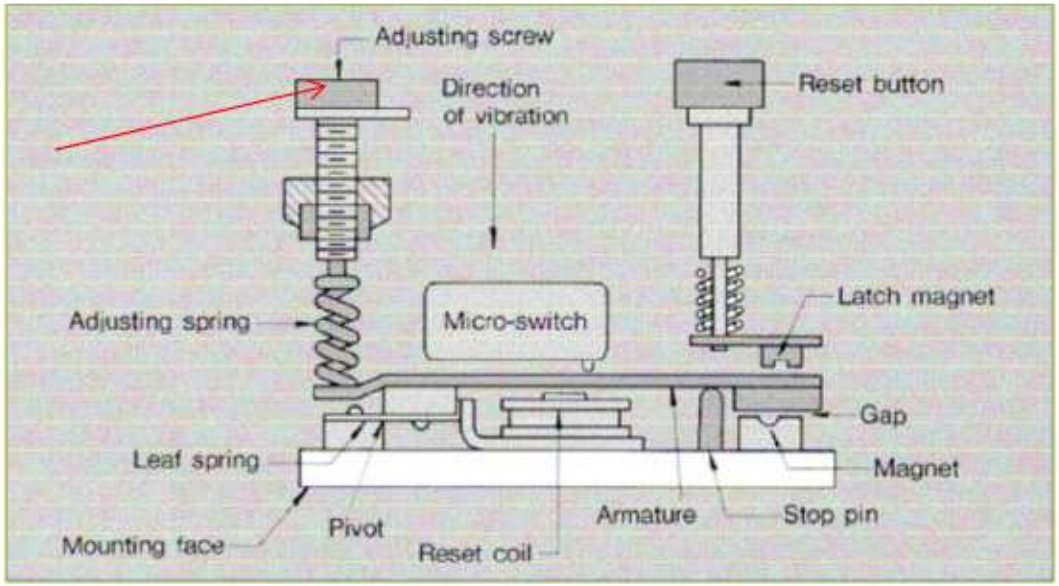
2. Fixed type – continuous monitoring
VIBRASWITCH 66W (fitted in M class vsls HFO purifiers).



2. VIBRASWITCH 66W (FITTED IN M CLASS VSLS HFO PURIFIERS).

Construction of the Detector;

If the detector is subjected to vibration, a moment will be set up around the spring joint of the armature, tending to separate the armature from magnet below it. Similarly the Adjusting spring is also generating the moment tending to separate the armature from magnet. When the sum of these moments is larger than the moment acting around the spring joint due to the attracting magnet, the armature will come away from the stop pin below and triggering the micro switch there by the machine stops or an alarm is given.



Case Study :1

AV TECHNOLOGY

Case History No.12
MOTOR DRIVE PULLEY STEADY BEARING FAILURE

K4420-3 is a two stage in-line reciprocating compressor which is driven by a two speed (960/400 rpm) Laurence Scott electric motor via a 9 belt pulley system giving a compressor speed of either 345 rpm or 144 rpm respectively.
This machine forms part of a monthly vibration monitoring schedule and is one of a team of three identical units that produce CO_2 for the chlorine liquefaction process, Figure 1 below shows the layout of the machine.

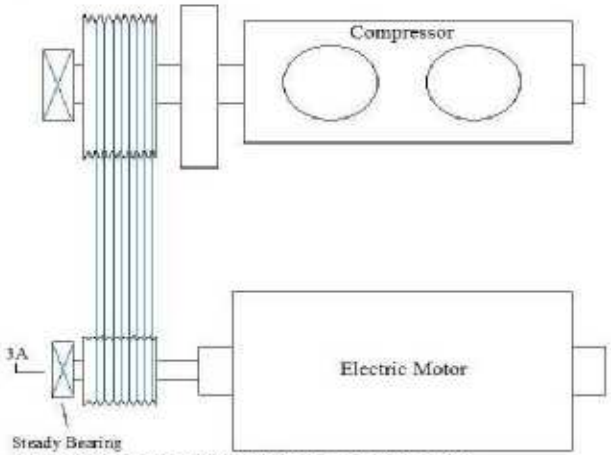


Figure 1 - Two stage reciprocating compressor

Historically, the overall vibration levels throughout the machine had been consistently low (around 1.4 mm/s rms) and had never given any cause for concern, however, the overall vibration levels recorded on the 30th September 1997 at the motor drive pulley outboard steady bearing exhibited a marked increase in the axial direction (position 3A), see Figure 2 below.

Figure 2 - Motor outboard pulley steady bearing

Examination of the vibration spectrum collected from this location exhibited several harmonic peaks across the 500 Hz bandwidth indicating a possible bearing defect at this location, see Figure 3.

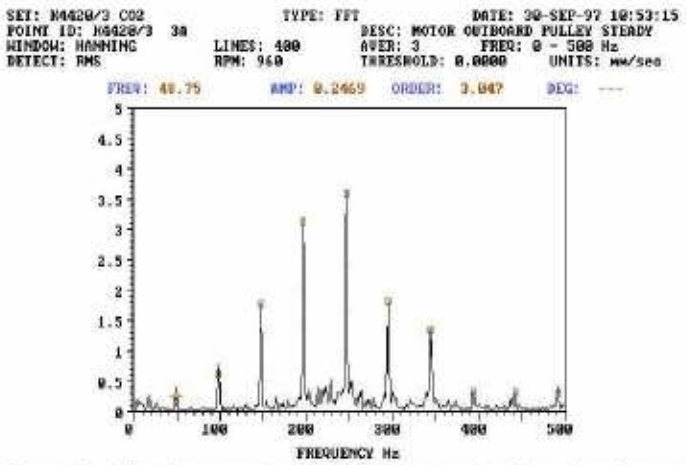


Figure 3 - Vibration spectrum indicating suspected bearing damage

The site Mechanical Engineer was immediately made aware of the change in the vibration levels with a recommendation to replace the bearing as soon as possible.
The machine was subsequently taken off line and the bearing replaced. On examination of the original bearing, a large area of flaking (spalling) was evident on the outer race, see Figure 4.

Figure 4 - Photograph showing bearing outer race damage

Due to the accurate analysis and prompt action by the Engineering Department a catastrophic failure had been prevented with a mechanical cost saving of several thousand pounds.

A clear case of 'Machines Talk and it Pays to LISTEN'

Case Study :2

MOL Encore all 3 HFO purifiers trouble case during 2011.

- Following message received from ECO regarding all 3 FO Purifiers trouble. Later on maker SE was arrange for investigation / Rectification at NY. Total cost incurred for the complete overhaul / renewal of critical spares = 35,000 USD.
- After this major break down the VIBER A was supplied on 4th Jan 2012 and ship staff started monitoring the condition of all machinery since then and recording same.
- Recent days we have not received any such complaints from vsl as the trouble is being detected immediately and tackled.

AA)) No1 HFO purifier;

-- Bowl cleaning was carried out frequently (normally 2000 hrs) about 500 hrs running due to hard sludge accumulation.

-- No excessive vibration observed.

-- Found worm wheel gear teeth worn suddenly. Teeth width is now of 2.2 mm (minimum recommended 2 mm). Last month (30 Aug 2011) measured value of gear teeth width was 3.6 mm.

BB)) No2 HFO purifier;

-- Bowl cleaning was carried out frequently (normally 2000 hrs) about 900 hrs running due to hard sludge accumulation.

-- No excessive vibration observed.

-- Found worm wheel gear teeth worn suddenly. Teeth width is now of 2.1 mm (minimum recommended 2 mm). Also three number of the gear teeth were found broken.

cc)) no3 HFO purifier;

we have renewed the friction drum as it found clearance more than 1.0mm

And renewed the friction pads holder disc as it was aged / worn beyond limit.

Presently No3 HFO purifier is running and we are trying to recover the no1 HFO purifier with available spares and operate two purifiers in parallel.

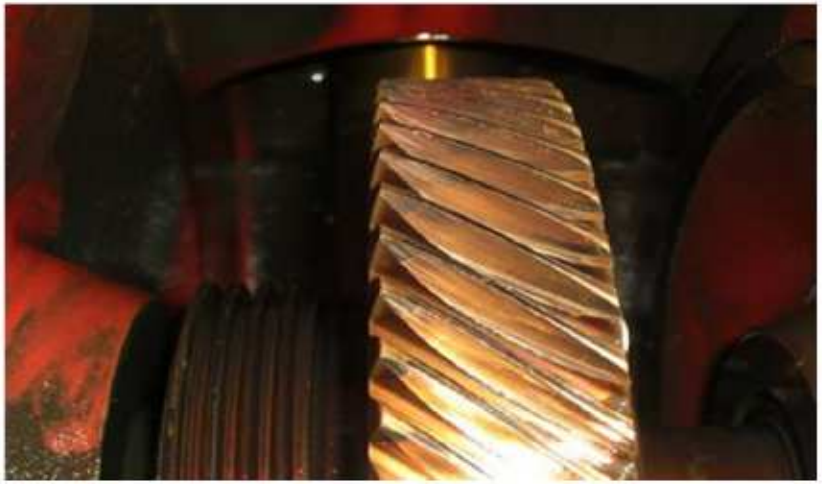
MOL Encore #1 HFO purifiers trouble case again during Oct. 2011.

- Heavy oil purifier #1 sudden damage to worm wheel- 3rd October 2011.

- During morning rounds of machinery on, noticed higher amperes 25
- A (normally about 23A) and slight vibration in HOP #1.
- Purifier immediately stopped and bowl assembly removed for inspection.

- Found excess sludge accumulation in the sliding piston. Disc stack is mostly
- clean. Rhrs since last cleaning is 288 hrs.

- Inspected the gear case and found worm wheel gear worn out. Teeth width is
- now of 2.2 mm (minimum recommended 2 mm). Last measured value of gear teeth
- width was 3.6 mm.



Message from ECO after measuring the vibration monitor readings.

- Please find attached Vibration monitoring sheet for various machinery on board.
- following pumps show high vibrations and suspected that these pumps vibrates due to the higher hull vibration at the surrounding area.

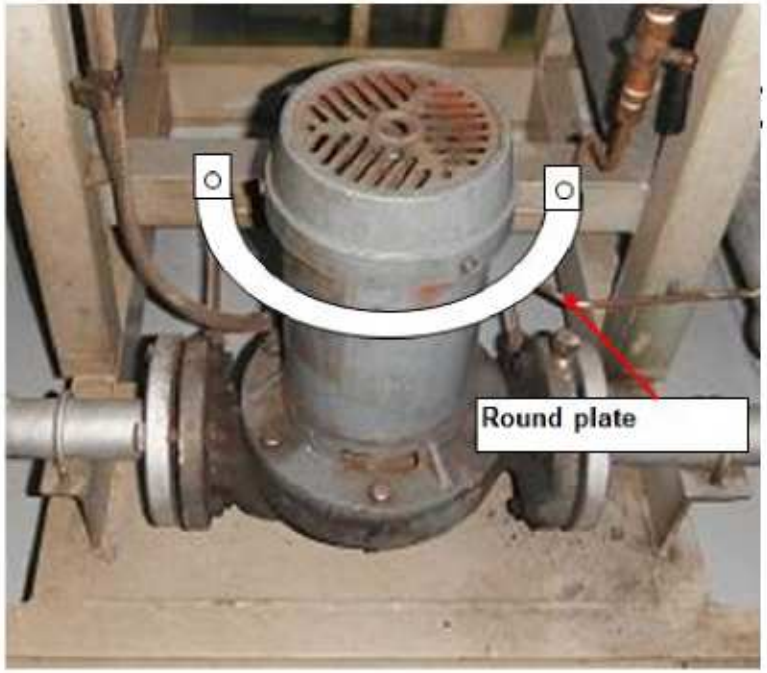
- 1.Crosshead LO pump no.1
- 2.ME T/C LO pumps
- 3.Sludge pump
- 4.Bilge pump

S.No	Engine casing	Motor			pump			
		Free side	Coupling side		Coupling side		Free side	
		Radial	Radial	axial	Radial	axial	Radial	axial
	Pumps	R1/R2	R3/R4	A1	R5/R6	A2	R7/R8	A3
39	Ballast & Heeling Pump	4.1/3.7	3.2/3.4	0.5	1.6/1.8	0.8	1.4/1.7	NA
40	T/G Condensate Pump No. 1	2.4/2.5	2.1/2.4	0.6	1.5/1.9	NA	1.0/1.2	NA
41	T/G Condensate Pump No. 2	2.6/2.8	2.4/2.3	0.9	1.6/1.5	NA	1.0/0.9	NA
42	T/G Cool S.W Pump No. 1	2.3/1.9	1.2/1.1	0.6	0.5/0.6	NA	NA	NA
43	T/G Cool S.W Pump No. 2	2.4/1.6	1.5/1.4	0.7	0.6/0.8	NA	NA	NA
44	Main Cool S. W. Pump No.1	3.2/3.1	3.1/2.7	0.8	1.4/1.1	1.5	NA	NA
45	Main Cool S. W. Pump No.2	3.5/3.7	3.0/2.9	0.6	1.2/1.2	1.7	NA	NA
46	Main Cool S. W. Pump No.3	3.1/2.9	2.9/2.7	0.9	1.2/1.7	1.5	NA	NA
47	Central Cool F. W. Pump No. 1	2.0/2.4	1.4/2.0	0.4	1.0/0.6	0.7	NA	NA
48	Central Cool F. W. Pump No. 2	2.2/2.2	1.6/1.8	0.3	0.6/0.7	0.9	NA	NA
49	Central Cool F. W. Pump No. 3	2.0/2.0	1.3/1.8	0.4	1.0/0.6	0.9	NA	NA
50	Crosshead L.O Pump No. 1	3.0/3.0	2.9/2.0	0.4	2.0/1.5	0.6	1.8/1.4	NA

Corrective action taken for excessive pump vibration

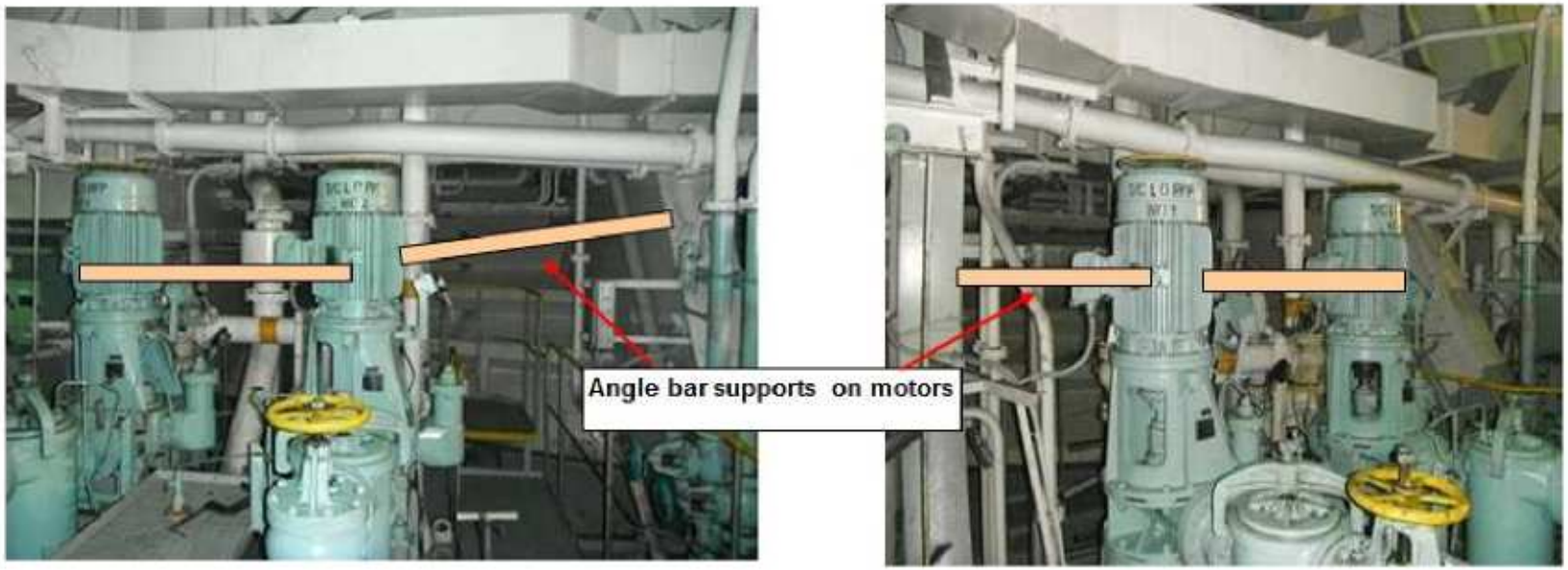
Arrangement to Reduce Vibration

SLUDGE PUMP



A round plate to be provided around the Motor with rubber packing on the round plate as well between motor and frame.

Corrective action taken for excessive pump vibration



Future developments
Wireless Vibration Monitor.

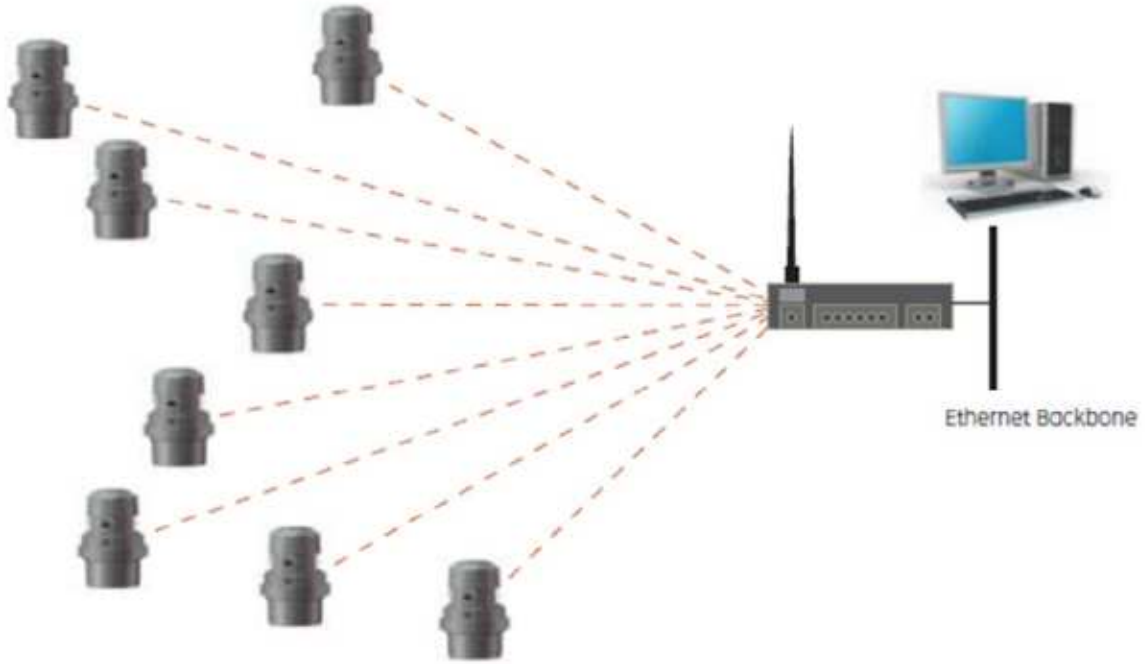
- Why use valuable manpower to collect vibration data on healthy machines?
- Why settle for measurements once a month when you can have them multiple times daily?
- Why have people venture into unsafe areas to collect routine measurements?
- **Wireless Vibration Sensors can safely "look" at the machine's health several** times a day and provide immediate **notification when warning or critical levels are reached.**

- Main Features
- Transmits long distances / Batteries last over 5 years
- Eliminates expensive cable runs / Runs stand alone or with junction box
- Stores data in ODBC format / Installs easily

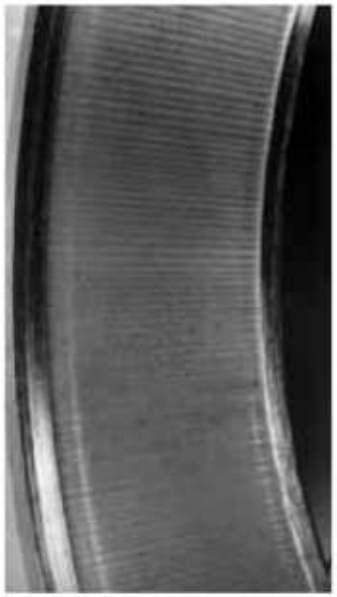
3. Wireless Vibration Monitor.

Wireless Vibration monitoring system;

Each field device can communicate with the wireless gateway and from the Gate way the collected information is analyzed / recorded & alerted with an alarm if the value exceed the normal set point.



Additional information



Bearings with vibration damage are also found in machines that are not in operation and are situated close to machinery producing vibrations.

Examples that can be cited are transformer fans, stand-by generators and ships' auxiliary blower motors which are attached to the Engine.