TECHNICAL REPORT

Vibration Analysis of Exhausters

CUSTOMER: M/s. SAIL, BHILAI STEEL PLANT

DATE OF WORKING: 26/06/2023 & 27/06/2023

LOCATION – BHILAI STEEL PLANT, BHILAI

WORK ORDER – CC-W/PO-4270012383/BF8-Electr Maint/OT/1538 (05/05/2022)

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Revision History

Version	Description	Reported by	Checked by	Date
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1.0 INTRODUCTION

This report pertains to the vibration analysis of the Exhauster Units of Sinter plant in Bhilai steel plant.

Sintering is an important process in the steel industry in which iron ore fine particles agglomerate into a porous compact heterogeneous lumpy mass. This process requires several equipment in the chain of activity and fans and exhausters play an important role.

Two large exhauster fans used in this process are investigated for the vibration behavior and to determine the causes of their reported shaft vibrations.

Results are given in the form of graphs, tables and supporting data. Remarks/ conclusions as relevant to the task are also discussed.

2.0 INSTRUMENTATION

Table 1 : List of Instrumentation / Sensor utilized for the present task

Sl.No.	Sensor/Instrument Description	Make	Model No	Serial No	Calibration due date
1	Multi-channel data acquisition system	LMS	SCM-01	47072801	Jun 2025
2	Tri-axial accelerometers	KISTLER	8763B050BB	5231964 5231965	Jan 2024
3	Data Processing/ analysis suite	LMS	Test.Xpress 3B	NA	NA
4	Impact Hammer	DYTRAN	5802A	2055	NA

3.0 TEST SETUP / MEASUREMENTS

Tri-axial accelerometers were mounted at DE & NDE side of the motor bearing housing and DE & NDE of the impeller fan. The accelerometers were then connected to a multi-channel data acquisition system.

The drive system containing the synchronous motor, pin bush type coupler and the impeller fan were run at the operating speed with load and were recorded for about 5 minutes continuously on the data acquisition system.

Additionally, run up and run down conditions of the system were recorded continuously for both the exhauster units to check for any critical speeds that are likely to be influencing the vibration response.

In the static condition of the motor / fan, impact force hammer tests were conducted on the motor body, exposed shaft on the driving end, on the spare fan kept in the shop floor. Impact tests were also done on the RCC block of motor foundation. These tests reveal any natural frequency coinciding with the operating speeds of the motor / fan and that are likely to influence the vibration responses.

4.0 SITE TEST PHOTOGRAPHS / SCHEMATIC

Figure 1: Site photographs taken during measurements

5.0 DATA PROCESSING

The processing of the recorded Vibration data is made as per the following steps:

1. Pre-processing and cleaning of the data is carried out to minimize the influence of extraneous vibration inputs and any other one-off events that are not a part of the considered vibration source for the present task.

2. The vibration acceleration data is converted to vibration velocity (mm/sec) using numerical integration method and the frequency bandwidth considered for the computation is from 1 to 1024 Hz.

3. The data is processed with peak-hold averaging to obtain vibration velocity v/s frequency spectra and are presented in mm/sec.

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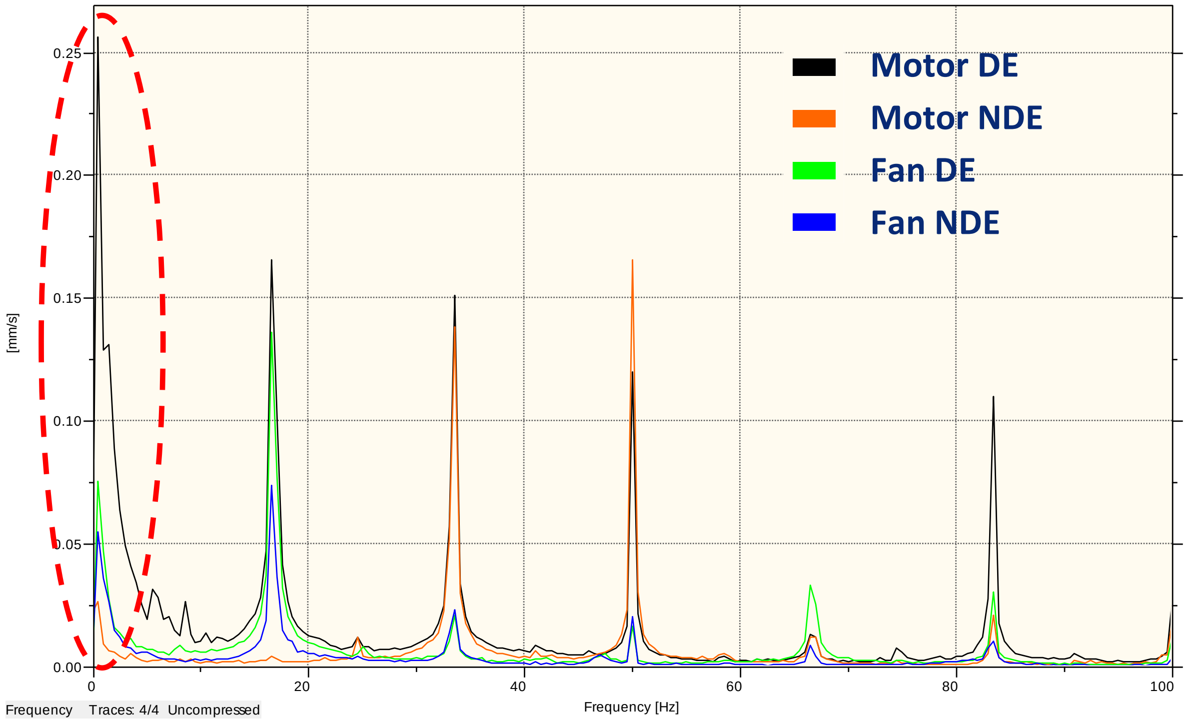
6.0 RESULTS & INFERENCES

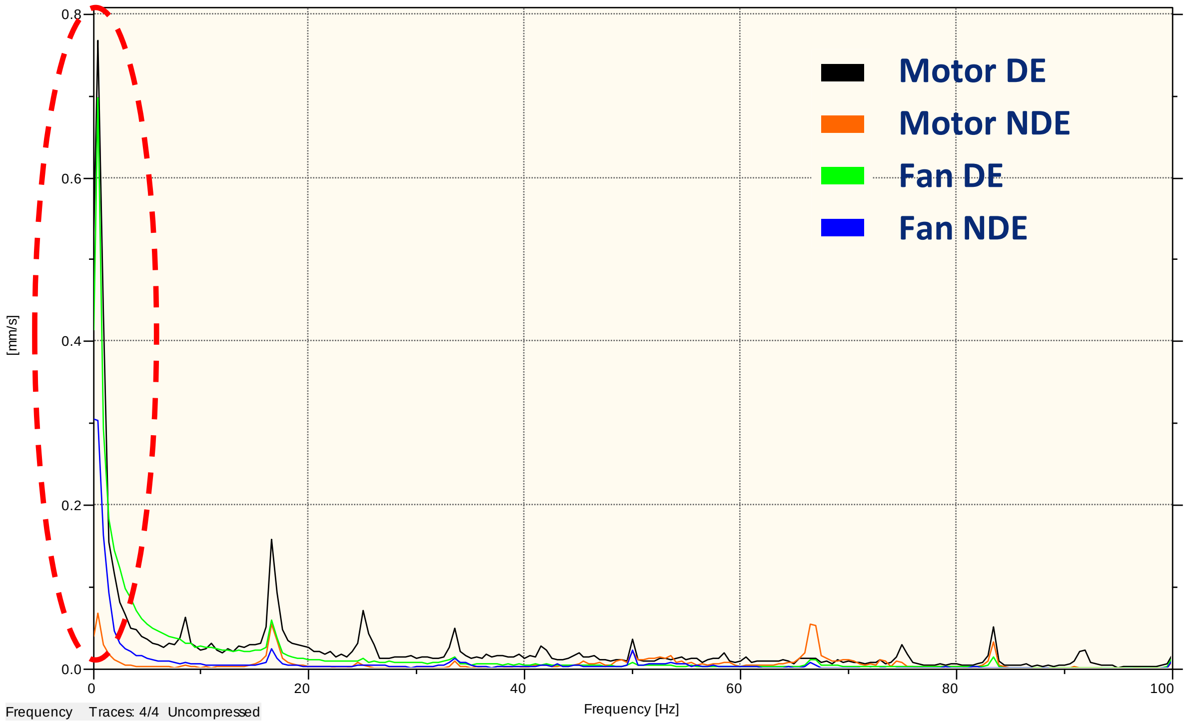
6.1 Exhauster unit 1

Table 2: Measurement results of Exhauster unit 1

Measurement Locations	Vibration velocity values (mm/s)			
	Direction	1 x RPM	2 x RPM	3 x RPM
Motor DE	X axis	0.17	0.15	0.12
	Z axis	0.16	0.05	0.04
Motor NDE	X axis	0.01	0.14	0.17
	Z axis	0.06	0.01	0.02
Fan DE	X axis	0.14	0.02	0.02
	Z axis	0.06	0.02	0.01
Fan NDE	X axis	0.07	0.02	0.02
	Z axis	0.03	0.02	0.02



Graph 1: Vibration velocity v/s frequency spectrum of Exhauster unit 1 in X axis



Graph 2: Vibration velocity v/s frequency spectrum of Exhauster unit 1 in Z axis

The motor DE shows presence of 1x vibration components followed by distinct and dominant harmonic peaks upto the 5th multiple of the fundamental frequency (around 17Hz/1000 RPM) of the motor rotation. Observe from the Graph 1 above that the 1x vibrations are higher in radial-horizontal direction (identified as X-axis) at the Motor DE and at the Fan DE ends.

While the 1x vibration frequency is distinctly indicated in the vibration spectrum at motor DE and Fan DE hinting at possible unbalance in the system, the absolute magnitudes (of under 0.2mm/sec) do not strengthen the case as these are allowable values for the equipment of this size and kilowatt rating (refer ISO 20816 standard).

The axial direction measurements (identified as Z axis) in the Graph 2 above also show higher 1x frequency vibrations at Motor DE and Fan DE whose magnitudes are as same or higher than radial direction vibrations, which is unusual. The initial inference from such a vibration behavior indicates that there is a possible misalignment between the fan DE bearing support to the motor DE bearing support.

Both the radial and axial direction vibrations tend to show significantly lower values at Motor NDE and Fan NDE locations thus indicating that there are likelihood problems around the DE bearings of Motor and Fan with the coupling as an interface.

The Z-axis (axial direction) vibration graph also indicates presence of very low-frequency (sub- 1Hz) vibrations (circled in the graphs above). This usually indicates loss or change in lateral (axial) stiffness of the shaft axis.

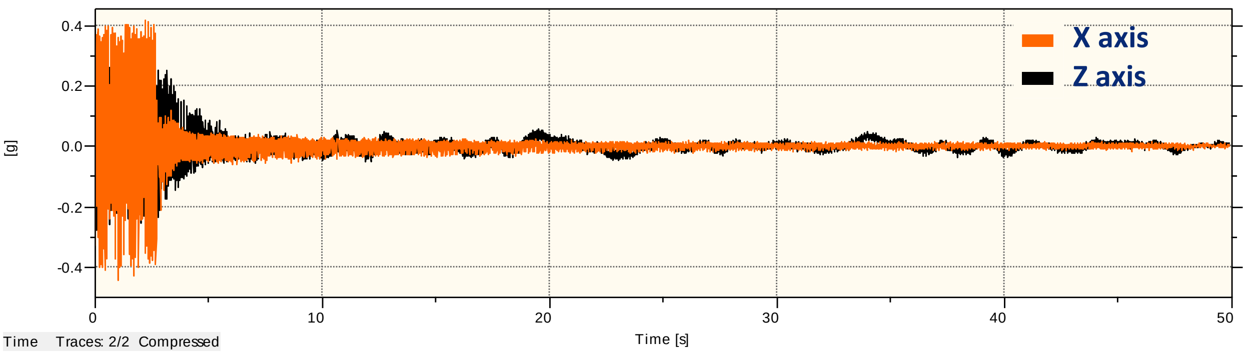
The fan support bearings have sleeve / journal type with self-aligning capability and thus exhibit lower vibrations. The probability of the residual unbalance and misalignment induced vibrations showing predominantly at the motor DE bearing are a good possibility since they have rigid bearings (rolling elements).

Since the motor bearing housing, motor body and the connected mounting structure are adequately rigid, the relatively less rigid member of the system, which in this case is the motor shaft connected to the visco-elastic coupling, is responding with higher shaft vibrations.

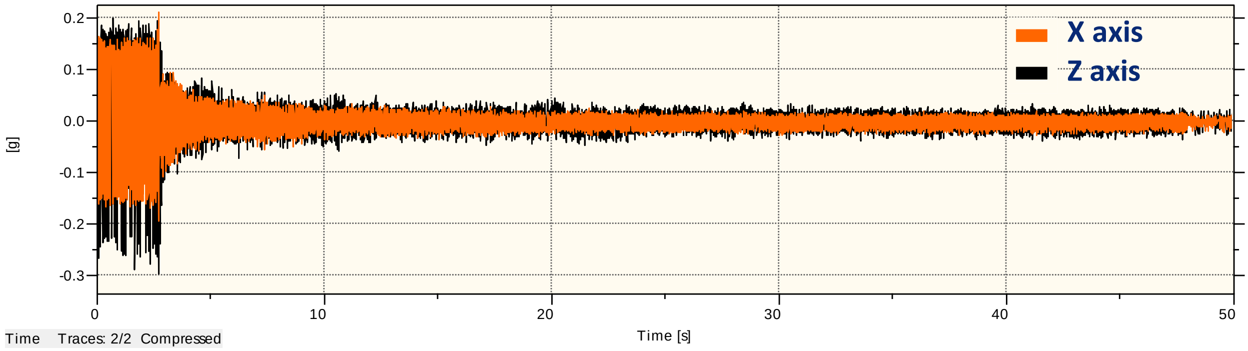
There is also a good possibility of differential thermal gradients on the drive shaft across the coupling member which is likely to cause higher shaft vibrations on the motor DE. To ascertain the effect of this, a few cycles of cold starts are required, keeping the temperatures across the coupling at around the room temperature.

If it is found that the motor DE shaft vibrations are lower and within limits of allowable values with cold running condition, it will be a definite indicator of thermal elongation on the shaft axis resulting in dynamic misalignment and increase in Z(axial) direction vibrations; this can very much influence the shaft vibrations as a consequence. It is also likely possible that the rubber coupling members have lost their visco-elastic properties and their dimensions have elongated in the axial direction due to long time usage with varying boundary conditions.

The vibration run-down data with switching off the electrical power to the motor is mapped and a representative graphs (of about 1 minute) is shown
Graph 3 and Graph 4. The results indicate normal response with no critical speed behavior shown anywhere through the coast down period till the motor comes to a stop. This test and its results confirm that the motor / fan units are operating within the rigid rotor concept and the critical frequency remains beyond the maximum operating speed of the system.



Graph 3: Vibration acceleration v/s time – Motor DE of Exhauster unit 1 – Rundown



Graph 4: Vibration acceleration v/s time –Motor NDE of Exhauster unit 1 – Rundown

Effectively, the Exhauster-1 took under 25 minutes to fully stop from its start of power-off and Exhauster-2 had a coast down time of over 35 minutes; this is a fringe observation that points to higher inertial resistance in Exhauster-1 due to misalignment in the axis that resists the rotational movement.

Impact hammer tests conducted on the motor body / spare fan unit and on the foundation block of the motor did not indicate any typical frequency of response that matches with the rotational frequencies (RPM) of the motor / fan.

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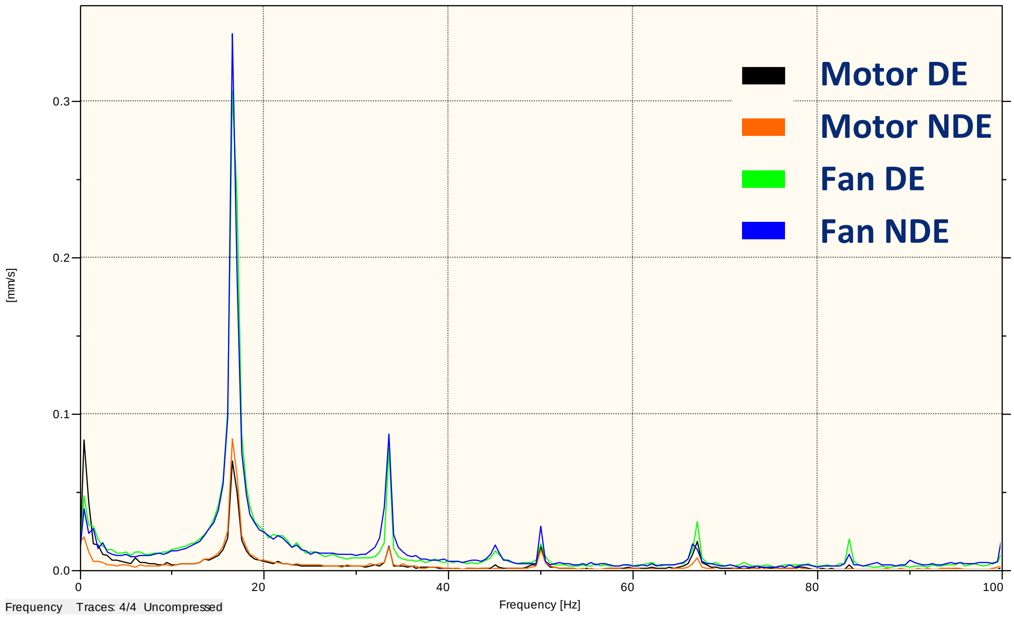
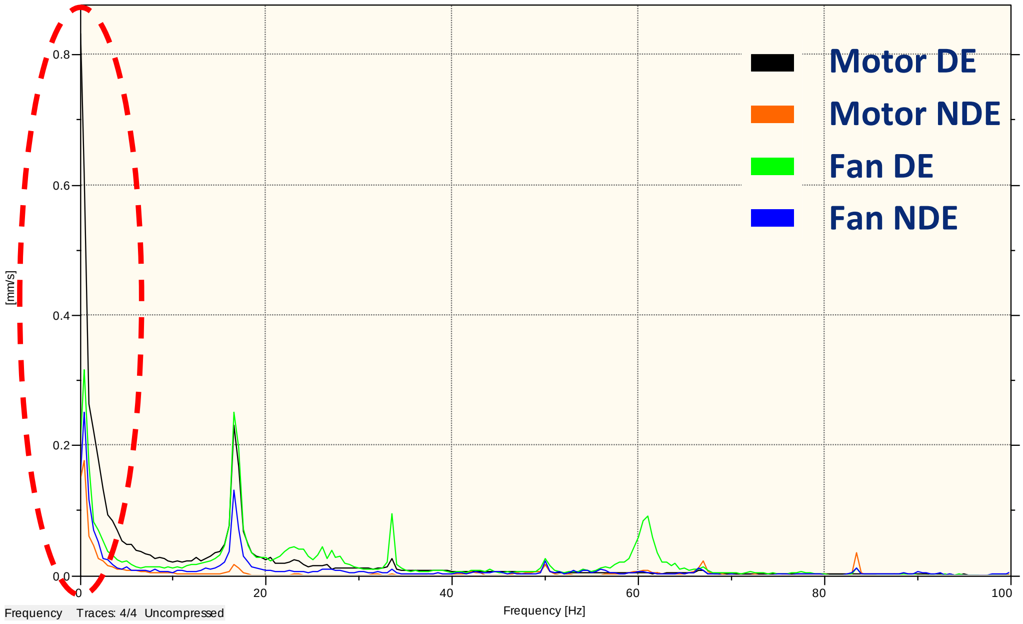
6.2 Exhauster unit 2

Table 3: Measurement results of Exhauster unit 2

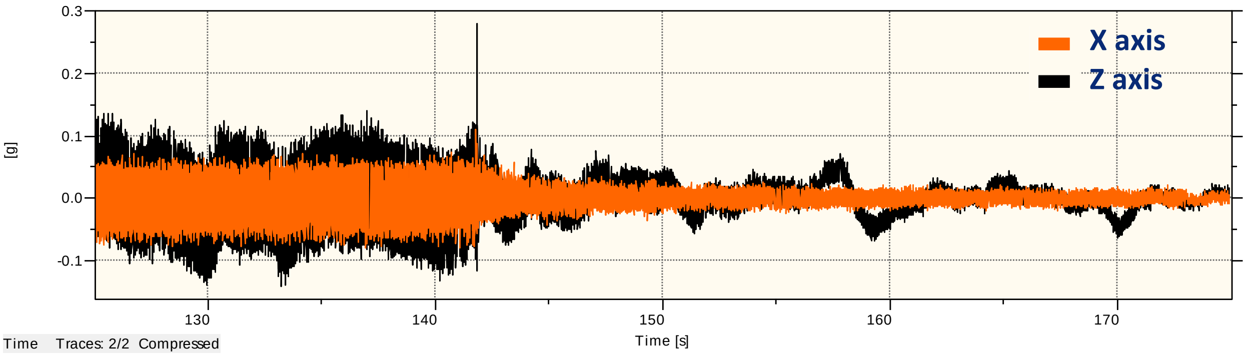
Measurement Locations	Vibration velocity values (mm/s)			
	Direction	1 x RPM	2 x RPM	3 x RPM
Motor DE	X axis	0.07	0.02	0.02
	Z axis	0.23	0.03	0.01
Motor NDE	X axis	0.08	0.01	0.01
	Z axis	0.02	0.01	0.02
Fan DE	X axis	0.30	0.08	0.02
	Z axis	0.25	0.01	0.03
Fan NDE	X axis	0.34	0.09	0.03
	Z axis	0.13	0.01	0.02



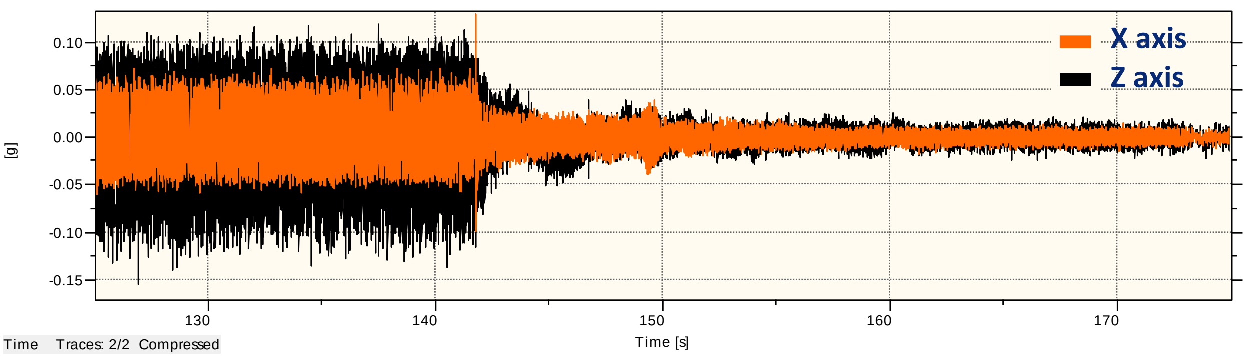
Graph 5: Vibration velocity v/s frequency spectrum of Exhauster unit 2 in X axis



Graph 6: Vibration velocity v/s frequency spectrum of Exhauster unit 2 in Z axis



Graph 7: Vibration acceleration v/s time –Motor DE of Exhauster unit 2 – Rundown



Graph 8: Vibration acceleration v/s time –Motor NDE of Exhauster unit 2 – Rundown

The Exhauster-2 exhibits lower axial vibrations at all the measured bearing support locations and has lower harmonic vibrations in the radial direction. The 1x RPM vibration that typically represents the residual unbalance in the motor units is under 0.4 mm/sec, which can be addressed by conducting site balancing activities. From this observation, it can be established that the shaft vibrations in this motor are lower as compared to the Exhauster-1 motor (due to the absence of higher harmonic vibrations).

It is also observed that the low frequency (sub 1Hz) vibrations do show up at the Z-axis (axial) and in the X-axis (radial) show up with lower magnitudes, indicating better alignment between the Motor DE and the Fan DE axis.

As in the case of Exhauster-1, both the run-down tests and impact response tests did not indicate any possible presence of natural frequency and resonance conditions influencing the vibration behavior on the Motor / fan unit.

Bearing conditions of both the motor units indicate healthy response with the lower acceleration, spike energy, kurtosis and crest factors. However, the health assessment of bearings on the fan unit couldn't be ascertained as these are not anti-friction type.

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7.0 REMARKS/CONCLUSIONS

- From the detailed vibration analysis, it is inferred that the most possible cause of higher shaft vibrations at Motor DE in Exhauster-1 is due to a combination of residual unbalance in the motor / coupler / fan assembly combined with higher Z-axis vibrations caused by misalignment. Thermal gradient on the shaft axis across the coupling and depletion of physical characteristics of the coupling unit are also likely to be contributing to higher shaft vibrations in Exhauster-1.

- On both the exhausters, it is highly recommended to disconnect the coupling completely from the motor shaft, conduct vibration studies on the motor independently (including conducting balancing) and establish its performance both for housing and shaft vibrations.

- Once this is done, connect the coupling and align them as per SOP and establish alignment limits as prescribed. With this done, a complete assembly balancing of fan + motor is to be conducted, identifying the plane separations correctly. A multi-plane balancing is highly recommended to assess the unbalance coefficients and their phase responses and make corrections in all possible planes simultaneously; this is an effective approach to contain Z-axis vibrations where multiple bearing supports are involved.

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