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MONITORING AND DIAGNOSIS OF VIBRATION IN ROTATING MACHINERY

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1.0 SCOPE

This data sheet provides guidelines for periodic and continuous monitoring programs for rotating machinery considered important to plant operations.

Information on vibration monitoring of reciprocating machinery can be found in Data Sheet 13-26, *Internal Combustion Engines.*

1.1 Changes

January 2000. This revision of the document has been reorganized to provide a consistent format.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Operation and Maintenance

The recommended approach to vibration monitoring is as follows:

2.1.1 Immediately after installation of a turbomachine or a new rotor, baseline traverses from zero to maximum speed should be made for each bearing. These traverses should be done using tracking filters so that plots of amplitude vs. speed can be obtained. They should be done, at least, with bearing cap instruments mounted horizontally. Traverses with the instruments mounted vertically and with the shaft proximity probes may be taken if desired. The purpose of the latter would be to confirm that cap instrumentation is more sensitive to unbalance.

2.1.2 At some convenient later time, similar traverses should be taken during a deceleration.

2.1.3 When an increase in vibration occurs, especially if it is sudden, a diagnostic vibration analysis (including vibration frequency analysis) should be made. The increase of concern would be 0.5 mils for machines running at 0.5 mil or less, or 1.0 mil for machines operating at over 0.5 mils. (One mil equals 25 microns.)

The diagnostic analysis should consist of:

1. A frequency analysis of the vibration signal at the operating speed by means of an analyzer, which produces a spectrum of vibration amplitude vs. frequency component, and

2. A vibration scan (preferably with bearing-cap instrumentation) during a deceleration from, and acceleration to, operating speed. The scanning instrument should have a tracking filter to produce a record of vibration over the speed range, and to analyze such record into its individual frequency/amplitude spectrum.

The vibration scan referred to above is of most value when there is a baseline scan available as part of the machine record. Such a baseline would pinpoint bearing criticals and their amplitudes, as well as indicate—by vibration buildup as operating speed is approached—the proximity of the first rotor mode to the operating speed.

2.1.4 Evaluation of the diagnostic traverses should involve comparing amplitudes with baseline signatures at maximum speed, and as the machine passes through its critical speeds. A significant increase in amplitude at a critical speed implies that an unbalance has developed in the rotor.

It would be expected that the increase in amplitude would occur without a change in the critical speed. If a shift in critical speed has occurred, the cause should be sought in the bearing pedestals or supports. Weakened or broken bearing supports lower the critical speed.

If there is any indication that the rate of buildup of amplitude at operating speed has changed, a shift in the rotor-mode critical speed should be suspected. The most likely cause of this would be a severely cracked shaft If a shaft proximity probe or a shaft rider is installed, a scan of its response should be obtained for confirmation.

In evaluating the data from diagnostic traverses, the more sensitive instrumentation—bearing cap or shaft monitoring—should be used. Only parallel traverses can indicate with certainty which type is more sensitive for a given type of machine.

Table 1 is a guide for interpretation of vibration readings and trends and provides guidelines for action. Bearing vibration is unpredictable. The table presents the most likely causes of a given symptom and suggests the most efficient approaches for investigation.

Table 1. Guidelines for the analysis of bearing vibration trends

A. Abrupt Increase:	0.5 mil (12.5 microns) for units operating at 0.5 mil (12.5 microns) or less; 1.0 mil (25 microns) for units operating over 0.5 mil (12.5 microns); 2.0 mil (50 microns) for units operating over 1.0 mil (25 microns).
Action:	Perform vibration frequency analysis and accel/decel scans.
Diagnosis:	1/rev. vibration: Possible fracture of blade, shroud and/or other rotor part. Possible cracked disk or spindle. A dismantle and internal inspection should be done immediately. Other possible causes are (1) a bowed or bent shaft, and (2) disks loose on the shaft Significant components of 2/rev. or 3/rev.: Possible pedestal looseness; check and correct.
B. Pronounced Increase over a period of 4–5 days:	
	0.5 mil (12.5 microns) for units operating initially at 0.5 mil (12.5 microns) or less; 1.0 mil (25 microns) for units initially operating over 0.5 mil (12.5 microns); 2.0 mil (50 microns) for units initially operating over 1.0 mil (25 microns).
Action:	Perform vibration frequency analysis and accel/decel scans using both bearing-cap and shaft-monitoring instrumentation.
Diagnosis:	1/rev., possibly with components of 2/rev. and 3/rev.: Possible crack progression in shaft Investigate at once.
C. Gradual Increase over a period of 3-6 months:	
	0.75 mil (19 microns) for units operating initially at 0.5 mil (12.5 microns) or less; 1.5 mil (37.5 microns) for units initially operating over 0.5 mil (12.5 microns); 3.0 mil (75 microns) for units initially operating over 1.0 mil (25 microns).
Action:	Perform vibration frequency analysis and accel/decel scans.
Diagnosis:	0.4-0.5/rev. vibration: Possible oil whip in hydrodynamically lubricated bearings. Special investigation necessary; internal bearing clearance or oil viscosity may have changed. 1/rev. vibration: Action depends on object, as follows: *Steam Turbine:* Possible buildup of deposits on blades. Wash turbine with wet steam. Review efficiency records. If cleaning does not work there is a possibility that disks may be loose on the shaft A dismantle and internal inspection should be performed within 3 months. *Gas Turbine:* Possible buildup of deposits on compressor or turbine blades. Review performance to see if location of buildup can be identified. Clean compressor. If cleaning does not reduce the vibration, blade ## erosion may be the cause. Schedule an internal inspection within 3 months. *Dynamic Compressor:* Possible buildup of deposits on blades. Clean compressor rotor. Review efficiency records. If cleaning does not correct the vibration, schedule a dismantle and internal inspection at a convenient time. *Fans and Blowers:* Possible buildup of deposit on blades. Review flow and efficiency records.. Reduction in flow capacity implies deposits. If cleaning equipment is installed, the blades should be cleaned. If efficiency only is affected, excessive erosion may be the cause. An internal inspection should be scheduled to determine the problem and make the necessary repairs. *All Units:* Possible buildup of hard deposits in splined, lubricated coupling, leading to misalignment of coupling. Inspect and clean coupling. *High Frequency:* Rolling-element bearing or gearbox damage, depending on frequency. Inspect and replace bearing or gears, as necessary.