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Understanding Vibration Analysis

Vibration analysis is a useful method of performing all of the following:

- evaluating current machine condition
- diagnosing faults associated with operational machines
- monitoring and trending the overall condition of machines over time.

A complete vibration analysis consists of three distinct components:

- absolute vibration measurements
- bearing condition measurements
- FFT frequency analysis

The initial measurements, absolute vibration measurements, are an important indicator of the current state of a machine. They can be measured quickly and easily and have been successfully used for decades for the evaluation of overall machine condition.

In order to standardize methods of measurement and facilitate comparison of data, a number of national and international guidelines have been established and are currently in practice. Since 1964, VDI guideline 2056 has served as the basis of several standards regarding execution of the measurements, selection of the measuring points and limits of evaluation.

In accordance with VDI 2056, the standard vibration measurement is the root mean square (rms) value of the vibration velocity measured in the frequency range of 10 to 1,000 Hz (1 Hz is one cycle per second).

This same guideline specifies that the measurements should be preferably taken at the bearings of the machine in the following six locations:

1	drive end	horizontal
2	drive end	vertical
3	drive end	axial
4	outboard	horizontal
5	outboard	vertical
6	outboard	axial

To evaluate the vibration level, the largest amplitude of the 6 measured points is selected. This is known as the vibration severity.

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The guidelines define limit values for the evaluation of the vibration severity. VDI 2056 classifies machinery into six machinery groups. We are primarily concerned with three of the six groups:

Group K — small machines, individual parts of engines and machines and complete machines, especially production electric motors up to 20 hp.

Group M — medium sized machines, especially electric motors between 20 and 100 hp, without special foundations. rigidly mounted machines on special foundations, with rotating parts only, up to 400 hp.

Group G — large sized machines mounted on rigid and heavy foundations. large engines and machines with rotating parts only.

In accordance with VDI 2056, the limit values for vibration severity for Groups K, M & G are as follows:

group	grade	vibration velocity in/sec rms
Group K	good	up to .027
	permissible	.027 to .070
	still permissible	.070 to .177
	not permissible	above .177
Group M	good	up to .043
	permissible	.043 to .110
	still permissible	.110 to .275
	not permissible	above .275
Group G	good	up to .070
	permissible	.070 to .177
	still permissible	.177 to .433
	not permissible	above .433

DIN-ISO 2373 sets acceptance limits for electric motors according to shaft heights and service speeds. The vibration levels are graded as normal, reduced and special. The normal level vibration acceptance limit for an 1800 rpm motor with a shaft height of 5.2 to 8.8 inches (common 25-50 hp motor, group M) is .110 in/sec rms which is the same as the permissible limit according to VDI 2056 for a group M machine (coordination between guidelines).

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An example of overall comparative vibration data for three similar machines is presented in spreadsheet form (last page). Please refer to this report for instructional purposes. Assuming a Group M machine (75 hp motor), **permissible** vibration levels (.043 to .110 in/sec rms) are in **black**. **Still permissible** vibration levels (in excess of .110 in/sec rms) are in **yellow**. **Not permissible** vibration levels (in excess of .275 in/sec rms) are in **red**. IE, the vibration severity for the motor on machine #3 is **not permissible**.

The second component of the analysis is the bearing condition evaluation. The BEARCON method is a special program unique to Schenck equipment that detects faults in rolling element bearings. This evaluation method is based on the measurement of shock impulses associated with bearing faults and the vibration at the surface of the machine. The information is expressed as a calibrated measurement in BCU's (bearing condition units). The bearing reaches a damaged phase when the BCU values exceed 10 to 20 times the measurement when the bearing was new. Multiple machines can also provide comparative data in leu of new bearing measurements. This data is presented on the sample spreadsheet. Bearing condition measurements in **blue** are **good**. Typical **normal** bearing measurements are in **black**. Bearing condition measurements that indicate initial stages of **deterioration** are in **yellow**. Bearing condition measurements that indicate **failure** stages are in **red**.

The final component of the analysis is the FFT. The Fast Fourier Transform is a computerized mathematical algorithm for transforming vibration signals from the time domain (time waveform) into the frequency domain. The Fourier Transform, a plot of vibration amplitude vs frequency, is especially useful for frequency analysis which is the analytical method most often used for fault recognition in operational machines. Machines can be examined during regular operation, start-up and run down or during tests and experiments. This analysis can be performed without interrupting the normal operation of the machine. FFT's are helpful in diagnosing faults associated with unbalance, misalignment, eccentric components and damaged bearings, shafts, gears or motor electrical faults.

Periodic vibration analysis can be implemented over time to monitor and trend the operational condition of machines. This data is used to predict faults and impending failures. Non linear trends (sharp increases in vibration levels or bearing condition levels) generally are an indication of impending problems. This warning enables the maintenance department to schedule the necessary repairs before an unexpected failure occurs, causing downtime and lost productivity.

A trend analysis (overall vibration measurements, bearing condition measurements, FFT's and BCS's (bearing condition spectrums)) is implemented on a monthly, bi-monthly or quarterly basis (as required) following a complete initial analysis as a baseline. Reporting is easily customized to suit the customer's needs and may be presented either in hard copy or electronically, or both.

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Sample Vibration Data Spreadsheet

		#1	#2	#3
motor	1 dh	0.09	0.25	0.14
vibration	2 dv	0.09	0.27	0.15
	3 da	na	na	na
	4 oh	0.08	0.23	0.14
	5 ov	0.05	0.15	0.59
	6 oa	0.08	0.11	0.26
bearing	d	0.20	0.26	0.38
condition	o	0.30	0.08	0.11
compressor	1 dh	0.05	0.18	0.06
vibration	2 dv	0.07	0.20	0.17
drive side	3 da	na	na	na
	4 oh	0.06	0.15	0.06
	5 ov	0.09	0.21	0.15
	6 oa	0.06	0.11	0.23
bearing	d	0.59	0.63	0.89
condition	o	1.37	0.49	2.12
compressor	1 dh	0.06	0.16	0.09
vibration	2 dv	0.07	0.21	0.15
outboard	3 da	na	0.13	0.21
	4 oh	0.06	0.16	0.08
	5 ov	0.09	0.20	0.13
	6 oa	0.06	na	na
bearing	d	0.48	0.70	1.17
condition	o	0.89	0.95	0.88

Group M (medium machines) vibration velocity in in/sec rms

up to .043	good
.043 to .110	permissible
.110 to .275	still permissible
above .275	not permissible
bearing condition in BCU's	good, normal, fair, poor

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