MACHINE VIBRATION STANDARDS:
OK, GOOD, BETTER & BEST

Part 3 - Absolute, Machine Specific Standards

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Different Types Of Vibration Standards

1) ABSOLUTE, GENERAL (OK)

2) ABSOLUTE, MACHINE SPECIFIC (GOOD)

3) COMPARATIVE (BETTER)

4) HISTORICAL (BEST)
Absolute, Machine Specific Vibration Standards

These machine-specific standards improve in relevance versus general standards for most real problems as they are adjusted to best fit the unique design and operation of specific types of machinery. They are typically based on real historical data from equipment fitting the description involved. Some examples are as follows:

1) Technical Associates Standards
2) Sohre-Erskine R/C Standards (shaft vibration, fluid film bearings)
3) ISO 7919 (shaft vibration, fluid film bearings)
4) OEM Specifications

PROS:

a) Can be applied to plant equipment from the beginning of a condition monitoring program. No prior machine history is necessary to make a basic assessment of a machine’s condition.

b) Takes into account the basic differences between different types of machinery & base types (ie: pump versus fan, rigid versus isolated base, etc).

CONS:

Your plant’s machinery, process, loading, speed, mounting, etc is no doubt unique in some ways that can make your final vibration levels end up on the high or low side of these standards without anything being wrong with the equipment or in some cases with a whole lot wrong with the equipment.
Technical Associates

Machine Specific Standards[12]

- These standards account for both the machine type & base type of rotating equipment.

- In the opinion of the author, these standards represent an excellent starting point for overall vibration alarm levels on machinery.

- In addition to these overall standards, recommendations for the levels of common parameters such as 1x rpm, 2x rpm, vanepass frequencies, bearing frequencies, etc are made.
R/C Method (fluid-film bearings) Erskine & Sohre have suggested the use of relative shaft vibration (R) and bearing clearance (C) for the evaluation of the condition of machines with fluid film bearings. The state of the bearing is judged by the ratio R/C and rotor speed. This provides a basis that is directly applicable to the specific machine in question. Erskine divided his results into two speed categories — turbine generators (3,600 RPM) and centrifugal compressors (10,000 RPM). These could also be applied to other machines such as motors & pumps with similar speeds. The work of Erskine was refined by Eshleman and Jackson.
ISO 7919: Shaft Vibration[13 & 16]

- Chart at right is from ISO 7919 and relates relative shaft vibration severity to shaft speed.
- All vibration is relative to bearing (ie: from proximity probes ).
- Shaft vibration is expressed in displacement, micrometers pk-pk
- 100 micrometers ~ 4 thous of an inch.

Zone Descriptions:

Zone A – Newly commissioned machinery.

Zone B – Acceptable for unrestricted, long-term operation.

Zone C – Unsatisfactory for long-term operation.

Zone D – Damage likely occurring to machine.

A complete copy of this vibration standard is available from the ANSI website at the following: http://webstore.ansi.org/
ISO 7919: Shaft Vibration[16] (cont):

Below are the formulas from ISO 7919 that define the vibration Zone boundary limits as a function of machine operating speed (rpm).

Zone A/B boundary limit (micrometers, pk-pk) \[ S_{(pk-pk)} = 4,800/\sqrt{rpm} \]

Zone B/C boundary limit (micrometers, pk-pk) \[ S_{(pk-pk)} = 9,000/\sqrt{rpm} \]

Zone C/D boundary limit (micrometers, pk-pk) \[ S_{(pk-pk)} = 13,200/\sqrt{rpm} \]

100 micrometers ~ 4 thousandths of an inch

A complete copy of this vibration standard is available from the ANSI website at the following: [http://webstore.ansi.org/](http://webstore.ansi.org/)
Three different approaches to defining the vibration level \( S_{\text{max}} \) used in the chart are suggested by the ISO as follows:

1) The maximum of the two orthogonal measurements \( (X \& Y) \).

\[
S_{\text{max}} = S_X \text{ or } S_Y
\]

2) The result of the following calculation:

\[
S_{\text{max}} = \sqrt{S_X^2 + S_Y^2}
\]

3) Measuring the real maximum displacement \( (S_{\text{max}}) \) directly from the orbit as shown at right.

A complete copy of this vibration standard is available from the ANSI website at the following: [http://webstore.ansi.org/](http://webstore.ansi.org/)
ISO 7919: Shaft Vibration (cont):

- Before applying these shaft vibration standards, please take into account both the available bearing clearance & the type of fluid film bearing used (use common sense).

- For example, if the standard says 100 micrometers vibration is ok and you only have 120 micrometers bearing clearance to work with, you may want to shift the boundary zones as needed (ie: B becomes C or C becomes D, etc).

- Be aware of not only how much vibration is occurring, but where it is occurring relative to the bearing geometry (shaft position + orbit).

- Examples of fluid-film bearing profiles are shown at right: grooved, offset, tapered land, elliptical, tilt pad.

Examples Of Fluid-Film Bearing Designs[17]
The OEM’s of most rotating equipment today have their own vibration standards used to aid both customers and technical personnel in determining machine condition.

Most of the time OEM’s have unique knowledge of their equipment and can be of great assistance in both determining machine condition as well as aid in solving problems – why not ask their opinion.
We can offer the following suggestions for the baseline measurement that will act as a starting point in a trending program. These levels are estimates for a ‘typical’ industrial gear drive on a ‘typical’ solid foundation where all vibration is measured on a rigid structural component of the gearbox and expressed in velocity units of inches/second-Peak.

<table>
<thead>
<tr>
<th>Vibration Level IPS-P</th>
<th>Gearbox Health Assessment</th>
<th>Required Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 0.2</td>
<td>Normal operational levels</td>
<td>None</td>
</tr>
<tr>
<td>0.2 to 0.3</td>
<td>Slightly elevated, long term life may be compromised</td>
<td>Investigate source, watch for upward trends</td>
</tr>
<tr>
<td>0.3 to 0.5</td>
<td>Elevated, some components are trending to a failure condition</td>
<td>Correct cause at future maintenance outage</td>
</tr>
<tr>
<td>Above 0.5</td>
<td>High, some components are at or near a ‘failure’ point</td>
<td>Correct causes very soon</td>
</tr>
</tbody>
</table>

Based on the above discussion I suggest the following levels for ‘typical’ industrial equipment:
- Alarm --- 0.35 IPS-P
- Shut down --- 0.5 IPS-P

We recommend using velocity as the vibration measurement unit for most equipment since it can be a single limit value over the frequency range of most gearbox mechanical defects.
REFERENCES, PART 3:


14) Eshelman, Ron, Machinery Vibration Analysis 2, Gears & Gearboxes, p.326, VI Press, IL, 1996

15) ISO 7919 Mechanical Vibration Part 1: General guidelines

16) ISO 7919 Mechanical Vibration – Evaluation of machine vibration by measurements on rotating shafts Part 3: Coupled industrial machines