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thermal science

Tips for Establishing Need and Collection of Comprehensive Vibration Data

Monitoring new and existing cooling towers for vibration is critical to maintaining long term performance. As with any rotating or moving mechanical equipment, vibration on the cooling tower structure and noise associated with the drive system is to be expected. Compared to other mechanical equipment, cooling tower excitation forces are at relatively low rotational speeds.

This paper helps determine whether a vibration issue is present and the necessary steps to help resolve the issue. Cooling tower vibration limits are defined by Cooling Technology Institute (CTI) Standard for Vibration Limits in Water Cooling Towers STD-163. Compliance with this standard requires data taken on the tower itself. Acceptable vibration limits for cooling towers are higher relative to general machinery. Qualitative monitoring of the tower while in operation such as listening for rattling is not sufficient to define a tower as having a vibration issue. Vibration switches and continuous monitoring systems on the tower can be helpful in determining if more detailed vibration analysis is necessary.

CTI STD-163 comprises two parts. The first defines overall vibration limits that can be used for settings in a continuous vibration monitoring system. Overall limits are divided into four separate severity zones: Low (A), Acceptable (B), Alarm (C), and Shutdown (D). These limits are measured as velocity and are shown in Table A1. Per CTI STD-163, speeds may be locked out on the VFD where vibration levels peak then return to normal as speed increases.

If vibration levels fall into severity zone C or D, Table A2 lists component-specific vibration limits to be utilized on a more in-depth tower analysis. Use a vibration analyzer to determine vibration levels at all frequencies to create the overall vibration signature of the cooling tower mechanical equipment. Four primary vibration frequencies are used for cooling tower mechanical system analysis:

1. Fan rotational speed – Revolutions per minute (RPM)
2. Motor rotational speed – Revolutions per minute
3. Blade passing frequency – Fan rotating speed x number of blades in fan
4. Gear mesh frequency – cycles per minute of gear tooth contact

Refer to Table A2 & Figure A1 for the definition of frequency specific vibration severity.

In certain cases, issues present due to tripped vibration switches or alarms on vibration monitoring systems can be resolved with a tower inspection.

1. For any noisy or rattling components verify that hardware is tightened. If necessary use additional stiffening or secure the noisy items.
2. Ensure mechanical components are aligned per the product specification.
3. Confirm fan tip clearance exceeds minimum allowed for diameter and there is no rubbing on fan cylinder.
4. Be cautious about VFD operation below 14 Hz to avoid motor cogging symptoms and to ensure adequate gear drive lubrication.

If the vibration issue is not resolved through these steps a more thorough analysis using transducers and an analyzer to collect data may be necessary. Accelerometer type transducers are preferred but velocity transducers may also be used. For the data to be useful, the analyzer must be capable of transforming the raw waveform received from the transducer into a frequency spectrum through Fast Fourier Transform (FFT) and integrating the signal to velocity and/or displacement to aid in analysis. It is recommended that the FFT be performed using a frequency range of 0-6,000 CPM with at least 800 lines of resolution. A third-party vibration testing firm can perform the analysis if vibration testing equipment is not available.

Vibration data is most easily gathered from the motor and the fan cylinder. If possible and safe, data can also be gathered from the gearbox housing. Follow all relevant safety precautions and lock out/tag out procedures. A full modal analysis of the cooling tower is unnecessary for determining compliance with CTI STD-163. On the motor it is recommended that data is taken in the horizontal, axial, and vertical directions at both the inboard (drive) end and the outboard (opposite the drive) end of the motor on the housing itself. Bearing caps, bolting bosses or other solid surfaces are best. Data collection on cooling fins and fan shrouds can give erroneous results. Axial data may be taken from a motor foot if necessary. Figure 1 below shows typical motor mounting locations.

Vibration data on the fan cylinder should be collected at a point near the fan elevation. Typically the transducer must be held by hand against the outside part of the cylinder. If the tower is on a VFD consider collecting data from half speed to full speed to determine if any specific operating frequencies are generating vibration values above CTI STD-163.

Physical inspection of the tower, checking alignment and verifying hardware is tightened should always be the first step. If the issues still persist, then detailed vibration data should be collected. After conducting measurements at the locations defined above and then analyzing the data, if the values are above CTI STD-163 limits, provide the data set to SPX Cooling Technologies. SPX will analyze the data for potential root cause and offer solutions that comply with CTI STD-163.

Key Takeaways

- Monitoring vibration is critical for long term maintenance of the cooling tower.
- Vibration limits are governed by CTI STD-163 and are higher than for general machinery.
- If vibration switches trip or vibration monitors alarm, further investigation is needed.
- In certain cases a physical inspection of the tower may determine the cause of the issue.
- If the physical inspection does not offer a conclusion, vibration data can be collected.
- Full modal analysis is unnecessary; the motor and fan cylinder are the critical measurement locations.
- If the measured data is outside of CTI STD-163 limits, share the data with SPX for further analysis.

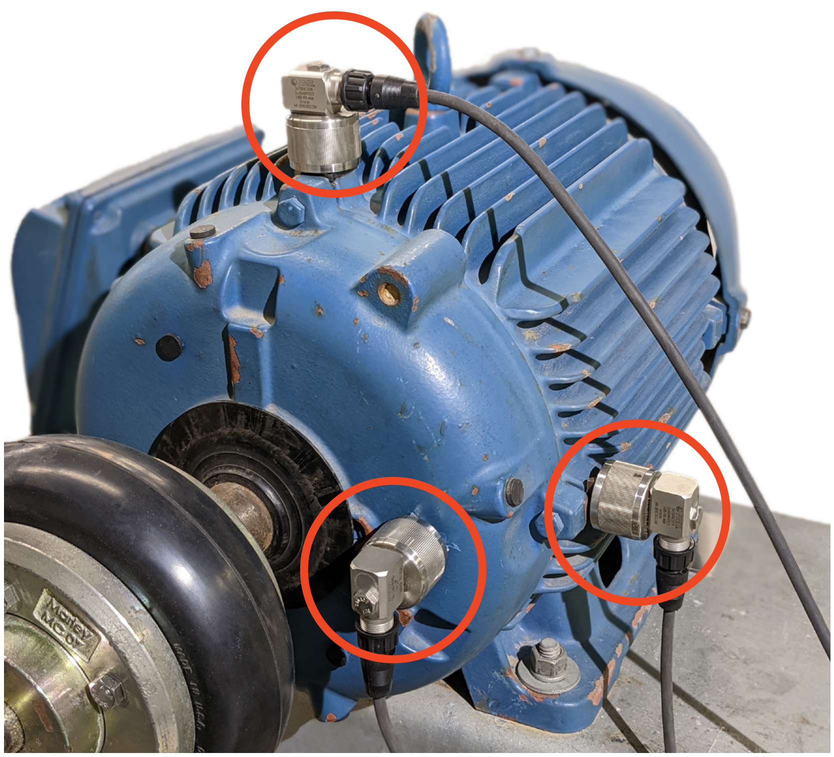

Figure 1: Typical transducer motor mounting locations

Appendix

Severity Zone	Condition	Velocity (in/sec)		Velocity (mm/sec)	
		Peak	rms	Peak	rms
A	Low	0.35	0.25	8.9	6.4
B	Acceptable	0.5	0.36	12.7	9.1
C	Alarm	0.6	0.43	15.2	10.9
D	Shutdown	0.7	0.50	17.8	12.7

Table A1: Broadband Vibration Limits for Field-Erected Wood or Fiberglass-Framed Cooling Towers

<table>
<tr><th rowspan="2">Measurment Location</th><th rowspan="2">Frequency Range
(cpm)</th><th colspan="3">Zone Classification</th></tr>
<tr><th>A
Velocity
Inches/sec
(mm/sec)
Peak</th><th>B
Velocity
Inches/sec
(mm/sec)
Peak</th><th>C
Velocity
Inches/sec
(mm/sec)
Peak</th></tr>
<tr><td>Motor Horizontal, Vertical or Axial at Shaft Centerline</td><td>Motor Speed, Blade Pass or Harmonics
(600-1800)</td><td>0.2
(5.1)</td><td>0.3
(7.6)</td><td>0.45
(11.4)</td></tr>
<tr><td rowspan="2">Gear Drive Horizontal, Vertical or Axial at Input Shaft Bearings or Output Shaft Bearings</td><td>Motor Speed, Blade Pass or Harmonics
(600-1800)</td><td>0.2
(5.1)</td><td>0.3
(7.6)</td><td>0.45
(11.4)</td></tr>
<tr><td>Gear Mesh and Higher Harmonics
(6000-120000)</td><td>0.1
(2.5)</td><td>0.15
(3.8)</td><td>0.30
(7.6)</td></tr>
<tr><td>Fan Cylinder Horizontal at Fan Operating Plane</td><td>Blade Passing
(600-3000)</td><td>1.0
(25.4)</td><td>1.5
(38.1)</td><td>2.0
(50.8)</td></tr>
<tr><td colspan="5">Fan Balance Quality</td></tr>
<tr><td></td><td>Frequency Range
(cpm)</td><td>A
Mils
(mm)
Peak to Peak</td><td>B
Mils
(mm)
Peak to Peak</td><td>C
Mils
(mm)
Peak to Peak</td></tr>
<tr><td>Motor, Gear Drive or Fan Shaft Bearings Parallel to Fan Rotational Plane</td><td>Fan Speed
(60-150)</td><td>6.5
(0.165)</td><td>10
(0.254)</td><td>15
(0.381)</td></tr>
<tr><td>Motor, Gear Drive or Fan Shaft Bearings Parallel to Fan Rotational Plane</td><td>Fan Speed
(150-600)</td><td colspan="3">Refer to Displacement Chart for the fan speed of interest</td></tr>
</table>

Table A2: Frequency Specific Vibration Guidelines for Field-Erected Wood or Fiberglass-Framed Cooling Towers and Factory-Assembled Steel or Fiberglass Towers

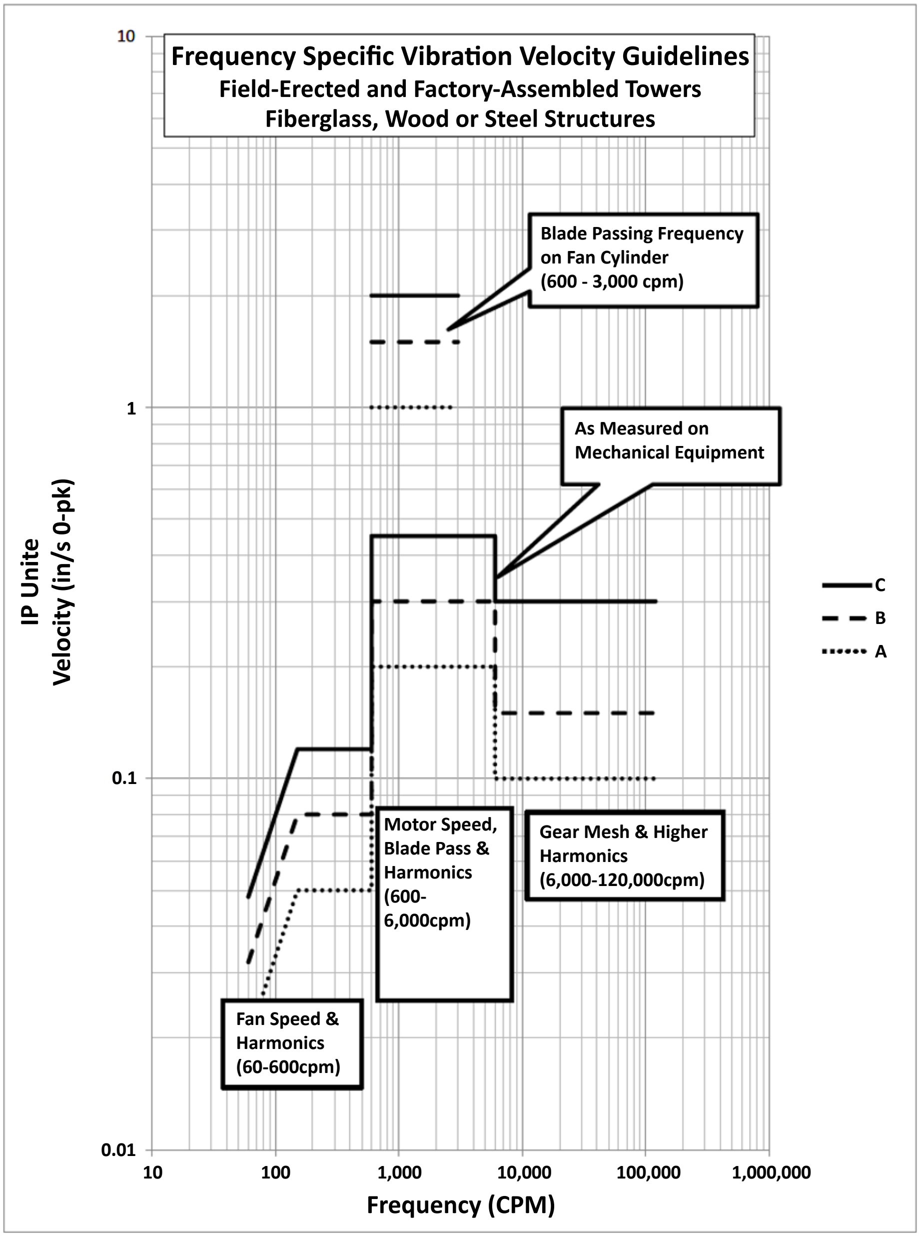

Figure A1: Frequency specific vibration limits

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