

Vibration Monitoring at Weirton Steel

By Joe Dominick, Weirton Steel, and Tom LaRocque, CTC

The mission of the Predictive Maintenance (PdM) Department at Weirton Steel is to provide high-quality condition based monitoring and proactive maintenance services. Over 30,000 routine vibration collection points are monitored regularly, with critical machines monitored monthly and the other points monitored either bi-monthly or quarterly. As a result of this effort, over 2,250 work orders are generated by the PdM department annually. And last year, the PdM department documented over \$5 million in product loss avoidance due to vibration analysis alone.

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The PdM Department monitors many different types of rotating machinery, including DC motors and large gearboxes, rolls (each driven by smaller DC motors and gearboxes), and large turbo machines with sleeve bearings. There are also numerous pumps and direct-driven and belt-driven pumps and fans throughout the mill, each driven by AC motors. Routine vibration readings consist of capturing a spectrum and trending overall and narrow-band values. A single measurement point could have between 5 and 12 narrow-bands depending on the machinery set-up. Waveforms are stored if an alarm is triggered on the overall or one of the narrow-bands. Alarms have been set based on general rotating equipment machinery standards. Some alarms have been refined based on historical data; however, specific machinery vibration data is necessary to take full advantage of narrow-band alarming.

Currently, 90% of the vibration data collection is done through portable measurements with accelerometers. There are some areas where permanently mounted accelerometers are used due to safety concerns or because the measurement points are very hard to reach during a route.

The major types of vibration related faults at Weirton Steel consist of:

- Roller bearing failures - 27%

- Misalignment - 23%
- Mechanical looseness - 16% (including bad bearing fits)
- Structural looseness - 13% (including most resonance problems)
- Imbalance - 9%
- Other (gears, electrical, flow, belts, etc.) - 12%

Since the primary vibration related fault is due to roller bearing failures, the accuracy of the data above 120,000 CPM is critical for the early detection of bearing problems. And one of the most significant aspects of accelerometer accuracy and repeatability is the mounting technique.

To illustrate the significance of mounting techniques for routine vibration data collecting and trending, data was collected from a 3500 hp induced draft fan motor, with sleeve-type bearings and turn speed of 1200 rpm. Data was collected using a data analyzer, a 6-foot straight cable, and 100 mV/g accelerometers. Three mounting techniques were used: a flat magnet on a magnet target, a two-pole magnet for curved surfaces, and a stinger. Two readings were taken for each mounting arrangement in the horizontal direction on the outboard motor bearing.

Figure 1 illustrates the results. The high frequency band, typically set out to 300,000 CPM at Weirton Steel, is important for detecting early stage bearing defects and electrical problems. The spectrum of the stinger did not register major vibration frequencies from 100,000 CPM to 180,000 CPM. The stinger has passed its mounting resonance, and the faults, in this case electrical-related defects, did not register on the spectrum. The two-pole magnet was able to pick up the vibrations between 100,000 CPM and 180,000 CPM, but was unable to pick up the vibrations between 200,000 CPM and 300,000 CPM, indicating that it also has passed its mounted resonance. Therefore, the electrical-related faults would not have

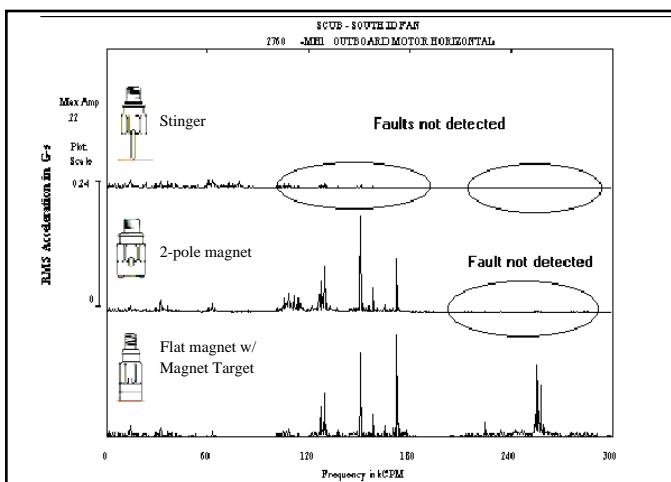


Figure 1 - 3500 hp induction draft fan motor.

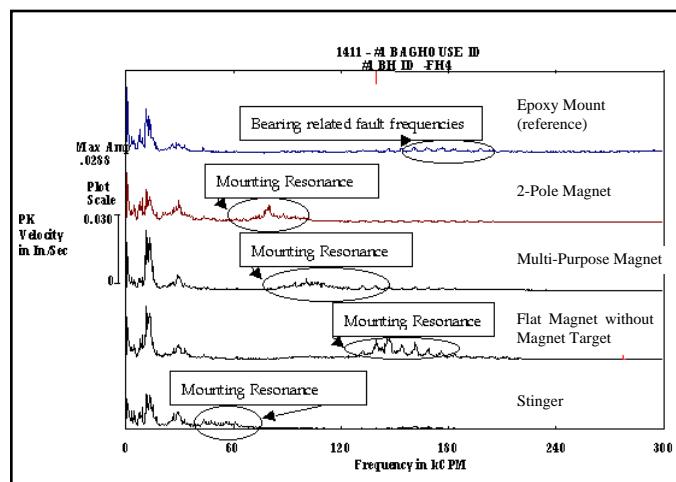


Figure 2 - Bag house fan. The mounting resonance was greatly reduced from over 300,000 CPM to approximately 150,000 CPM.

Different Mounting Techniques Used

Accelerometer performance specifications are based on stud mounting, which uses the entire measurement capability of the accelerometer. To generate accurate vibration



Flat Magnet

2 Pole Magnet

Stinger



Multi-Purpose Magnet

data, a flat frequency response over a wide frequency range is desired. A stinger compromises an accelerometer high frequency response with a specified measurement capability of 900,000 CPM to only 30,000 CPM. Other mounting techniques, such as magnets and quick disconnects; fall in between a stinger response and a stud mounted response (See below).

The ability to accurately repeat a measurement on a machine during routine data collection is critical in the trending of machine condition. Since accurate measurement at the same measurement

point is essential, the location of the measurement point must be consistent. The surface of the measurement point on the machine and the type of mount are also very important when trying to obtain repeatable readings. In this case, Weirton Steel requires accurate vibration amplitude levels over 120,000 CPM on faster rotating machinery (>1,200 rpm), which restricts the use of a stinger or curved surface magnet mounted accelerometer.

Lower frequencies (<30,000 CPM) can pass through most mounting systems, so for faults such as imbalance, misalignment and fundamental bearing defects, a stinger may provide accurate data. At higher frequencies (>30,000 CPM), however, the accelerometer mounting technique is critical to achieving accurate vibration data. For instance, in order to detect early stages of bearing faults, the mounting system must be able to detect frequencies as high as 200,000 CPM. If incorrect mounting hardware is used, such as a stinger or magnet for curved surfaces, this early detection may not be observed, and the bearing would have to deteriorate further before the fault is noticed.

Therefore, the proper mounting technique should be the primary consideration when deciding the frequency spans required for monitoring certain machines.

Mounting Techniques

Probe Tip	Curved Surface Magnet	Quick Disconnect	Flat Magnet w/Flat Target	Adhesive Mount	Stud Mount
500 Hz (30,000 CPM)	2,000 Hz (120,000 CPM)	6,500 Hz (390,000 CPM)	10,000 Hz (600,000 CPM)	10,000-15,000 Hz (600,000-900,000 CPM)*	10,000-15,000 Hz (600,000-900,000 CPM)*
Maximum Frequency Response (within +3dB)					
* Depending on specified high frequency response of individual accelerometer.					

been identified by either the stinger or the two-pole magnet, even though they were clearly evident using the flat magnet on a magnet target.

Another example of the importance of the correct mounting technique for data collection and trending is illustrated in Figure 2. Data was taken on a bag house fan bearing with spherical roller bearings and turning speed of 890 rpm. Data was collected using an analyzer, a 6 foot coiled cable, and a 100 mV/g accelerometer.

Five mounting techniques were used: a flat magnet onto the machine surface without a mounting target, a stud-mounted accelerometer to an adhesive mounted pad on the bearing cap, a two-pole magnet for curved surfaces, a multi-purpose magnet and a stinger. Readings were taken for each mounting arrangement in the horizontal direction on the outboard fan bearing. The reference spectrum is of the stud mounted accelerometer to the adhesive mounted pad on the bearing cap. From this spectrum, early bearing-related defects can be seen between the frequencies of 120,000 CPM and 180,000 CPM.

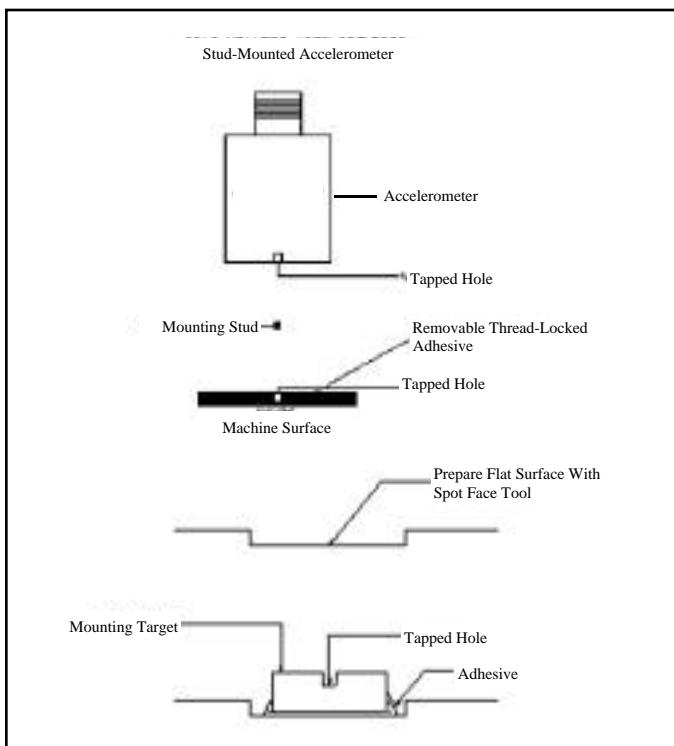
A clear illustration of mounting resonance can be seen with the stinger. At approximately 30,000 CPM, the spectrum of the stinger shows a sustained amplitude until approximately 80,000 CPM, after which the amplitude decreases significantly. This shows the effects of a vibration frequency at the mounting resonance when compared to the flat magnet, the magnification of the vibration amplitude at resonance, and then the resulting decrease in amplitude. The bearing-related defects would not have been detected during this routine measurement.

Note how the mounting resonance of the magnet for curved surfaces has been reached at approximately 80,000 CPM. The same amplification at mounting resonance observed for the stinger is observed here, with a vibration frequency being amplified at the beginning of the mounting resonance. The bearing-related defects would not have been detected during this routine measurement.

The mounting resonance for the multi-purpose magnet is slightly higher, but the effects of unreliable readings after mounting resonance has been reached can be observed. The frequencies between 120,000 CPM and 180,000 CPM are much lower in amplitude, and may not indicate the early bearing-related defect.

It is important to note the spectrum of the flat magnet mounted accelerometer which has been attached directly onto the machine surface without a magnet target. The flat magnet mounted accelerometer is detecting the bearing defects between 120,000 CPM and 180,000 CPM; however, the increased amplitude of the vibration frequencies indicates that this technique is also approaching its mounting

Vibration Analysis



Weirton Steel's PdM Program identifies early signs of bearing faults, gear-mesh faults, and motor defects (rotor bar or slot passing frequencies), and it is critical that the mounting technique is capable of measuring the high frequency span of the fault frequencies that can be present with these types of faults. The number of points and the collection frequency necessary to monitor all of the machinery require that accurate data be collected the first time.

resonance. Note how the increased amplitude decreases significantly after approximately 180,000 CPM.

The mounting resonance was greatly reduced from over 300,000 CPM in Figure 1 to approximately 150,000 CPM in Figure 2. This is due to the effects of collecting vibration data directly from the surface of the machine. Contaminants such as the paint on the bearing cap, grease, oil and dirt, affect the transfer of high frequency vibration between the machine surface and the magnet-mounted accelerometer by reducing the mounting stiffness. Installing magnet targets directly on the surface of the machine with an adhesive and then protecting the mounting target from debris and paint with a cap cover when not in use allows Weirton Steel to effectively monitor high frequency vibration greater than 150,000 CPM.

Mounting stiffness can also be increased in a mounting system by adding a coupling fluid to the interface. The coupling fluid fills the very small voids between the surfaces and facilitates vibration transfer.

- For a permanently mounted interface, epoxy or removable thread-locking adhesive (i.e., mounting the pad or accelerometer to a machine surface) (Figure 3A).
- For a temporary interface, silicone greases (i.e., magnet to the mounting pad) (Figure 3B).

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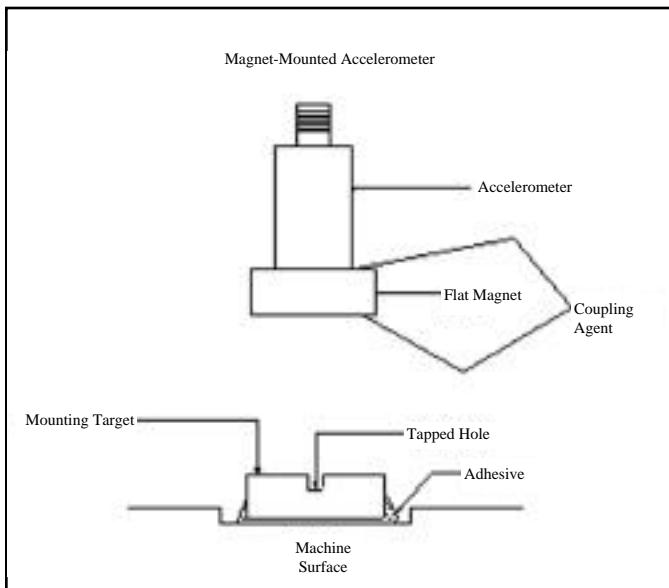


Figure 3A (left) - Coupling agent location - permanent mounting

Figure 3B (above) - Coupling agent location - portable measurement.

require that accurate data be collected the first time. Once a potential bearing or gear problem is identified from high frequency vibration analysis, it is then trended and monitored closely. This has proven to be a very important part of the success of the PdM Program.

Based on observations from data similar to the two examples, Weirton's PdM department changed from using a 2-pole magnet mounted accelerometer for 100% of acquiring portable measurement vibration data to using a flat surface magnet mounted accelerometer for 80% of the portable measurements (wherever a flat surface can be contacted or a magnet can be mounted).

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