Why Motor Vibration Monitoring?

Written by:
Bryce Brewer
IIoT Application Engineer
Grace Technologies, Inc.

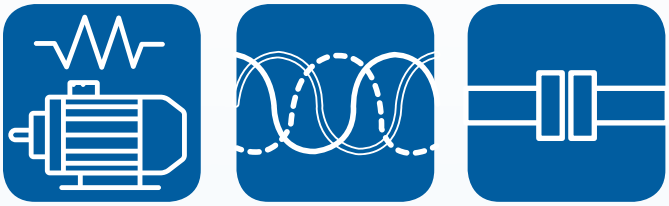
Many industrial facilities across the globe use route-based vibration analysis to aid in maintaining a reliable plant. In the best of cases, this occurs on a monthly basis on critical equipment yet it is more common to be performed once every two months or a quarter. Less critical equipment is oftentimes never analyzed for any vibration related issues after it is installed. They are simply run until failure. Run until failure is perfectly acceptable in cases where the motor being unavailable for couple days or a week will not impact the manufacturing process drastically. This requires redundancy, a well-stocked maintenance storeroom, and a risk analysis to be performed on the cost of doing vibration analysis vs running to failure to determine the proper route. In cases where run to failure isn't an option, most companies look to motor vibration analysis to combat unexpected downtime.

Why Motor Vibration Analysis?

Motor vibration analysis is the gold standard used to determine the condition of a motor. Other types of sensing are sometimes used to determine motor health. These can be a more general type of monitoring, such as overall current draw or temperature on a motor or bearing. This is great data to capture alongside a vibration regimen. If current draw increases on a motor or a bearing is heating up, this could have been detected in advance and remedied by vibration monitoring. Oftentimes irreversible damage has occurred by the time significant current draw or temperature rise is detected. In some cases, that means simply replacing a bearing using one off the shelf, but other times it requires a specialized part that will take weeks to arrive.

There are also specialized tests that exist for analyzing a motor, such as the insulation resistance test and power quality tests. These tests should be implemented where possible, especially upon installation and startup of a project. They can be combined with vibration monitoring as well to provide a more complete picture. Other maintenance items including proper shaft alignment and proper motor

footing are key to ensuring a healthy motor that runs for years to come. While vibration analysis can pick up on these issues, it is best to head them off through proper machine design and installation where possible.



Insulation Resistance | Power Quality | Shaft Alignment

Who Performs Motor Vibration Analysis?

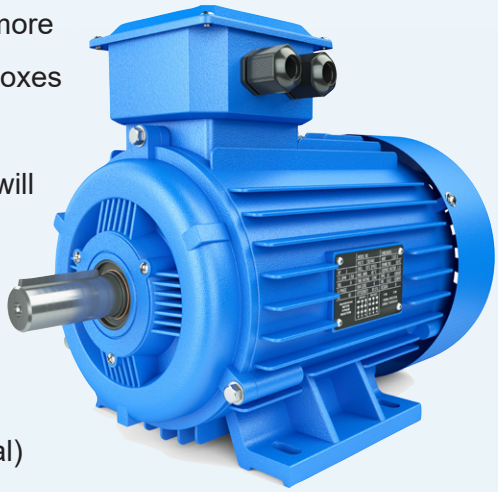
Vibration analysis is more complex than simply placing an accelerometer on a motor, getting an overall amplitude, and saying that a motor is going bad. Overall vibration meters exist that can be used by an operator to spot check equipment as needed and that can be used to cue a full vibration analysis. This overall test in itself does not provide the maintenance team with a path forward or knowledge beyond that the overall amplitude has increased. If significant overall amplitude increase is detected, it more than likely could have been identified in advanced using vibration analysis.

It takes a skilled technician with portable accelerometer and analyzer to perform the vibration analysis in most cases. This is oftentimes outsourced to a third party to bring in a certified vibration analyst to collect data, analyze using the equipment, take additional data as necessary, and provide a report with their findings. Some larger facilities do have trained staff on hand who perform all of the routes on the equipment. Having untrained personnel perform these tests may lead to deteriorating motor conditions that are missed or invalid data that makes for unusable history. Details as simple as placing the accelerometer in the exact same place every time can have a major impact on final results.

What is Actually Occurring During Motor Vibration Analysis?

Vibration analysis is used to not only indicate if there is a problem with a motor or bearing, but also to diagnose what the problem is. The process oftentimes includes “advanced algorithms” and “proprietary analytics” on the data that is brought in from the sensor to help determine what faults are occurring. While each manufacturer of portable vibration analyzers uses a slightly different approach to processing information, the outcomes are very similar. The process of gathering data and translating into insightful results is covered below.

The trained vibration technician places accelerometers on the machine of interest. This is often done at the outboard and inboard of the motor and connected systems (bearing, fan, pump, etc.). Certain systems are more complex due to gearboxes and other mechanical transmission, but we will discuss the common case in this paper. Data is captured in the axial and radial (horizontal and vertical)

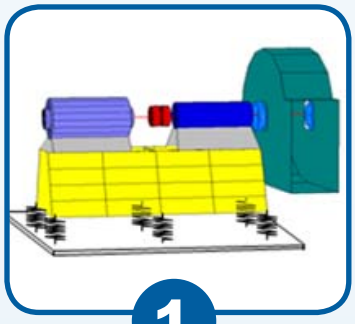


directions. These analog voltage outputs from the sensor are then digitized and processed using a Fast Fourier Transform (FFT). The FFT analysis can be summed up as taking the readings from the time dimension to the frequency dimension. Now that the data is organized in period or frequency, it is then categorized based upon the turning speed of the motor of interest and specific alarms can be put in place based on the frequency grouping. These frequency groupings are based upon the rotational speed of the motor and include:

- *Sub-synchronous* – below turning speed
- *Synchronous* – at turning speed
- *Harmonic* – an exact multiple of turning speed
- *Non-harmonic* – not an exact multiple of turning speed

The specifics of these categories are outside the scope of this paper, but knowing what category and if it is in the radial or axial direction, can assist in narrowing down potential problems. This information can be recorded and trended over time to provide a history of the motor, similar to a medical history. These values are compared against ISO standards to determine if the vibration velocity amplitudes are acceptable or in an alarmed state. If an anomaly is detected during a vibration analysis, a diagnostic test is performed to isolate to one or two most probable causes of impending failure. These diagnostic tests include:

- *Phase Analysis* – Compares sine wave phase relationship across couplings, axes, or mounting surfaces.



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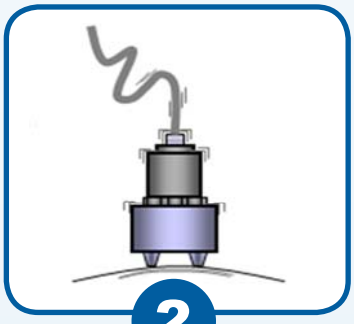
Machine of Interest



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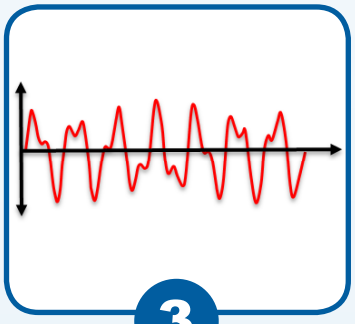
Calibrated Transducer 100mv/g



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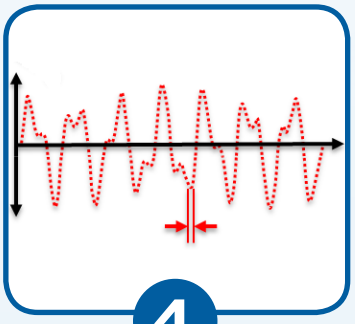
Analog Voltage Output from Transducer



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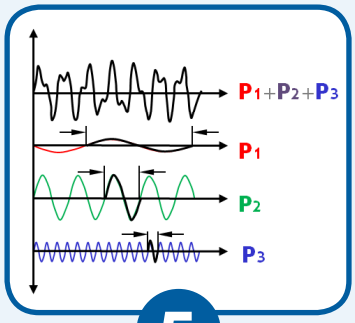
Analog Signal is Sampled and Digitized



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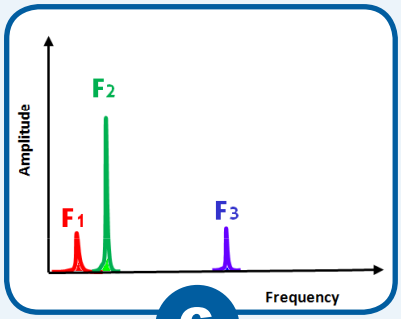
FFT Processor Finds the "Periods of Vibration" in the Overall Signal



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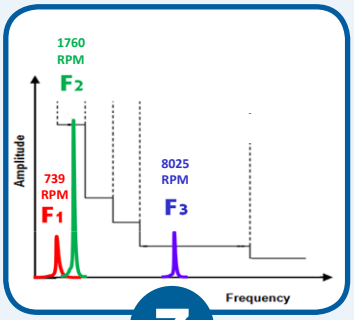
Frequencies Calculated from Periodic Components of Signal [F=(1/P)]



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Frequency Amplitudes Compared to Severity Requirements (Alarms)

- *Time Waveform* – Further investigation on raw time waveform that is performed typically on gear applications.
- *Ultrasonic* – High frequency vibration capture to detect high frequency impact events performed typically on roller element bearing issues.

Why Motor Vibration Monitoring?

Vibration monitoring is different than route-based vibration analysis in that an accelerometer is permanently installed on a piece of equipment. With the onset of IoT, being able to quickly deploy low-cost wireless solutions while maintaining a long battery life has been made possible. Some vibration monitoring options only trend overall vibration, similar to a vibration switch on a piece of machinery. They warn you that high vibration amplitude has been detected, but do not provide any defect classification or aid in the troubleshooting process.

An ideal vibration monitoring solution should incorporate the same concepts as a route based vibration analysis. This enables data capture and analysis hourly versus monthly with route based vibration analysis, providing over 700 times the number of readings than is normally recorded. Algorithms can be implemented to use collected data to build upon the ISO standards to refine thresholds based on the signature of the specific machine being monitored. This allows production and maintenance managers to be able to schedule a time to bring the line down for maintenance activities instead of being at the mercy of the equipment.

This solution empowers maintenance staff that might not be well versed in vibration analysis to be able to use the actionable information provided from a vibration monitoring system to make decisions. In cases where additional assistance is needed from trained vibration technicians or consultants, the wealth of gathered data will be able to aid the technicians in finding the root of the problem.

When making a large capital expenditure on machinery, customers should start to think about how they will monitor that equipment to ensure they meet the uptime numbers that are used to justify the expense. A more reliable plant is a more profitable plant.