LAYCO ELECTRIC INNOVATIONS

Your Premium Provider for Supply and Service of Electric Motors, Industrial Controls, and Power Distribution Solutions

Information Sheet # 09

Your Reliable Guide for Power Solutions

ANALYSIS and MEASUREMENT of Electric Motor Vibration

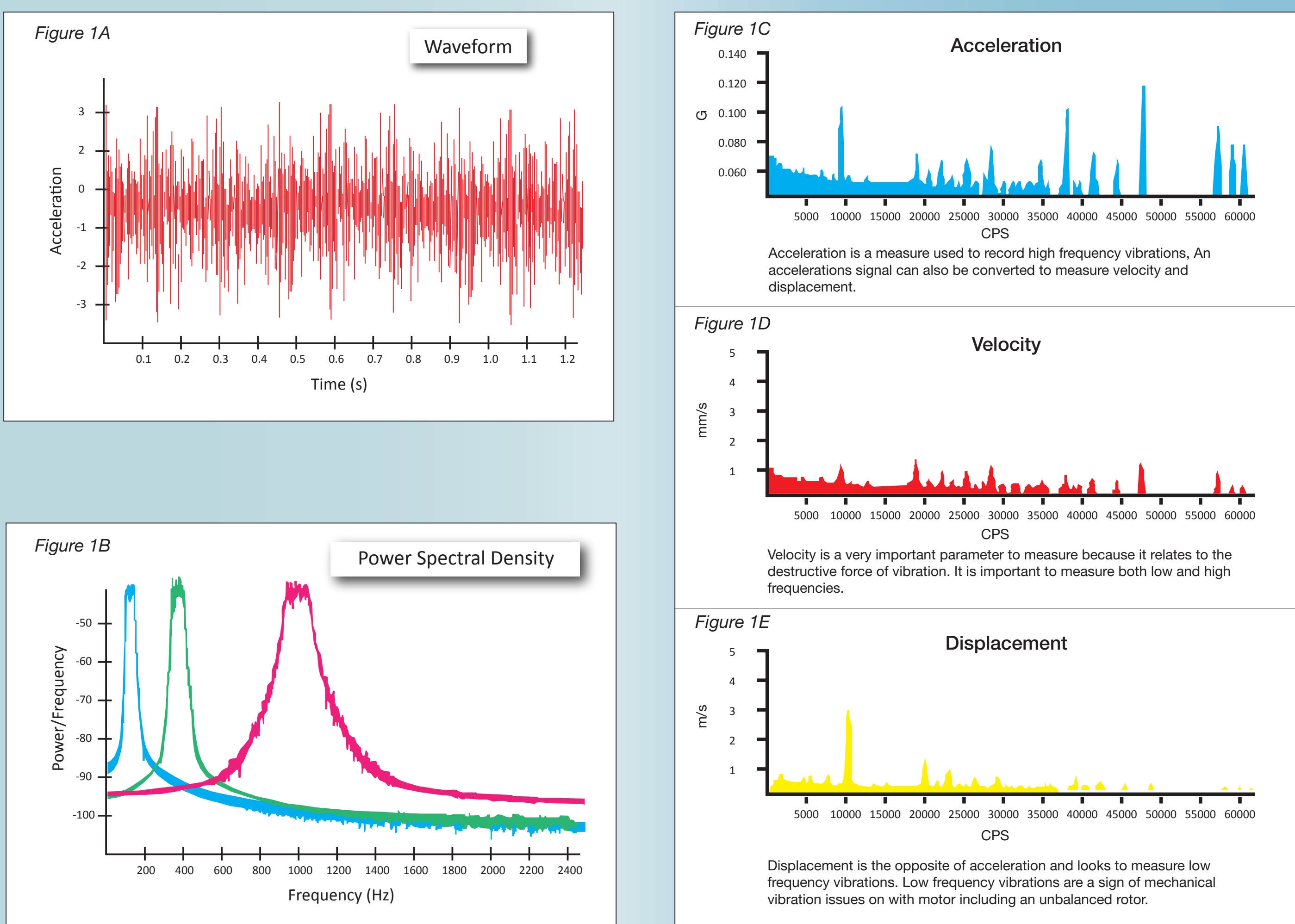
1.0 Introduction:

At some point in its life cycle an electro-mechanical device, such as an electric motor, will demonstrate vibration beyond a normal tolerance range. Vibration causes are numerous, including electromagnetic or mechanical imbalance, loose components, bearing issues, rubbing parts or resonance, refer to Information Sheet #08, Electric Motor Vibration Definitions and Sources within a Motor. Whatever the reason, it should be corrected quickly when detected and certainly during a routine maintenance cycle. Vibration problems can be irritating or a warning of impending failure. The strategy is to identify the vibration issues before equipment fails.

This information sheet discusses how to analyze and measure the various sources of vibration originating within an electric motor. In reading this sheet reference back to Information Sheet #08 that details the sources of vibration.

Figure 1

Frequencies Measured When Testing an Electric Motor



Acceleration is a measure used to record high frequency vibrations, An accelerations signal can also be converted to measure velocity and displacement.

Velocity is a very important parameter to measure because it relates to the destructive force of vibration. It is important to measure both low and high frequencies.

Displacement is the opposite of acceleration and looks to measure low frequency vibrations. Low frequency vibrations are a sign of mechanical vibration issues on with motor including an unbalanced rotor.

To fulfill our commitment to be the leading supplier, the Layco Electric Innovations team ensures they are always up-to-date with the current industry standards as well as industry trends. As a service, our **Information Sheets** are circulated on a regular basis to existing and potential power customers to maintain their awareness of changes and developments in standards, codes and technology within the power and motor control industry.

2.0 What is Vibration Analysis:

Vibration analysis is the process of measuring the vibration levels and frequencies of the electric motor and using the results to analyze how healthy the motor and its connected equipment is versus normal tolerance. The manner in which vibration is determines vibration can be complex, but it all starts with using an accelerometer to measure vibration. All motors vibrate to some degree, an accelerometer attached to the motor generates a voltage signal that corresponds to the amount of vibration and the frequency of vibration the machine is producing, usually how many times per second or minute the vibration occurs.

Data collected from the accelerometer is fed into software specific to vibration analysis. The software logs the signal is two ways:

- **Waveform** - Signal recording amplitude versus time, *figure 1A*.
- **Fast Fourier Transform** (FFT) - Amplitude versus frequency. Power spectral density (PSD) uses FFT to compare random vibration signals that have different signal strengths, *figure 1B*.

All of this data is analyzed by computer program algorithms. Engineers trained in vibration analyst determine the condition of the motor and highlight potential issues such as looseness, unbalance, misalignment, lubrication, etc.

3.0 Methods of Vibration Analysis:

Accelerometers are still the primary measuring tool for collecting vibration data. However, latest technology and enhancements in sensor technology now permit non-contact vibration detection. High speed laser sensors can detect vibration movements accelerometers could not enabling much more accurate and localized analysis.

Vibration analysis to predict the state of a motor usually covers specific data in four principal areas:

3.1 Time Domain:

When a vibration signal is picked up from a transducer (device that converts a physical quantity into an electrical signal) and displayed on the screen of an oscilloscope, it's called a waveform. This signal is in the time domain. The time domain is amplitude plotted against time. While most machine vibration issues are detected using spectrum analysis, some types are more easily seen in the waveform.

3.2 Frequency Domain:

When the waveform discussed earlier is subjected to spectrum analysis, the end result is a picture of frequency vs. amplitude, known as a spectrum. The spectrum is in the frequency domain like the vibration is in the time domain. Most in-depth analysis of machinery vibration is done in the frequency domain or using spectrum analysis.

3.3 Joint Domain:

As vibration signals vary with time, calculating more than one spectrum at once can be useful. To do this, a joint time technique called Gabor-Wigner-Wavelet can be utilized. This technique is used to calculate variations of the fast Fourier transform, including short-time Fourier transform (STFT).

3.4 Modal Analysis:

Modal analysis uses a computer model to input measured frequency responses in a motor. The computer model can be displayed with animations of all the different vibration modes. Adjustments can be made to the model by adding or subtracting various criteria such as mass and rigidity to analyze the effects on the motor.

4.0 Categories of Vibration Measurement:

The overall level of vibration can be detected by laying your hand on a running motor. The next step is Spectral Analysis using FFT, Common Applications for spectral analysis include the rotational speed of a shaft or how often tooth meshing occurs on a pair of gear wheels. Other measurements include:

4.1 Discrete Frequency Monitoring: In this process the vibration within a distinct part of the motor is measured.
4.2 Shock Pulse Monitoring: This is the use of hand held monitors using a natural frequency to detect rolling bearing vibrations.
4.3 Kurtosis Measurement: This measures the vibration spikes of random signals. Kurtosis can monitor fatigue in roller bearings.
4.4 Signal Averaging: Signals change with time and signal averaging in spectrum analysis demonstrates the level of signal at each frequency. Low frequencies measurements require a greater average time to obtain a statically accurate spectrum reading.
4.5 Cepstrum Analysis: Cepstrum analysis separates repeated patterns in the spectrum analyst that can get lost in the sidebands, It is used to look at the interactions of rotating components.

5.0 Vibration Analysis Measurement Parameters:

The methods used to measure and identify vibration are summarized in the three primary parameter groups:

- **Acceleration** - Important data for identifying high frequency vibrations, see *figure 1C*.
- **Displacement** - Used to measure low frequencies of rotating mechanical components including motor rotors, see *figure 1D*.
- **Velocity** - Velocity relates to the destructive component of vibration for both high and low frequencies, see *figure 1E*.

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