



PdM-202: Vibration Analysis... *Level II Plus*™

Abstract

A primary goal of modern condition-based maintenance programs is to maximize machinery reliability. The success of these efforts is often monitored by tracking mean-time-between-failures (MTBF), production uptime, product quality, maintenance costs, etc. Unfortunately, many programs fail to achieve the highest level of effectiveness because too much time is spent on the detection, rather than the analysis and prevention of problems. A key component of extending machinery life is effective analysis of the root cause of machinery failure, and using this knowledge to prevent recurrence of the failure.

Level II Plus™

This seminar aims to first qualify individuals to perform the vibration data collection and analysis tasks associated with ASNT vibration level II certification, and then certify them to ASNT level II. The result of this approach is that individuals who successfully complete the seminar will be qualified to perform level II vibration tasks, such as:

1. Set up a vibration instrument and acquire spectral, phase and time waveform data for analysis purposes for common machinery applications.
2. Analyze and make suggestions for resolving the common vibration problems.

This seminar focuses on use of practical vibration analysis and correction techniques. Its goal is to equip the analyst with the tools required to perform such analysis. Using our unique Activity Based Training™ format, analysts do not just learn the concepts of analysis, but receive detailed information on how to implement these concepts as a part of an effective machinery reliability program. The seminar addresses how to develop existing predictive technologies and interact with those in management, production and other departments. Analysts learn how much more value can be obtained by utilizing all resources available to obtain root cause solutions.

Whereas many training programs are available on general vibration analysis concepts, and others on specific instrument procedures, this seminar combines the two. It also addresses the subjects from the perspective of specific machine types and components which face the analyst on a daily basis. This seminar includes over thirty (30) guided hands-on activities, designed to maximize the retention of information. This unique approach better equips the analyst to apply the seminar content and to immediately solve problems upon returning to the plant.



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Seminar Duration

The standard duration of this seminar is 36 hours. Optional ASNT Level II certification is available subsequent to the seminar.

Who should attend?

This seminar is designed primarily for maintenance, engineering, technical support and management personnel whose job functions involve or relate to maximizing machinery reliability using current condition monitoring technologies. The scope of content is appropriate for those who collect vibration data, analyze machines, perform root cause failure analysis, or investigate and resolve premature machinery failure problems, as well as those who direct such activities. A prerequisite is to have successfully completed Level I training.

Associated Task(s)

1. Set up a vibration instrument and acquire spectral and phase data for analysis purposes for common machinery applications.
2. Analyze and make suggestions for resolving the following common vibration problems:
 - a. Unbalance
 - b. Misalignment
 - c. Resonance
 - d. Bearing defects
 - e. Looseness
 - f. Bent shafts
 - g. Gear defects
 - h. Electrical defects
 - i. Hydraulic/flow dynamics
 - j. Rubs
 - k. Belts and couplings
 - l. Eccentricity
 - m. Beats
 - n. Soft foot

Seminar Objectives

Upon completion of this training the student will be able to properly:

1. Explain the terminology, severity and data acquisition requirements for vibration analysis.
2. Explain how to select and correctly mount an appropriate vibration transducer for a particular application.
3. Recognize bad data and take appropriate steps to prevent it.
4. Verify the set up and operation of a vibration instrument and gather and record spectrum and phase data.
5. Explain, effectively analyze and correct /prevent the following vibration problems:
 - A. Resonance



- B. Unbalance
 - C. Misalignment
 - D. Looseness
6. Explain the operation of, common problems with, and the effective analysis of the following machines and components:
- A. Bearings
 - B. Motors
 - C. Gearboxes
 - D. Pumps
 - E. Fans
 - F. Belt Drives
7. Explain the phenomenon of beats and its effect on vibration data.
8. Explain and demonstrate how to perform analysis in low frequency applications.
9. Explain and demonstrate how to perform analysis in high frequency applications.
10. Explain and demonstrate when and how to perform Time waveform analysis.

Seminar Outline

1.0 Introduction

- 1.1 Reliability Overview
- 1.2 Review of Level 1 material

2.0 Data Acquisition Techniques

- 2.1 Safety and Health
- 2.2 Transducer Types and Limitations
- 2.3 Transducer sensitivities
- 2.4 Measurement Locations
- 2.5 Mounting methods
- 2.6 Special Transducers
- 2.7 Acquiring Phase Data

3.0 Signal processing

- 3.1 FFT Process Overview
- 3.2 FFT Settings
 - 3.2.1 Fmax
 - 3.2.2 Lines of Resolution
 - 3.2.3 Averaging
 - 3.2.4 Average Types
 - 3.2.5 Overlapping
 - 3.2.6 Windows
 - 3.2.7 Sample rates size
- 3.3 Filters
 - 3.3.1 High Pass
 - 3.3.2 Low Pass
 - 3.3.3 Band Pass
 - 3.3.4 Digital versus Analogue
- 3.4 Sampling Rate
 - 3.4.1 Fmax versus Lines of Resolution
- 3.5 Special Signal Processing Techniques
 - 3.5.1 Enveloping
 - 3.5.2 Demodulation
 - 3.5.3 Peak Vue
 - 3.5.4 Spike Energy

4.0 Codes, standards and specifications

5.0 Data Presentation

- 5.1 Scope and limitations of different testing methods
- 5.2 Waterfall/cascade plots
- 5.3 Linear versus Logarithmic
- 5.4 Trends
- 5.5 Changing units
- 5.6 True zoom and frequency expansion
- 5.7 Order CPM or hertz

6.0 The Analysis Processes



- 6.1 History
- 6.2 Machine Details
- 6.3 Audible Visual and Tactile Inspection
- 6.4 FFT
- 6.5 Phase
- 6.6 Time waveform
- 6.7 Orbit analysis
- 6.8 Bode/Nyquist
- 6.9 Trend analysis

- 7.0 Time Waveform Introduction
 - 7.1 Time waveform data acquisition
 - 7.1.1 Units of measurement
 - 7.1.2 $F = 1/p$
 - 7.1.3 Tmax calculation
 - 7.1.4 Sample size
 - 7.1.5 Digital vs. analog integration
 - 7.1.6 Averaging
 - 7.2 Waveform characteristics
 - 7.2.1 Sinusoidal
 - 7.2.2 Symmetry
 - 7.2.3 Amplitude Scale
 - 7.2.4 Repetitive vs. Non-repetitive
 - 7.2.5 Truncation
 - 7.2.6 Impacts
 - 7.3 Waveform Summation

- 8.0 Problem Identification
 - 8.1 Unbalance
 - 8.1.1 Amplitude
 - 8.1.2 Spectrum Symptoms
 - 8.1.3 Phase Symptoms
 - 8.1.4 Time waveform
 - 8.2 Misalignment
 - 8.2.1 Amplitude
 - 8.2.2 Spectrum Symptoms
 - 8.2.3 Phase Symptoms
 - 8.2.4 Time waveform
 - 8.3 Resonance
 - 8.3.1 Detection
 - 8.3.2 Analysis
 - 8.3.3 Confirmation
 - 8.3.4 Correction
 - 8.4 Bearing defects
 - 8.4.1 Amplitude
 - 8.4.2 Spectrum Symptoms
 - 8.4.3 Phase Symptoms
 - 8.4.4 Time waveform
 - 8.5 Looseness
 - 8.5.1 Amplitude
 - 8.5.2 Spectrum Symptoms



- 8.5.3 Phase Symptoms
- 8.5.4 Time waveform
- 8.6 Bent shafts
 - 8.6.1 Amplitude
 - 8.6.2 Spectrum Symptoms
 - 8.6.3 Phase Symptoms
 - 8.6.4 Time waveform
- 8.7 Gear defects
 - 8.7.1 Amplitude
 - 8.7.2 Spectrum Symptoms
 - 8.7.3 Phase Symptoms
 - 8.7.4 Time waveform
- 8.8 Electrical defects
 - 8.8.1 Amplitude
 - 8.8.2 Spectrum Symptoms
 - 8.8.3 Phase Symptoms
 - 8.8.4 Time waveform
 - 8.8.5 Current/Flux
- 8.9 Hydraulic/flow dynamics
 - 8.9.1 Amplitude
 - 8.9.2 Spectrum Symptoms
 - 8.9.3 Phase Symptoms
 - 8.9.4 Time waveform
- 8.10 Rubs
 - 8.10.1 Amplitude
 - 8.10.2 Spectrum Symptoms
 - 8.10.3 Phase Symptoms
 - 8.10.4 Time waveform
- 8.11 Belts and couplings
 - 8.11.1 Amplitude
 - 8.11.2 Spectrum Symptoms
 - 8.11.3 Phase Symptoms
 - 8.11.4 Time waveform
- 8.12 Eccentricity
 - 8.12.1 Amplitude
 - 8.12.2 Spectrum Symptoms
 - 8.12.3 Phase Symptoms
 - 8.12.4 Time waveform
- 8.13 Beats
 - 8.13.1 Amplitude
 - 8.13.2 Spectrum Symptoms
 - 8.13.3 Phase Symptoms
 - 8.13.4 Time waveform
- 8.14 Soft foot
 - 8.14.1 Amplitude
 - 8.14.2 Spectrum Symptoms
 - 8.14.3 Phase Symptoms
 - 8.14.4 Time waveform

9.0 Reporting Methodology

9.1 Technical reports



- 9.2 Management oriented reports
- 9.3 Oral reports
- 10.0 Qualification and Certification Activities
 - 10.1 Written Test
 - 10.2 Practical Hands-on Examination

