

## Bearing Fault Diagnosis

### Quick facts

Rolling element bearings keep our machines turning - or at least that is what we expect them to do - the sad reality however is that only 10% of rolling element bearings reach their design lifetime! If this is true then what does it mean for us in terms of maintenance costs, planned and unplanned downtime, the cost of replacing bearings and the possibility of catastrophic failures and accidents? What does this statistic imply in terms of the overall reliability of our plant?

There are two important aspects of bearings that we must be aware of: bearing wear and bearing care. How do we extend the life of our bearings and how do we know when they are failing? Our hope is that by the end of the course you will see the 10% lifetime statistic as an opportunity for improvement and you will go home intent on keeping those bearings turning!

### Course duration

**Duration: 2 days**

### Description:

This course is ideal for any person involved in condition monitoring, vibration analysis or reliability. The course begins by describing the importance of rolling element bearings in keeping industry moving after which it covers the root causes of bearing failure from specification and purchase to shipping and storage, installation, lubrication, contamination and vibration among other things. Vibration as a root cause of bearing wear is described along with a review of the vibration characteristics of common faults such as unbalance, misalignment, looseness and resonance. The bearing wear part of the course will cover the relationship between bearing geometry and bearing fault frequencies. It will contain an in depth study of the characteristic vibration patterns related to bearing wear from the early detection of lubrication problems to the last stages of mechanical wear. Vibration patterns will be explained in detail from the time waveform and spectrum to the high frequency tests such as PeakVue, SPM, gSE and demodulation etc.

### Who should attend?

People attending this course should have a basic understanding of vibration analysis and vibration analysis terminology. If you are familiar with the terms "amplitude, frequency, 1x, waveform, spectrum, harmonics and amplitude modulation" then you should not have a problem with the course. The course is appropriate for those who have been certified at the Cat I or Cat II level or who have taken a vibration awareness course - but there are no prerequisites and all are welcome.

### What is unique about this course?

The Mobius Institute employs 3D animations and simulators to help you visualize the concepts. In this course you will be able to clearly see the inside of a virtual rolling element bearings which will enable you to understand exactly what causes the vibration in the bearing as it begins to wear out and fail. You will see the very source of the bearing defect frequencies and will be able to clearly understand the difference between high frequency and low frequency vibration tests. You will listen to a bearing that requires lubrication versus one that does not via recordings of ultrasound readings. If a picture is worth a thousand words then a 3D animation is worth at least 10,000 words in terms of its ability to help you understand what happens inside a rolling element bearing. Our 3D animations and simulators will also provide insight into the relationship between unbalance, misalignment, looseness and bearing wear. We are sure that you will leave this course with a clear and in depth understand of rolling element bearings!

### Topics:

#### Overview of rolling element bearings and reliability

- Bearing care and bearing wear
- Bearings and reliability
- Overview of root causes of bearing failure
- Maintenance practices
  - Breakdown
  - Preventive
  - Condition based
  - Proactive

- ❑ Reliability spectrum
  - Managing bearings from pre-purchase to replacement

### What causes bearings to fail?

- ❑ Specification
- ❑ Shipping
- ❑ Storage
- ❑ Installation
- ❑ Lubrication
- ❑ Contamination
- ❑ Fatigue wear
  - Vibration
  - Unbalance
  - Misalignment
  - Looseness
  - Resonance

### Addressing the root causes of bearing wear

- ❑ Reliability spectrum
  - Acceptance testing
  - Root cause failure analysis
- ❑ Lubrication (Intro)
  - Ultrasound testing
  - Ultrasound greasing
  - Contamination
  - Training
  - 5 things you can do to improve your lubrication program
- ❑ Installation
  - Tools and training
  - Cocked bearing
- ❑ Storage / standby machines
  - False brinelling
- ❑ Fatigue wear
  - Balancing
  - Alignment
  - Soft foot / pipe strain
  - Resonance testing

### Acceptance testing

- ❑ Resolving problems before they become problems
- ❑ Contractual issues
- ❑ After repair QA
- ❑ Infant mortality
- ❑ Acceptance testing and reliability
- ❑ Closing the loop - root cause failure analysis and acceptance testing
- ❑ Things to test for and resolve (detailed)
  - Soft foot / pipe strain
  - Foundation issues

- Alignment
- Balance
- Resonance
- Cocked bearings

## Lubrication

- Types of bearings
- Over and under lubricating
- Ultrasound and lubrication (detailed)
- Training

## Part 2 - Condition Monitoring - Diagnosing bearing wear

### Condition based maintenance (brief) overview

- What are the goals of CBM
- The difference between CBM and Reliability
- RCM
  - How frequently to monitor
  - Protection systems
  - Surveillance systems
- Walk around systems

### Vibration analysis and rolling element bearings

#### Vibration analysis overview

- Collecting vibration data
  - Accelerometer
  - Mounting
  - General procedure / routes etc
- Time waveform
  - Frequency and period
- Spectrum
  - Frequency Hz / CPM / Orders
  - Order normalization
  - Synchronous / non synchronous
- Units
  - Displacement / velocity / acceleration
- Rules of vibration
  - Sine wave
  - Periodic / non sinusoidal wave
  - Impacts
  - Random noise
  - Amplitude modulation
- Data presentation
  - Normalization
  - Log / Linear / dB
  - Scaling
  - Baselines

### Bearing geometry

- Where do bearing tones come from?

- Calculated bearing defect frequencies
- Looking up bearings
- Understanding bearing defect frequencies (simulator)
  - Bearing tone simulator
  - Modulation
  - Harmonics
  - Inner race defect
  - Outer race defect
  - Ball spin
  - Cage rate

### **Vibration analysis procedure (spectrum analysis)**

- Identify 1x
- Verify data integrity
- Normalize data
- Identify shaft rate harmonics
- Identify known forcing frequencies
- Look for non synchronous tones
  - Harmonics
  - Sidebands
  - Noise
- Multi shaft machines
  - Step by step procedure
  - Which bearing is it?
  - Belt frequencies
- Practice examples

### **Progression of bearing wear (spectrum analysis)**

- Non synchronous tones
- Harmonics
- Sidebands
- Looseness
- Noise floor
- TWF analysis / relation between rules of vibration and spectral patterns

### **Understanding high frequency tests**

- Shock waves
  - How energy moves through matter
- The sound of the bell when it is rung
  - Repetition rate of ringing
- What rings?

### **Demodulation**

- General procedure
- Filtering
- Relating demodulated spectrum to regular spectrum
- Examples

### **Measuring high frequencies**

- Sensor mounting
- Sampling rate
- Disco effect

## Commercial high frequency tests explained

- Ultrasound
- PeakVue
- SEE
  
- SPM
- HFD
- etc

## Overview of high frequency tests

- When to use / when not to use
- Applications
- Suggestions
  - Confirmation
  - Early warning
  - Location
  - Low speed bearings

## Putting it all together

- Four stages of bearing wear

## Review of goals

- When to order repair
- How to measure success of program
  - Planned vs. unplanned work
  - Scheduling and production