Predictive Maintenance (PDM)
Questions & Answers

What is Predictive Maintenance (PDM)?
• Maintenance actions based on machine Condition Data
• Vibration, Ultrasonic, and other relative monitoring during normal operations
• Repairs when required with advanced notice prior to unscheduled downtime

How can PDM save money?
• Reduce repair costs – Early warning
• Reduce quantity of unnecessary inspections
• Eliminate catastrophic failure costs
• Reduce unscheduled downtime – Increase machinery Reliability

Why use Vibration for PDM?
• Adaptable to a variety of machines
• Indicates Overall machine condition
• Indicates problem severity
• Analysis indicates specific faults

What is Vibration?
• Motion of machine components
• Caused by dynamic forces

What types of Vibration are there?
• Periodic - (i.e., Machinery Shaft Speed)
• Random - (i.e., Varying)
• Transient - (i.e., Pump cavitation due to improper system line-up)

How is Vibration described?
• Amplitude - (i.e., Normally Velocity)
• Time (sec. or msec.)
• Frequency (Hertz or CPM)
• Phase (degrees)

How are Vibrations measured?
• Transducer - Converts Vibration - Motion into electrical signal for processing
• Vibration Meter - Detects only amplitude (i.e., No frequency components)
• Vibration Analyzer - Performs conversion of Amplitude vs. Time to Amplitude vs. Freq. (Spectrum Analysis)

What units are used to describe Vibration?
• Displacement = Mils [Peak-to-Peak] (1 mil = 0.001")
• Velocity = In/Sec. [Peak]
• Acceleration = g's [Peak] (1 g = 32.2 ft/sec-sec)

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Where are machinery Vibrations measured?
- Bearing Housings
- Machine Casing
- Support Structure

Examples
Typical Horizontal Machine

Typical Vertical Machine

How are Vibrations analyzed?
- Spectrum Analysis (Amplitude vs. Freq.)
- Parameter Trends (i.e. 1 x SS, 2 x SS, HFD – High Freq. Bearing Wear Detector)
- Waveform & Phase Analysis

How can faults be detected early?
- Full Signature (Spectrum) Analysis
- Frequency Analysis Parameter Sets (i.e., 1 x SS, 2 x SS, HFD) Used for detailed trending
- Overall Vibration Levels (i.e., Meters) used for initial trending. No specific machinery faults can be identified with this method.

What types of faults can be detected?
- Mis-alignment
- Looseness
- Bearing Defects / Wear
- Unbalance
- Internal Component Rubbing
- Structural Resonant Conditions

Why is Ultrasonic (UT) analysis now added to the PDM Process?
- Enhances roller element bearing and coupling fault detection
- Determines if correct amount of Lubricant is present in roller element bearings prior to creating faults
- Used to detect outer race spinning condition in roller element bearing housings

What are acceptable Vibration Levels?
- ISO & Rathbone Charts
- Machinery Comparison - History
- Manufacturer's Guidelines
- Trending - Relative Levels
**Predictive Maintenance (PDM) Questions & Answers**

**How long has UT been used for bearing condition analysis?**
- Evaluation period ten (10) years
- Simultaneous with Vibration Analysis
- IMPACT Programs’ acquire Over 80,000 UT Measurements / Year.

**What are the frequency ranges of normal sound vs. ultrasound?**
- Audible: 20 Hz – 10 kHertz
- Ultrasonic: 20 kHertz – 200 kHertz
- Acoustic Emission: 200 kHz – 2 MHzertz

**Why has Ultrasound now an integral part of Condition Monitoring?**
- Simple and quick measurement
- Indicates high friction condition – so bearings can be greased and saved!
- Provides early warning of developing faults so that planned repairs can eliminate catastrophic failures

**What are the details of UT test equipment?**
- Ultrasound frequencies are shifted into audible range with detailed audible characteristics
- 39 kHerz (fault detection proven by NASA and others)
- 4 kHertz Bandwidth (Narrow Band)
- Fixed frequency and filter (no tuning)
- Short wavelength (source location)
- No special sensor mounting (hand held)
- Precision Measurement (Digital Meter)

**Where do you measure Ultrasound?**

**With contact probe:**
- One measurement per bearing or on rigid structure to bearing
- Radial and/or Axial (load) direction
- Consistent locations
- Radial and/or Axial (load) direction

**With non-contact microphone:**
- Listen to coupling with extension tube

**How is bearing ultrasound severity determined?**
- **Good bearings** and Couplings produce smooth / mono-tone sounds **without distinct** characteristics
- **Under lubricated bearings** produce clicking sounds that indicate excessive friction associated with a dry condition
- **Bad / defective bearings** produce distinctive popping / excessive clicking sounds that typically do not reduce / disappear with greasing
- **Dry/worn/damaged Couplings** produce excessive popping / clicking
- In general, increases in dynamic loading or speed **increase** digital amplitude values measured

**What is the typical condition of bearings analyzed with UT?**
- Bearing OK
- High friction / Lack of lubricant – Grease!
- Developing fault – Greasing reduces UT and popping sounds but return after time
- Significant / severe fault present – Greasing does not reduce UT levels nor does severe popping reduce
**Predictive Maintenance (PDM) Questions & Answers**

**What are the advantages of the Ultrasound Technology?**
- Low cost with high benefits
- Less time to get results
- Requires less skill and training than vibration equipment
- Locates specific bearing with fault
- Non-contact measurement for coupling analysis in now available
- Early warning to save bearing or couplings with lubrication, coupling maintenance, or shaft alignment

**How is Machinery Problem Severity determined?**
- By Machine type
- Fault type
- Fault severity
- Spare machine availability
- Critical machine for operation
- Past experience with the type of fault
- Maintenance required and time to make repairs

**What Special Tests can be conducted?**
- Variable Speed / Load
- Impact Testing
- Relative Motion Analysis
- Driver un-coupled
- Shaft alignment check
- Balance sensitivity

**What is the problem feedback info. is useful?**
- Operational actions taken
- Details of faults found
- Possible cause of the fault
- Details of repair work done
- Actual repair costs
- Estimated costs if problem was undetected and had failed catastrophically

**Machinery problems are caused by?**
- Normal wear
- Poor installation - design
- Operational problems
- Improper maintenance procedures

**How Is Problem Severity Rated?**
- Severe
- Significant
- Developing
- None, continue to monitor

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