DETECTING AND PREDICTING MW WIND TURBINE DRIVE TRAIN FAILURES

David Clark
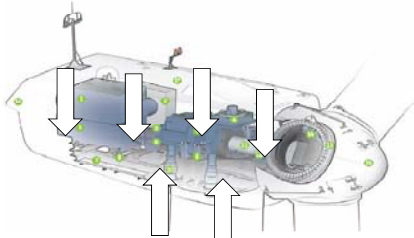Director, Turningpoint/Commtest

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Causes of vibration

- MISALIGNMENT
- IMBALANCE
- MECHANICAL LOOSENESS
- RESONANCE
- BEARINGS

90% of machine vibration is attributed to these 5 issues

THE ABOVE PROBLEMS MANIFEST THEMSELVES IN THE CONDITION OF THE ASSET

TYPICAL SENSOR LOCATIONS

Basically monitor what fails or what is expensive when it fails

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3 COMMON EXAMPLES OF MW WTG ISSUES

1. MISALIGNMENT
2. BEARINGS
3. PLANETARY GEARBOX

EXAMPLE # 1

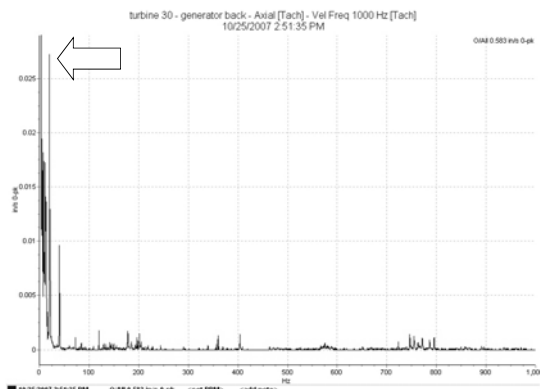- **Misalignment of a Megawatt class wind turbine**

- Gearbox to generator
- Shows as a high peak at the running speed
- First vibration signature shows .5 amplitude in a velocity measurement (before)
- Second shows .025 amplitude after alignment (after)

BEFORE .5

High amplitude at running speed

AFTER .025

turbine 30 - generator back - Axial [Tach] - Vel Freq 1000 Hz [Tach]
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EXAMPLE # 2

- **BEARING FAULT IN A MEGAWATT CLASS WIND TURBINE**
- COMMON BEARING ABREVIATIONS

- **BPFO** (outer race defect)
- **BPFI** (inner race defect)
- **FTF** (cage defect)
- **BSF** (rolling element defect)

- There are 2 ISO standards for alarms and 1 widely accepted 30 year study also used for alarming

Vibration Level

BPFO

Time

BPFO = Ball Pass Frequency Outer
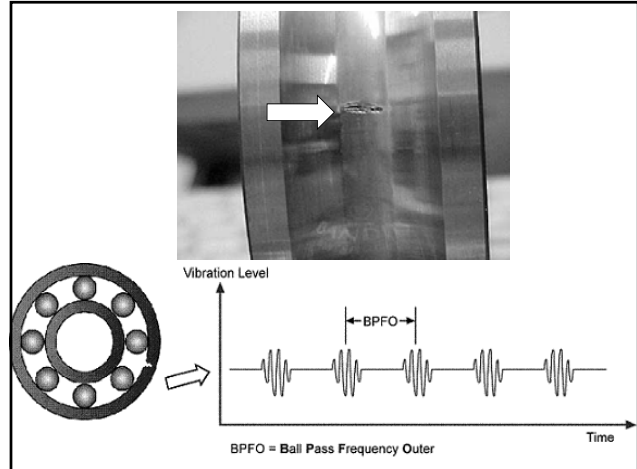
AMPLITUDE = SEVERITY
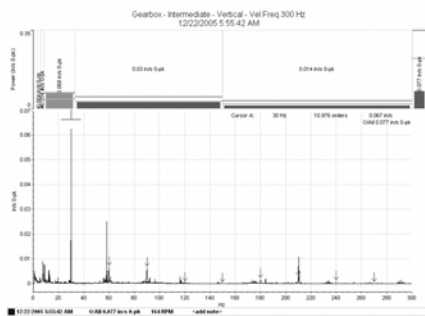
PROGRESSION OF THE FAILURE

- TYPES OF VIBRATION MEASUREMENTS INDICATE THE FAILURE PROGRESSION OF THE COMPONENT. *"VELOCITY"* AND *"DEMODULATED"* MEASUREMENTS GIVE AN APPROXIMATE TIMELINE

How do I interpret the results? Look for peaks at known bearing fault frequencies in both the normal vibration velocity spectra and the demodulated spectra.

**No peaks in either spectrum**: Condition is good, use as a baseline for future comparisons.

Peaks appear in Demod only: Early warning indication that defects exist (or the bearing needs lubrication).

Peaks appear in Velocity and Demod spectra: Plan replacement at next maintenance period.

Peaks appear in Velocity spectra only, combined with a rise in the Demod noise floor: Replace the bearing now!
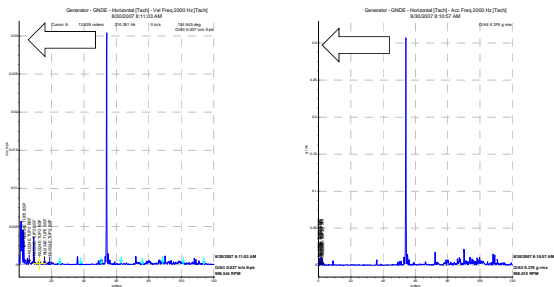
WIND TURBINES ARE VERY EASY TO COMPARE TO EACH OTHER TO DETERMINE A FAULT
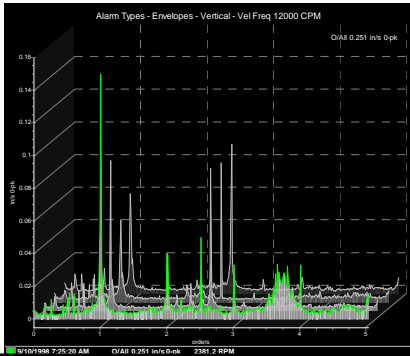
VIBRATION ANALYSIS INTERPRETATION IS REDUCED TO *TRAFFIC SIGNALS* WITH ALL MAJOR CONDITION MONITORING SUPPLIERS
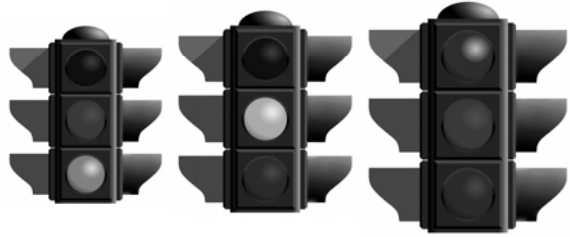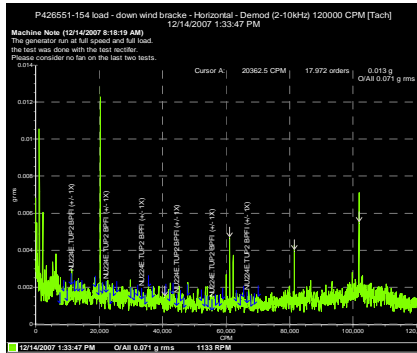

GOOD(.03) vs. BAD(.3)
Generator Bearing

■There are 2 ISO standards for alarms and 1 widely accepted 30 year study also used for alarming

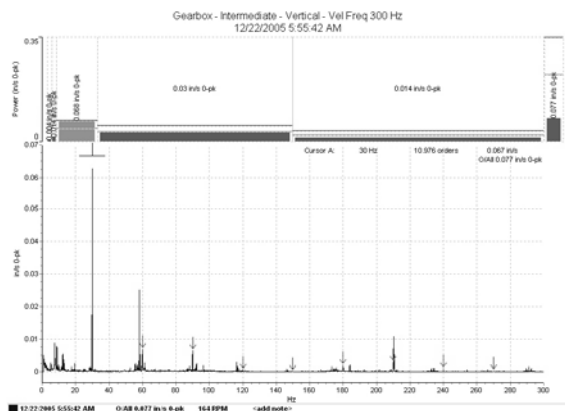## MEGAWATT GENERATOR BEARING
looks like this:

VIBRATION SIGNATURE IS LABELED WITH BPFI
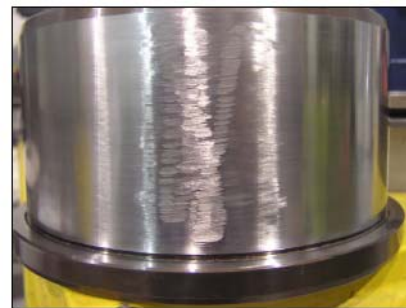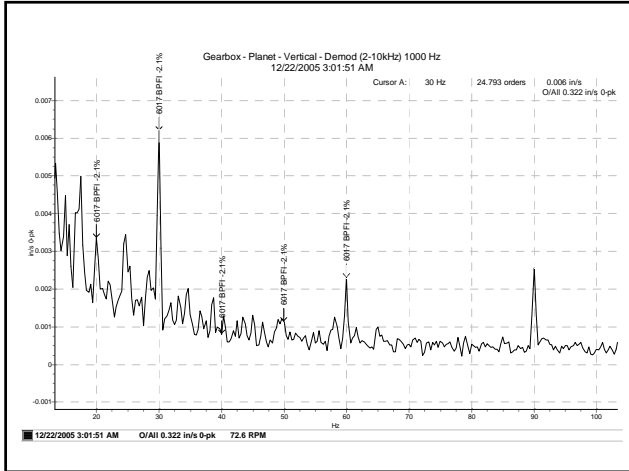### (INNER RACE DEFECT)

MEGAWATT CLASS GENERATOR BEARING
looks like this:

GEARBOX PLANET BEARING
looks like this:

Gearbox - Planet - Vertical - Demod (2-10kHz) 1000 Hz
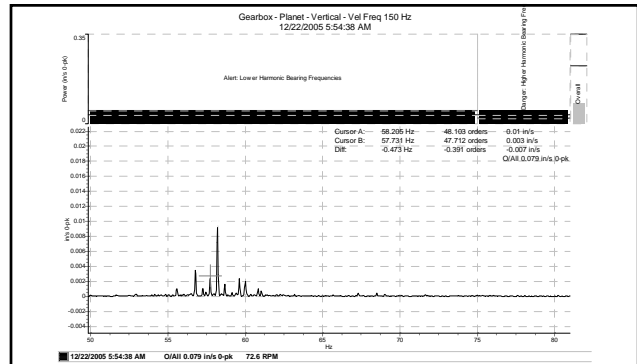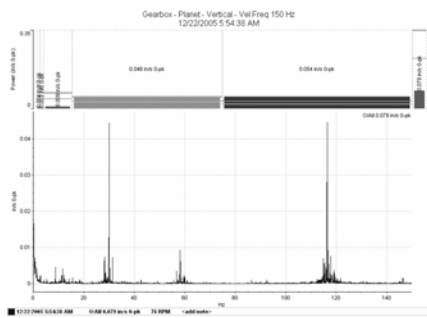12/22/2005 3:01:51 AM

EXAMPLE # 3

- **MW WIND TURBINE GEARBOX GEAR ISSUE**
  - There are 2 ISO standards for alarms and 1 widely accepted 30 year study also used for alarming

- GEAR MESH FAULT FREQUENCY = GEAR TOOTH COUNT x GEAR TOOTH COUNT x RPM

PLANETARY GEARBOX SIGNATURES

Gearbox - Planet - Vertical - Vel Freq 150 Hz
12/22/2005 5:54:38 AM

Alert: Lower Harmonic Bearing Frequencies

- Data captured on stage 2 mesh on the planet at 2:54 p.m.
- **Again, the problem appears to be with very early stages of gear wear on the carrier. No other faults were noted.**
- *As levels of vibration in all these tests seem quite low, and there is no substantial alarming; it is safe to conclude that we are seeing only early stages of wear in the gearboxes that require no immediate action, but warrant more frequent monitoring.*

WIND TURBINE MODELS USED IN THE EXAMPLES
(in no particular order)

- VESTAS V-80
- GE 1.5
- Clipper 2.5

PREDICTING USING VIBRATION

- Know before wind season starts
- Know before the warranty expires
- Know what needs to be fixed
- Know when it needs to be fixed
- Know what parts need to be ordered
- Know if it's an up tower repair or crane call
- Know if it was rebuilt or installed properly