

DETECTING AND PREDICTING MW WIND TURBINE DRIVE TRAIN FAILURES

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Adopted for
Wind Power Management class
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Causes of vibration

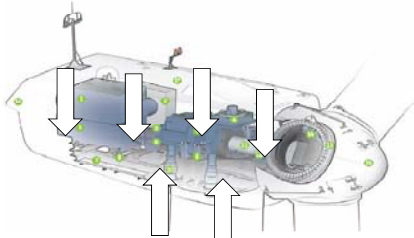
- MISALIGNMENT
- IMBALANCE
- MECHANICAL LOOSENESS
- RESONANCE
- BEARINGS

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



Allianz Zentrum für Technik GmbH Condition Monitoring Systems		Allianz Zentrum für Technik GmbH Requirements for Condition Monitoring Systems for wind turbines		Allianz	
Item	Object	Requirement	Ref.1	Ref.2	
1.	Main monitoring requirements	Four shaft, main bearing, gear, generator, nacelle and tower vibration - rotor, main bearing, tower equipment, gearbox, gear bearings, yaw drive		1	
2.	Signal and sensor technology	1.2. Excitation sensor, frequency range 0.1 Hz – 10 kHz, rotor bearing (1st gear 1st) generator (2nd gear) 2. Acceleration sensor, frequency range 0.1 Hz – 100 Hz, nacelle (nacelle and yaw) - 2.1. High resolution, accuracy 0.1 mm/s², 2.2. High resolution, accuracy 0.1 mm/s² - rotor and generator shaft, analysis of vibration spectra - Sensor mounting on each shaft bearing (at least 2 sensors are needed for each bearing)		1.1.1	
3.	Transfer of characteristics of operating condition	- Load monitoring (power or torque) - RPM (rotational speed) - Torque		1.1.2	
4.	Other operating parameters	Temperature (bearing, oil, nacelle, windings, steel structure), air temperature, wind speed		1.1.3	
5.	Signal acquisition	8 x 16-bit resolution (12 bit), sampling rate per channel = 22 kHz, and 8000 samples, synchronous acquisition		1.1.4	
6.	Signal processing and analysis	1. Frequency analysis (FFT, wavelet transform, etc.) 2. Time domain analysis (RMS, peak, etc.) 3. Statistical analysis (trend, etc.)		1.1.5	
7.	Alarm and reporting	1. Thresholds for alarm and reporting 2. Alarm and reporting via SCADA system 3. Alarm and reporting via email		1.1.6	
8.	Summary of requirements according to Report 03.01.069 dated 27.03.2003				
Comments:		3 Page(s) Bismarck Appendix(1)			
Author:		Thomas Sülzmann, Georg Pflüger			
Date:		12.01.2003			
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3 COMMON EXAMPLES OF MW WTG ISSUES

- 1. MISALIGNMENT
- 2. BEARINGS
- 3. PLANETARY GEARBOX

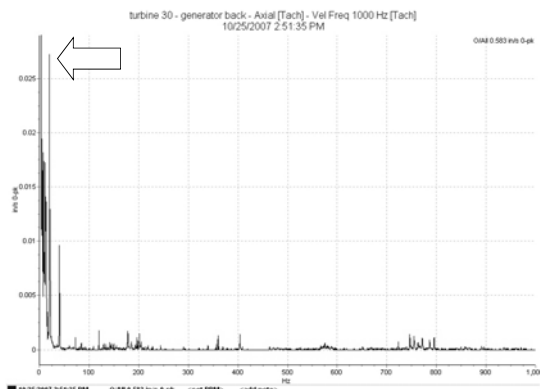
EXAMPLE # 1

- 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

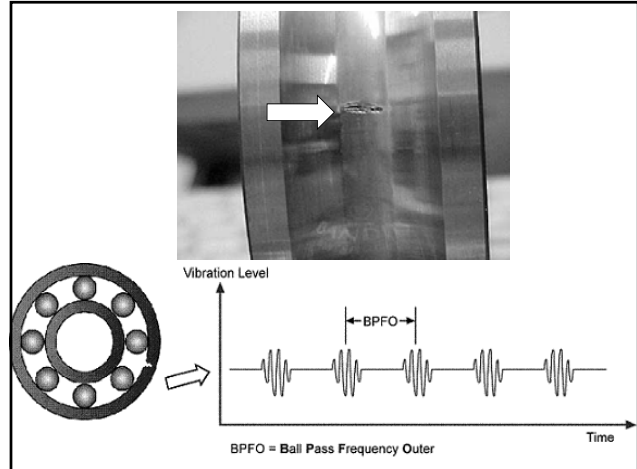
High amplitude at running speed
←

AFTER .025

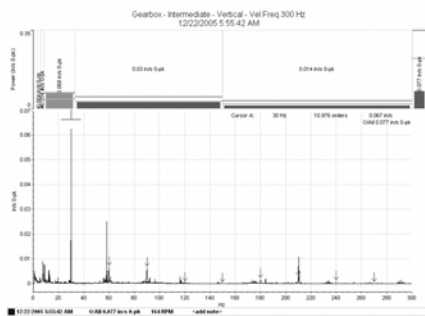


EXAMPLE # 2

- BEARING FAULT IN A MEGAWATT CLASS WIND TURBINE
- COMMON BEARING ABBREVIATIONS
 - 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



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.

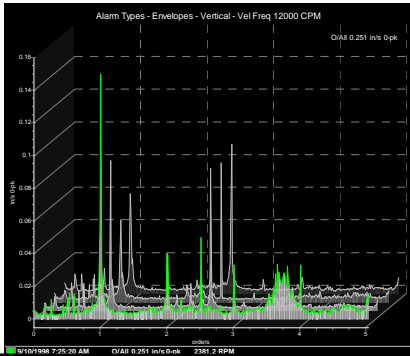
No peaks in either spectrum: Condition is good, use as a baseline for future comparisons.

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

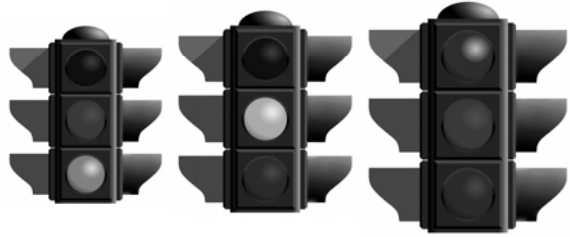
Peaks appear in Velocity and Demod spectra: Plan replacement at next maintenance period.

Peaks appear in Velocity spectra only, combined with a rise in the Demod noise floor: Replace the bearing now!

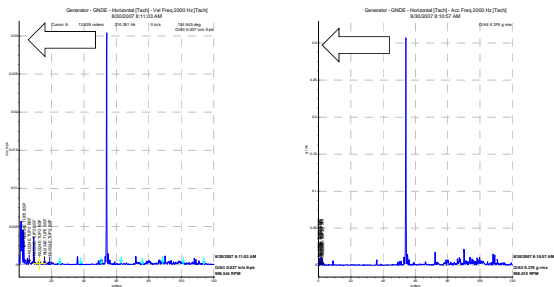
WIND TURBINES ARE VERY EASY TO COMPARE TO EACH OTHER TO DETERMINE A FAULT



VIBRATION ANALYSIS INTERPRETATION IS REDUCED TO *TRAFFIC SIGNALS* WITH ALL MAJOR CONDITION MONITORING SUPPLIERS



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



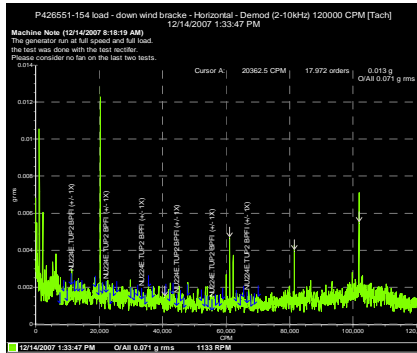
■ There are 2 ISO standards for alarms and 1 widely accepted 30 year study also used for alarming

MEGAWATT GENERATOR BEARING

looks like this:

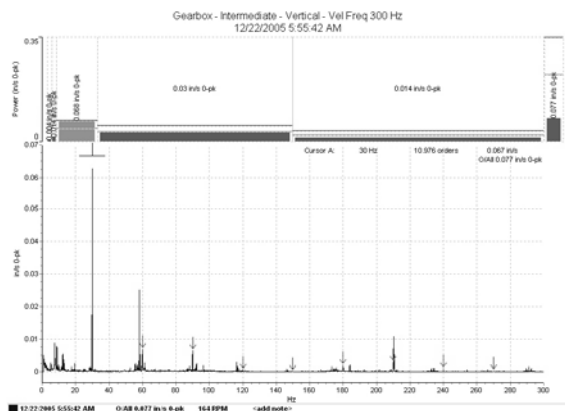


**VIBRATION SIGNATURE IS LABELED WITH
BPFI
(INNER RACE DEFECT)**



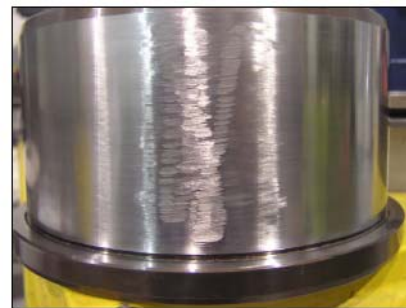
**MEGAWATT CLASS GENERATOR
BEARING**

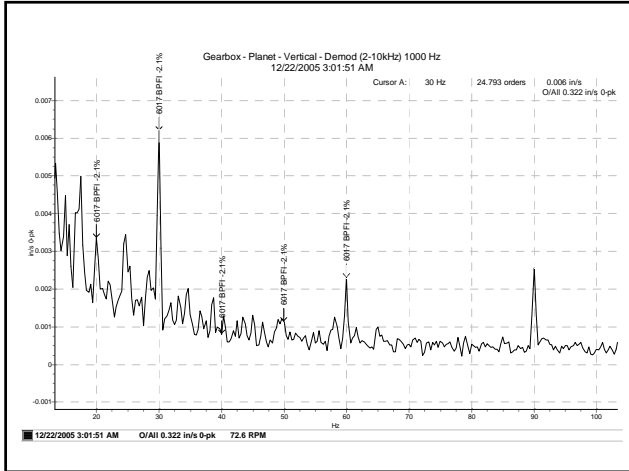
looks like this:



GEARBOX PLANET BEARING

looks like this:





EXAMPLE # 3

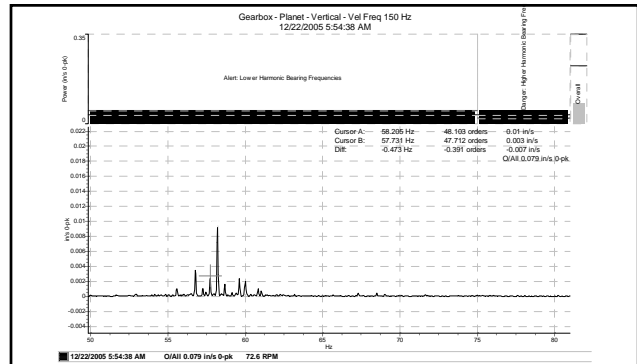
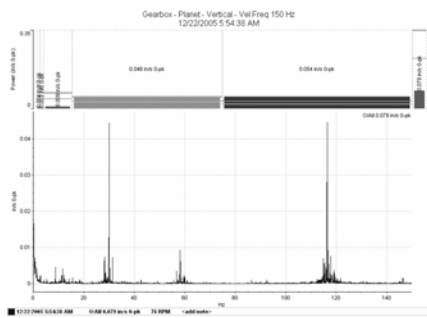
MW WIND TURBINE GEARBOX GEAR ISSUE

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



- 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