Stage 4: (1% - 1 revolution of remaining life) As the defect worsens, multiple cracks, flaking holes or spalls appear. The rolling element may deform and the cage may disintegrate. In this stage most, if not all, of the bearing failure indications disappear: BDF spectral peaks, sidebands & harmonics.

However, the running speed (1X) forces will increase as the shaft has more freedom to move around inside the bearing. Additionally, the noise floor of the entire spectrum may increase since generated frequencies will no longer occur at exactly the same time interval.

When the previous frequencies disappear and the noise floor of the spectrum or the signal at 1X running speed increases it is recommended to remove the machine from service ***immediately***, as the bearing is subject to complete failure at any time.

The role of Electrical Signature Analysis in Detecting Rolling Element Bearing Failures

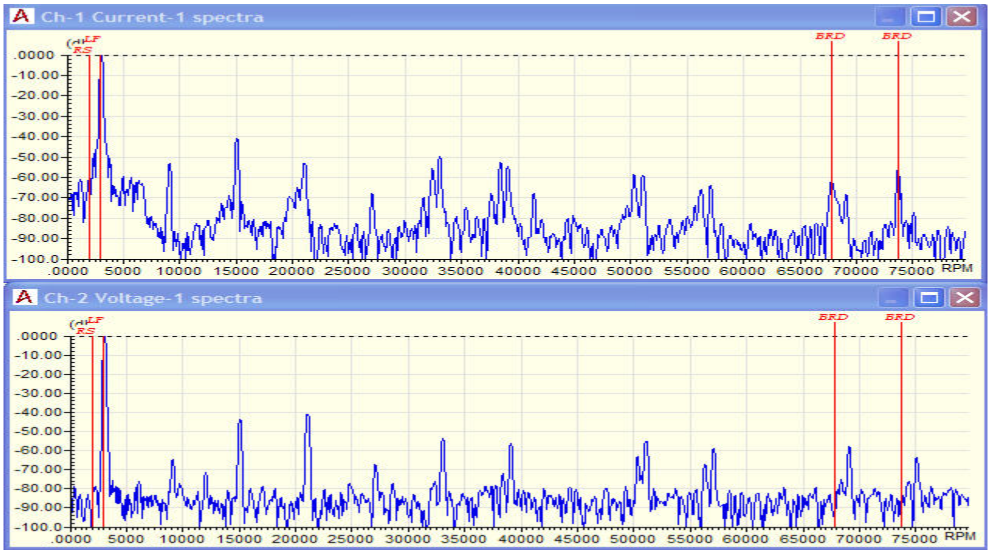
Most Rolling Element Bearing Faults can be picked up in stage 2 using Electrical Signature analysis.

ESA uses magnetic flux changes in the air gap of the motor as its transducer. In many cases ESA has identified rolling element bearing faults as early as stage 2. These faults have been confirmed using Acceleration Enveloping. The frequencies in the ESA spectrum were the same as they were using Acceleration Enveloping.

ESA identifies machine faults by locating spectral peaks spaced at line frequencies (normally 50 or 60 Hz) around a center frequency. Line frequency side bands that are present in the Current Spectrum but are not present in the voltage Spectrum indicate that the fault is coming from the machine or the process.

The bearing defect frequencies spectral peaks that appear in the ESA spectrum will be the same frequencies as in the vibration spectrum. Additionally, the BDF signals will appear in the electrical spectrum at about the same time as they will in a vibration spectrum. In both cases this indicates that the bearing has achieved a stage 3 fault.

In this ESA current spectrum a stage 3 defect appears at the BPFI of 35374 with 3000 CPM (50 Hz) sidebands. It also appears at 2 X its BPFI as line frequency (50 Hz) side bands around the system 70748 CPM ≈1179.13 Hz.



The 50 Hz sidebands also had sub synchronous sidebands which indicate a late stage 3 fault.

Also note the broad bases of the spectral peaks that indicate that the measured frequency isn't exactly the same for each sample, which is also an indication of a late stage 3 fault. This fault was verified using a Vibration Velocity measurement. The frequencies were the same in the Vibration spectrum as they were in the Electrical Current Spectrum.

Note the spectral peaks in the current spectrum on the top spectrum; those peaks are not present in the voltage spectrum below. This indicates the fault is coming from either the motor or the load.

As the defect progresses, it will appear as line frequency side bands around the BPFO or BPFI.

Conclusion

Identifying Rolling element bearing faults is a very key process in the successful operation of any plant containing rotating equipment. Electrical Signature Analysis provides plants with additional tools to quickly identify not only internal motor faults, but in addition can provide early detection of rolling element bearing failures.

Electrical Signature Analysis (Overview)

Electrical Signature Analysis (ESA) is an on-line test method where voltage and current waveforms are captured while the motor system is running and then, via a Fast Fourier Transform (FFT), a spectral analysis is done by the provided software. From this FFT, faults related to incoming power, the control circuit, the motor itself, and the driven load are detected and can then be trended for Condition Based Maintenance/Predictive Maintenance purposes.

ESA testing will provide valuable information for AC induction and DC motors, generators, wound rotor motors, synchronous motors, machine tool motors, etc. Since ESA is new to many people, the chart below illustrates ESA's evaluation of the major components within an AC induction motor system.

	POWER	CONTROLS	CONNECTIONS	CABLES	STATOR ELEC	STATOR MECH	ROTOR	AIRGAP	INSULATION	BEARINGS	ALIGNMENT UNBALANCE	LOAD	DRIVE
ESA	Yes	Yes	Yes	-	Yes	Yes	Yes	Yes	-	Yes	Yes	Yes	Yes

For more information please go to our website www.alltestpro.com or email info@alltestpro.com.

BIOGRAPHY: William Kruger has been involved in predictive maintenance for almost 40 years. He is a graduate of the US Navy Nuclear Power School and earned his BS degree from San Diego State University. His first introduction to predictive maintenance came from operating the vibration program on-board a SSBN submarine. He spent 10 years at San Diego Gas & Electric where he started their predictive maintenance program. He then worked as an applications engineer for the DYMAC division of Spectral Dynamics.

For the past 20 years Mr. Kruger has focused on training in the field of Predictive Maintenance. He was a senior instructor at Update International. Mr. Kruger has conducted training courses on 6 continents and is known worldwide for his practical approach to machinery analysis and his ability to present complex technical material in easily understood principles and demonstrations.

Mr. Kruger is currently the Technical Support & Training Manger for ALL-TEST *Pro*. He has authored several technical papers and made presentations at various meetings, including the Vibration Institute, EPRI, Canadian Pulp & Paper Expo, & International Maintenance Conference. He has held memberships in ASME, Vibration Institute, ANST, IEEE & many other professional organizations.