What Are Enveloping and *SEE?*

What Is Enveloping?

Envelope detection is a method for intensifying the repetitive components of a dynamic signal to provide an early warning of deteriorating mechanical condition. Common applications are concerned with rolling element bearings and gearmesh fault analyses.

The vibration frequency caused by a race or anti-friction roller bearing defect depends upon how often the defect strikes another part of the bearing. The rolling element impacts the defect and the repetitive impulse depends on number of balls, bearing geometry, and defect location. For example, if there is a chip on an outer race, each roller will strike it as it goes by and cause a vibration signal. This signal can often be identified as some multiple of shaft rotational frequency. The multiple is estimated by knowing a bearing's geometry and number of rollers.

A vibration signal from a defective bearing is made up of low frequency signals from rotational components, defect impulse signals, and machine noise. Often bearing fault signals are of very short duration which translate in the frequency domain as small harmonic amplitudes spread over a wide frequency range and buried in machine noise. Machine noise masks the early stages of bearing faults making spectrum analysis alone a difficult diagnostic tool.

Envelope analysis first filters out the low frequency rotational components from the complex signal. The high frequency repetitive components are enhanced and converted down to the bearing spectrum range while machine noise is reduced by a significant signal-to-noise factor. If vibration amplitudes appear in the envelope spectrum that is related to bearing defect frequencies it can be deduced that an incipient bearing defect is in progress.

Envelope analysis techniques permit an earlier prognosis of an eventual bearing failure by reducing masking noise and by enhancing the significant spectral components relating to bearing performance.

The output of the envelope detector can be measured as RMS average (ENV AVE), which signifies the vibration energy of the measurement, or as envelope peak (ENV PEAK), which is mainly influenced by the signal crest factor (true peak value divided by true RMS value). Initial bearing wear probably shows more change in ENV PEAK when viewed in a trend comparison. As a bearing defect broadens, ENV AVE will be the better diagnostic trend indicator.

What Is *SEE?*

SEE Technology is a new type of bearing fault detection method developed by SKF in order to better monitor bearings. This method of monitoring bearings breaks away from the traditional approaches to the problem by using high frequency, acoustic emission detection in the frequency range of 250,000 Hz to 350,000 Hz. This technique has characteristics that set it apart from normal vibration analysis at 0 to 20 kHz and other enveloping techniques at 5 kHz to 60 kHz. *SEE* provides an excellent way of monitoring problems with bearings that other current technologies cannot provide. Some of these advantages are detection of: early bearing defects, lubrication problems which stem from contamination, and fretting.

An acoustic emissions transducer is sensitive to metal-to-metal contact that occurs when bearing elements roll over a bearing race without an intervening lubricating layer. The transducer emits a high-frequency, pulsed voltage that gives evidence of the defective event. Thus *SEE* Technology, like enveloping, provides an early warning of deteriorating mechanical condition.

A higher-than-normal *SEE* reading, based on a statistical mean and standard deviation, would suggest either insufficient lubrication or the beginnings of a bearing defect. If the readings were to return to normal after the application of additional lubrication, you can assume that the proper corrective action was taken.

SKF®

"What Are Enveloping and SEE?"

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SEE readings can appear to return to the normal range after a defect spreads. At this point, acoustic emissions may be reduced as the impact stress factors between ball and race become marginal.

Taking *SEE* Measurements

Low frequency vibration is measured by firmly placing a sensor close to the part of the machine being measured. The more securely the sensor is placed, the better the reading is. This is not true with *SEE* readings. Secure placement doesn't necessarily mean better readings.

A vibration probe actually moves with the machine it is resting on. The machine's vibration is transferred to the probe which has a crystal inside which shakes with the probe. The crystal converts the mechanical motion into electrical signals.

The *SEE* sensor is, for all practical purposes, a microphone. It does not have to be held firmly against the machine to get a good reading. The *SEE* sensor is ***listening*** for acoustic signals to be transmitted from the surface under it. Since these acoustic signals attenuate very easily, and air is an excellent attenuator for acoustic signals, they certainly will not reach the *SEE* sensor if the transducer is just held against the machine.

The secret is in the coupling between machine and sensor. The coupling most widely used is grease. Grease fills the air gap between the sensor and the surface of the machine resulting in the acoustic signals traveling from the machine, through the grease, to the *SEE* sensor.

Because of the nature of the *SEE* signal generating mechanism, it is important to note that zero readings or trends do not necessarily indicate that there is no bearing defect. The following tables show some probable correlation's between normal vibration and *SEE* enveloping readings.

Experience with *SEE* measurements and case histories developed by successful use of *SEE* have provided the following guidelines:

0 to 3 *SEE*	No identifiable problem.
3 to 20 *SEE*	Lubrication problem, contamination, bearing defect with light load, or a small bearing defect with normal load.
20 to 100 *SEE*	Bearing defect or contamination.
100 *SEE* and above	Severe bearing problem.

Table 1. Bearing With Damage

Both *SEE* and Vibration Readings	**Vibration Readings But No *SEE* Readings**
• *SEE* because of bearing defect. • Other vibration processes such as unbalance, misalignment, and looseness.	• No *SEE* because of good lubrication in conjunction with bearing defect. • Other vibration processes such as unbalance, misalignment, and looseness.
SEE Readings, But No Vibration Readings	**No *SEE* Readings or Vibration Readings**
• Good *SEE* signal-to-noise ratio and poor vibration signal-to-noise ratio. • Bad Lubrication. • Contamination.	• Bad *SEE* signal-to-noise ratio (good lubrication?) and bad vibration signal-to-noise ratio.

Table 2. Bearing With No Damage

Both *SEE* and Vibration Readings	**Vibration Readings But No *SEE* Readings**
• Pump cavitation or other non-bearing related *SEE* signal combined with vibration from unbalance, misalignment, vane passing, looseness, and so on. • *SEE* from bad lubrication or contamination.	• Other vibration processes such as unbalance, misalignment, and looseness.
SEE Readings, But No Vibration Readings	**No *SEE* Readings or Vibration Readings**
• Pump cavitation or other non-bearing related *SEE* signal. • *SEE* from bad lubrication or contamination.	• A good running bearing. • A good running machine.

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