Bently Nevada has a rich history of machinery condition monitoring experience and has always placed a high priority on educating and helping customers manage & maintain their equipment better. Every week, an article or Application Note that was published by Bently Nevada ‘back in the day’ will be highlighted. Although the format may be dated, the information is just as valid and informative as the original printing.

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**Introduction**

Bently Nevada aeroderivative gas turbine monitoring systems are currently designed using specifications established by the engine manufacturers. These specifications require seismic vibration transducers which have limitations. Monitoring systems which are based solely on casing or bearing housing seismic measurements cannot provide information to protect against certain types of engine malfunctions. The following information presents options that can greatly enhance the current seismic based systems.

**Machinery Considerations**

Most common machine malfunctions, including unbalance and misalignment, originate at the rotor and cause a change in shaft vibration. The extent to which this vibration may be transmitted to the bearing housings and machine casing depends upon the machine’s transfer ratio. Using seismic transducers to monitor the effects of shaft vibration requires that the transfer ratio be large and relatively constant with varying machine speed. Experience has shown that transmission of
shaft vibration is not constant along the rotor span or machine frame and may vary due to the nature of the vibration source and machine speed.

Seismic measurements, although useful for detecting some machine problems, provide only an indirect indication of shaft vibration. They are not ideal for rotor monitoring purposes and offer limited information for rotor behavior diagnostics.

Rotor vibration occurs typically in the frequency range of 25 Hz (1500 cpm) to 400Hz (24,000 cpm). Turbine blade passage vibration exists at much higher frequencies, typically 5 kHz (300,000 cpm) to 15kHz (900,000 cpm). Blade passage vibration routinely causes very high acceleration amplitudes, typically 10 to 100 times higher than the levels from rotor vibration sources.

Measurement Considerations

When seismic transducers are specified, the type that has demonstrated the best ability to survive the temperature and vibration environment of aeroderivative gas turbines is the high temperature accelerometer. This transducer, however, has its own set of limitations.

As was stated previously, blade passage vibration acceleration amplitudes are typically 10 to 100 times higher than those from rotor vibration sources. Reliably extracting the small rotor vibration signals from the high amplitude blade vibration signals is not a simple task. The monitoring system must have a wide dynamic range to prevent saturation by blade passing frequency vibration. Both signal integration and special filtering are needed. The monitoring system becomes very complex. Because of this complexity, the system is more susceptible to false alarms and/or missed detection of a real machine malfunction.

To achieve very reliable machine information, a vibration monitoring system must be simple. Direct measurement of rotor vibration can play an important role in achieving this reliability. It allows the monitor to be simple and thus more reliable.

Direct Measurements

Bently Nevada offers shaft and bearing outer ring observing displacement transducers and vibration monitoring systems for aeroderivative gas turbines. These systems provide more complete machinery vibration information than seismic transducer based monitoring systems. These monitoring systems do not need the wide dynamic range, special filtering, and electronic integration required by seismic systems. As a result, they are simpler and more reliable.

Since these are direct measurements, they do not depend on a transfer ratio which is seldom constant. Since displacement is being measured, a wide dynamic range is not required to prevent saturation by blade passing frequency vibration. This is because blade passing frequency vibration, even though it has high acceleration amplitudes, has low displacement amplitudes. As an example, 50 g’s (490 mm/sec2) acceleration at 10kHz (60,000 cpm) is only 9.78
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microinches (0.248 micrometres) displacement.

These systems are based on proximity probes specially developed for this application. The probe tip and body will operate at temperatures up to 500°F (260°C). Two types of probe cable are available. One is a flexible cable that will operate at temperatures up to 482°F (250°C). This will withstand the temperatures normally encountered exiting the compressor portion of the turbine. The other is a semi rigid cable that will operate at temperatures up to 1800°F (982°C). This will withstand the temperatures often encountered when exiting the turbine through the hot gas path. These transducers overcome most of the temperature problems that are encountered with installation of proximity probes in aeroderivative gas turbines.

Rotor support in aeroderivative gas turbines is provided by rolling element bearings. Many utilize squeeze film dampers. Standard sensitivity proximity probes are often very effective in measuring shaft vibration in these cases. A proximity probe can observe either the shaft near the bearing or the outer ring of the bearing. The motion of the outer ring of a squeeze film damped bearing is essentially the motion of the shaft because virtually all of the shaft motion appears across the damper.

Direct shaft relative measurements with standard sensitivity proximity probes are also useful with rigidly mounted bearings, especially when made several shaft diameters away from the bearings.

In the case of rigidly mounted rolling element bearings, a monitoring system is available that uses a special high sensitivity proximity probe transducer system called REBAM ® (Rolling Element Bearing Activity Monitor). The REBAM proximity probe directly measures the small deflections in the outer ring of a rolling element bearing. In addition to providing rotor related information, REBAM is useful in detecting bearing failure.

Proximity probes can also be used to provide a once-per-rev (Keyphasor*) signal. This is very useful in balancing and rotor diagnostics.

Summary

Seismic transducers have limitations. One must understand and consider these limitations when specifying seismic transducers exclusively for monitoring aeroderivative gas turbines. Direct reading shaft or REBAM probes overcome many of these limitations and can provide superior performance. Bently Nevada Corporation is ready to help you engineer and install the proper combination of vibration measurements to provide a reliable and effective monitoring system for your aeroderivative gas turbine.