As the number and importance of permanently installed vibration sensors increases, so does the importance of proper installation and operation.

Proper sensor selection requires special attention to three main issues: sensor design, dynamic expectations, and application environment.

Sensor design encompasses the actual sensing element and the physical material and component selection for the sensor. Preferred industrial accelerometers employ a shear sensing element with either a ceramic or a quartz crystal.

Quartz sensing elements are typically used when long-term stability and minimum temperature induced output shifts are desired. Ceramic sensing elements are used for low-frequency, low-level measurements. Shear-design sensors are preferred because of their inherent insensitivity to adverse environmental influences, such as case or base strain and thermal transients. Internal case isolation and shielding reduce the effects of erroneous signals from ground loops and pick-up of electromagnetic and radio frequency interference. Other critical material selection criteria include nonmagnetic 316L stainless steel housing, hermetic sealing, and industrial military connectors.

Dynamic expectations are application-specific and refer to the frequency range of measurement and the anticipated amplitudes of vibration. After careful review of the machinery to be monitored, a minimum and maximum measurement frequency range may be established. The minimum measurement frequency is normally related to any subharmonics of running speed or any lower frequencies where vibration data is to be collected. The maximum measurement frequency of interest is determined by the maximum number of harmonics of an event such as running speed, bearing frequencies, or gear mesh. This measurement frequency range should be well within the specified frequency range of the sensor.

Amplitude range refers to the anticipated levels of vibration to be measured. These values are related to the alarm levels set for the machine. By carefully evaluating the idiosyncrasies of the machinery, the predictive maintenance engineer can estimate the minimum expected vibration levels and ensure that the electrical noise floor of the accelerometer is less than those levels.

Environment of the application is a critical consideration during program implementation. The sensor must be capable of surviving the conditions to which it will be exposed. The specified temperature range of the sensor must conform to the fluctuations of the environmental temperature. If harsh industrial chemicals are present, the sensor requires hermetic sealing and construction that resists corrosion. Finally, the specific location of the sensor within the environment must be appropriate because both cable and sensor may be damaged by imprudent installation in heavily traveled, physically punishing areas.

Sensor calibration

Accelerometers are precision measuring instruments. They are highly engineered to provide accurate electrical signals representative of the vibration being monitored. Each sensor is calibrated by comparison with a known acceleration level. Calibrations may include frequency response curves, resonant frequency measurements, and transverse sensitivity, as well as other tests. Applications requiring a high degree of accuracy or those in plants requiring certification and traceability require full calibration test results.

Some applications have much less stringent requirements for calibration certification. Simple sensitivity measurements at a single frequency may be sufficient. Operational verification and certificates of conformance to published specifications may satisfy the calibration needs of many plants. Reducing the final calibration requirements reduces the cost of manufacturing the sensor and should lower the price for predictive maintenance users.

Periodic recalibration may be required by plants with strict certification and traceability requirements. It is always recommended that the user has the sensor recalibrated periodically, particularly if the sensor has experienced a high shock level or extreme temperatures for extended periods. Some plants develop in-house calibration capabilities for periodically verifying the performance of accelerometers. Products are available that provide a set 1g-acceleration level at a fixed frequency for quick sensor checking.

Sensor mounting

Another environmental condition to consider is the mounting method of the vibration sensor. Four primary methods are used for attaching sensors to monitoring locations for predictive maintenance: stud mounted, adhesive mounted, magnet mounted, and nonmounted, a term which includes handheld probes or stingers. Each method affects the high-frequency response of the accelerometer. Stud mounting provides the widest frequency response and the most secure, reliable attachment.

Ideal surface preparation for stud-mounted sensors is specified in the accompanying drawing. In addition to the surface being as flat as possible, clean and free of debris, with the mounting hole perpendicular, the mounting surface should be lightly coated with a lubricant. This coating aids in the transmissibility of the higher-frequency vibrations and improves high-frequency response of the sensor. Silicone vacuum grease, heavy machine oil, or beeswax is commonly used.

The other three methods reduce the upper frequency range of the sensor. By removing the sensor from intimate contact with the measurement point and inserting alternate mounting pieces, such as adhesive pads, magnets, or probe tips, a mounted resonance is introduced. This mounted resonance is lower than the natural resonance of the sensor and reduces the upper frequency range. The farther the sensor is from the measurement point, the lower the mounted resonance and the lower the usable frequency range.

Sensor cabling

The selection of connectors and cables has a direct impact on the ruggedness and reliability of the installation. Internally amplified, two-wire accelerometers require two leads: one for the power and signal, and one for the common and signal return. Often, coaxial cables are used because they are inexpensive. However, erroneous signals can be introduced into systems through ground loops, electromagnetic interference (EMI), or radio frequency interference (RFI) when coaxial cables are used. To avoid ground loops, there should be only one ground in the system.

Permanent installations require two-conductor shielded cables to insure clean vibration signal transmission. Two-conductor shielded cables allow the signal and the signal return (common) to be fully shielded from the sensor to the readout equipment. For the best shielding from EMI and RFI, and to insure that ground loop signals are not induced, the shield should be terminated at one end only. Typically, the shield of a two-conductor shielded cable is left open or not connected at the sensor end and is tied to earth ground at the instrumentation end.

Troubleshooting

Piezoelectric sensors are dynamic measuring instruments. They use piezoelectric sensing elements to convert or transduce the mechanical phenomena into an electrical signal. The mechanical parameter may be force, pressure, or vibration. The raw electrical signal from a piezoelectric element is a high-impedance charge signal. This charge signal can be converted to a low-impedance voltage signal by either an external charge amplifier or an external voltage amplifier. The cables between the charge sensor and amplifier must be high-quality and low-noise, and must be kept as short as possible. Because of high-impedance circuits, charge mode systems are not well suited for factory environments.

ICP* sensors are internally amplified sensors that employ miniature amplifiers to convert the high-impedance charge signal into a low-impedance voltage signal that is compatible with a dirty factory environment.

Because these amplifiers are internal to the sensor, they do not require low-noise cables or external amplifiers. These internal amplifiers have set gain so that output sensitivities are standardized.

The constant-current dc input and bias voltage output of the ICP sensor design provides troubleshooting opportunities. The power supply is typically 18 to 30 volts dc current limited via a constant-current diode between 2 and 20 mA. Typical battery-operated supplies offer 2 mA of constant current to extend battery life, while continuous monitoring systems offer more current in order to drive longer cables.

The signal output of the sensor is a low-impedance voltage signal proportional to the dynamic measurement. This voltage is carried on a dc bias voltage. The ac dynamic signal is superimposed on the dc bias voltage and is allowed to swing between the supply voltage and ground. (Operational amplifier types use a plus and minus supply and allow the signal to ride on ground and swing between the plus and minus rails).

The dc bias voltage, which can be measured with a dc volt meter, can be used as a diagnostic tool. The voltage provides a means of verifying that the amplifier is turned on.

If the sensor is plugged in while measuring the supply voltage, and the meter stays at the supply voltage level, something in the system is open or not connected. If the meter reads zero, something in the system is shorted. If the meter reads approximately half the supply voltage, then the sensor and cabling are functioning properly.

Vibration monitoring programs are effective only if the data that is analyzed is accurate and reliable. Proper selection and installation of industrial accelerometers insures the data collected is correct. **MT**

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