

Measurement technologies and sensors for condition monitoring applications

Overview

Condition monitoring systems monitor equipment degradation. Typically, an equipment criticality and reliability assessment is performed to identify important equipment and common failure modes. With the selected equipment and failure modes in hand, you can identify sensors to monitor specific components of the equipment for degradation and the initiation of identified failure modes.

Measurement Technologies and Sensors for Condition Monitoring Applications

Many sensors detect changes in equipment components. Vibration sensors are the most commonly used sensors when monitoring rotating machinery. They are often credited for sensing the mechanical degradation of equipment components two months or so in advance of a failure, as shown in Figure 1.

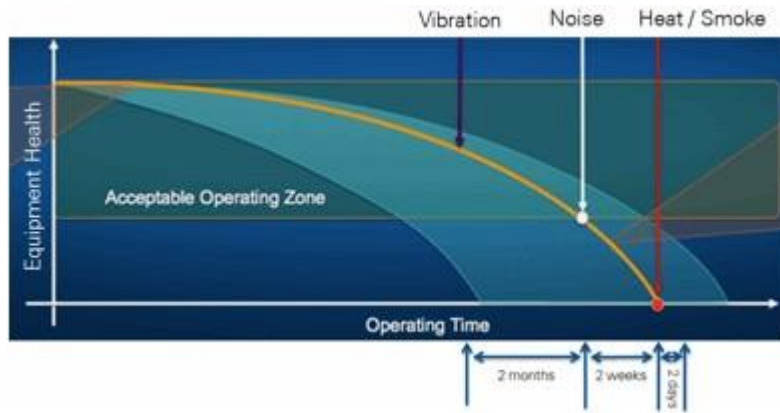


Figure 1. Asset degradation can be detected in advance by using sensors.

Other sensing technologies used in equipment condition monitoring as shown in Figure 2 include motor current, oil analysis, thermography, dynamic pressures, and operating state sensors such as speed.

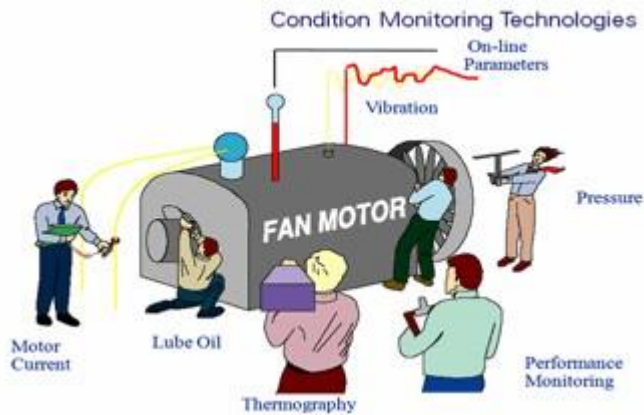


Figure 2. A variety of condition monitoring technologies help asset specialists understand asset health.

Table 1 lists the types of sensors and sample vendors used in condition monitoring.

Measurement	Sensor	Frequency Range	Possible Signal Conditioning Needs	Vendors
Vibration	Accelerometer	>100 Hz	IEPE AC/DC coupling ±24 V input or AC couple Anti-alias filter	IMI Sensors Connection Technology Corporation Endevco/Wilcoxon
Vibration	Velocity	>20 Hz to <2 kHz	IEPE AC/DC coupling ±24 V input or AC couple Anti-alias filter	IMI Sensors Connection Technology Corporation Endevco/Wilcoxon

Vibration	Proximity Probe (Displacement)	<300 Hz	Modulator/demodulator Anti-alias filter ±30 V input range	Connection Technology Corporation
Speed	Proximity Probe	<300 Hz	Modulator/demodulator Anti-alias filter ±30 V input range	Connection Technology Corporation
Speed	Magnetic Zero Speed	Up to 15 kHz	24 V DC power ±20 V	Honeywell SPECTEC
Motor Current	Current Shunt Current Clamp	Up to 50 kHz	±333 mV or ±5 V	Magnelab
Temperature	RTD Thermocouple	Up to 10 Hz	Noise rejection, excitation, cold-junction compensation	NI
Temperature	Infrared Camera	Multiple frames per sec	GigE Vision over Ethernet connection	FLIR Systems
Pressure	Dynamic Pressure	>100 Hz	AC/DC coupling IEPE (some models) ±24 V or AC coupling Anti-aliasing filter	Endevco PCB Kulite Kistler

Oil Quality	Viscosity		mA current input	Kittiwake
Oil Particulate	Contamination	Up to 10 Hz	±10 V input	Honeywell
	Particulates		50/60 Hz noise rejection	HYDAC
				Poseidon Systems

High-Frequency "Noise"	Ultrasonic	>20 kHz	AC/DC coupling ±24 V input range Anti-aliasing filter	UE Systems
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Table 1. There are a variety of measurements, signal condition needs, and vendors for condition monitoring sensors.

Figure 3 shows a typical sensor and a sample failure mode of an asset the sensor monitors.



Figure 3. Typical sensors and failure modes that can be detected.

Each sensor offers the ability to monitor the degradation of mechanical and electrical components within rotating machine equipment.

1. Vibration sensors are used to detect roller bearing wear, gearbox wear, shaft misalignment, unbalance, and mechanical looseness.
2. Speed sensors work with vibration sensors to correlate vibrations to rotating speed and shaft angular position.
3. Motor current sensors are commonly placed at the motor control center. They can detect eccentric rotors, loose windings, rotor bar degradation, and electrical supply unbalance.
4. Dynamic pressure sensors are used for combustion dynamics, flow turbulence, and cavitations.
5. Temperature sensors are typically used to detect heat caused by friction. They often accompany vibration sensors to collaborate vibration-detected degradation.
6. Thermal imaging detects hundreds of temperatures within the camera's field of view.
7. Ultrasonic sensors can detect electrical problems including corona, arcing, and tracking. They can also be used to detect early signs of roller bearing wear.
8. Oil sensors can detect wear debris from bearings and gears. They also can detect contaminants in the oil that reduce the lubrication ability of the oil.

Once you have identified equipment, failure modes, and sensors, the next step is to choose measurement hardware to digitize the sensors. Your choice of measurement hardware depends on your sensor characteristics including frequency range, voltage range, and signal conditioning needs.

With respect to frequency range, you can choose from two types of sensors: static and dynamic. Dynamic sensors measure frequency ranges well above 2 Hz. For example, a typical accelerometer has a frequency range of 1 Hz or 2 Hz to 15 kHz or 20 kHz. The ultrasonic sensor frequency range extends to 100 kHz or more, with a heterodyne output ranging from a few hundred hertz to 40 kHz. On the contrary, static sensors convert the monitored physical property into an electrical signal at rates of 1 Hz to 10 Hz or 20 Hz.

The other two sensor characteristics are voltage range and signal conditioning needs. Some sensors produce a voltage as high as 30 V, while others might produce only a few millivolts. Some sensors need sensor power such as IEPE power, while others might need cold-junction compensation. Table 1 lists the common signal conditioning needs for each measurement and sensor.