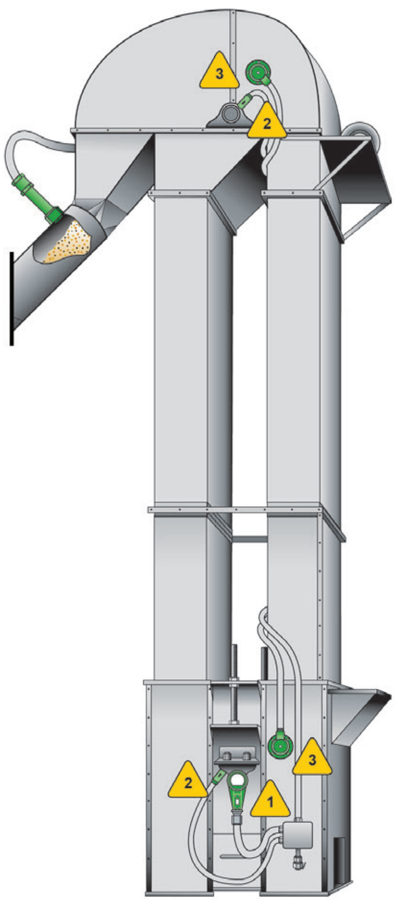
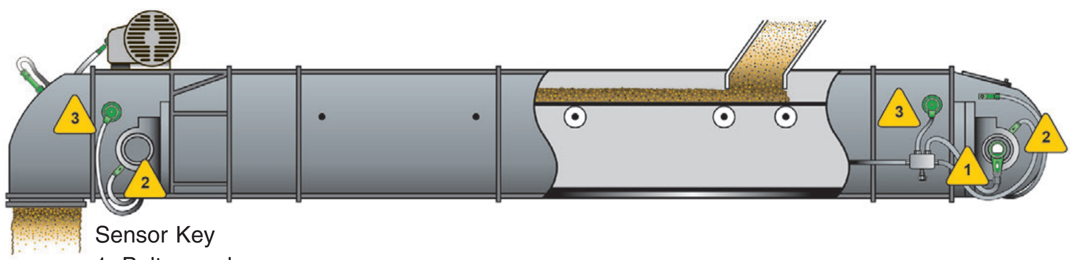
Latest Technology for Testing and Verifying Conveyor Monitoring Systems

By Brian Knapp, 4B Components Ltd

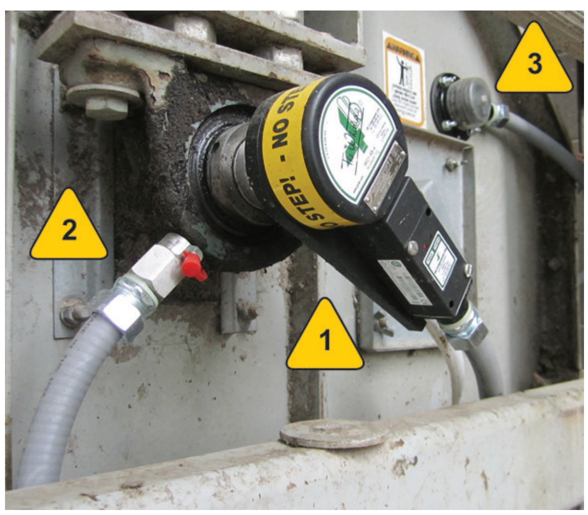
Belt conveyors and bucket elevators, like all conveying equipment, require regular maintenance. However, even with regular maintenance, things can fail unexpectedly. Bearings can overheat, belts can slip, and belts can misalign. Any of these conditions can lead to downtime, damage to equipment, and, if combustible dusts are present, fires or explosions. Due to the commercial and safety risks associated with these issues, many companies will install electronic sensors and controls to monitor their equipment. A typical system will have temperature probes to monitor for excessive bearing temperature, sensors to monitor for belt misalignment and sensors to monitor for belt slip. Typical bearing temperature sensors are probe style with a housing that installs in place of the bearing's grease fitting and has a grease through port. Belt misalignment sensors are usually installed at both ends of the conveyor, and are either force activated switches or temperature activated rub blocks. Finally, speed monitoring is installed at the tail pulley to monitor for belt slip. In order to properly protect equipment, it is critical that these sensors are correctly commissioned, regularly tested, and that the associated controls are verified.

Even when reliable sensors are installed, system testing is still important. Over the years, systems have become more sophisticated, which has resulted in a higher level of complexity, leading to numerous pitfalls. Firstly, facilities are monitoring many devices and processes in the plant and so there are many inputs to track. This can increase the risk of mislabeling a sensor, resulting in the operator being presented with incorrect information. For example, a bearing on the top of the main receiving elevator could be overheating, but the operator is presented with an alarm showing the bottom of the shipping elevator. When the maintenance staff checks the bearings at the bottom of the shipping elevator and finds that they are not hot, the operator may ignore the alarm leading to a serious condition on the main receiving elevator with potential catastrophic consequences.





Sensor Key
1. Belt speed sensor
2. Bearing temperature sensor
3. Belt misalignment sensor



Typical sensor arrangement at the tail (boot) of a bucket elevator

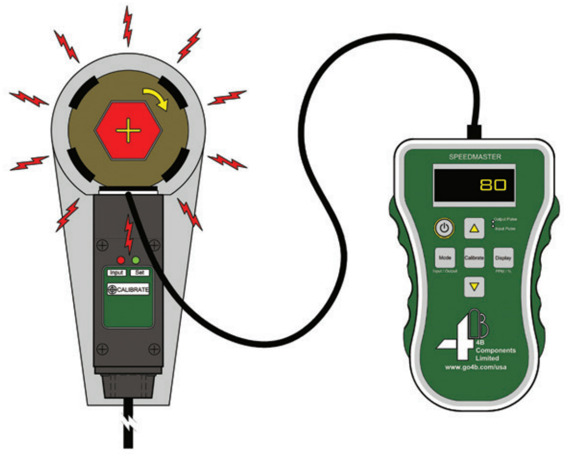
A further complexity issue is that there are many different instruments that provide the same type of signal. For example, many devices have a 4-20 mA output. This type of signal could come from a temperature, pressure, vibration, speed, or numerous other types of sensors. Imagine the confusion that would be caused by a vibration sensor being reported as a speed sensor on the controller. Thirdly, many facilities are using PLCs (programmable logic controllers) that will normally have software that is custom to each site. Naturally, there is more risk for error because it is difficult to fully test everything in a custom program before bringing it online and connecting all of the I/O (inputs and outputs). For example, the program may be written with the expectation that the shipping leg will shut down when it has a shaft underspeed. However, the receiving leg is mistakenly shutdown instead of the shipping leg.

Now the question becomes how to overcome these potential errors. It is recommended that the sensors are commissioned and tested upon installation and subsequently tested on a regular basis to ensure that the system continues to operate as expected. The tests will verify the function of the sensors as well as all of the associated controls. Each type of sensor may have several methods of testing.

Speed sensors will typically be calibrated for a normal running speed of the equipment and will provide an output at one or more underspeed levels. A crude method of testing the sensor would be to produce a zero speed by either removing the sensor from the shaft or blocking the target from the sensor. While this will test what happens in the event of stopped belt/shaft motion, it will not verify the actual speed at which it triggers the underspeed signal and therefore will not test for belt slip. In some cases, the underspeed can be simulated in a controller such as a PLC or with a simulation device connected between the sensor and controller, but a simulation is not a full test from the sensing element of the sensor through the entire system.

To perform a true test, one must reduce the speed of the target that the sensor is detecting. One method is to use a VFD (variable frequency drive) to reduce the motor speed and verify that the speed sensor produces an underspeed signal at the proper speed. However this is rarely possible as many motors are not controlled by VFDs. Another method is to remove the target and sensor from the shaft and control the speed with some type of variable speed drill. This method is crude and labor intensive and it can be difficult to control the speed of the drill with any precision. The latest and most advanced method is to use a specialized target masking pulse generator. This device has an input mode that reads the shaft speed, and an output mode that electronically blocks the shaft mounted targets from the sensor and masks it with a speed controlled by the user. The user can perform a full test of the speed sensing system without changing anything with the installation or wiring and, most importantly, it is a real test and not a simulation.

Bearing temperature sensors should report a continuous temperature which is visually displayed on a controller which also provides a user adjustable alarm temperature. For the most accurate temperature reading, the bearing temperature sensor's probe should be inserted through the bearing housing so that the probe tip is as close as possible to the bear-



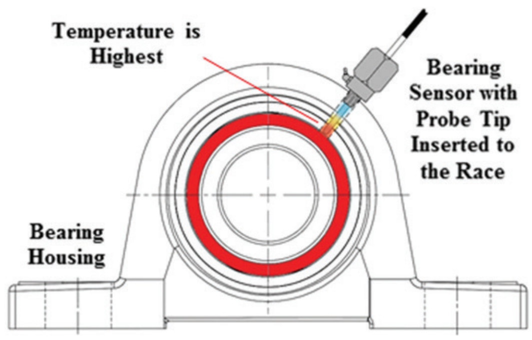
Shaft speed sensor testing (alarm state)


Speed switch sensor testing

ing race without touching it. Just like speed monitors, there are multiple ways to test the bearing temperature sensors and some are more sophisticated than others. A crude method is to use a freeze spray to cool the sensor and verify that the temperature drops in the controller display. This will verify that the sensor is identified properly within the controller, but it will not confirm what will happen when the bearing exceeds the alarm temperature, and therefore it is not a complete test. Similar to the speed sensor, it may be possible to simulate a hot bearing in the PLC or by connecting a simulation device between the sensor and controller, but again, this is not a complete test. The only way to fully test the bearing temperature sensor is to heat it to the trip point. In order to heat the sensor to the trip point in a safe and controlled manner, the facility will need a device like a dry well calibration block. These types of devices provide a portable battery-powered heating block that heats the bearing sensor probe to a selected temperature and verifies that the system will behave as expected when the probe reaches that temperature.

There are two common styles of belt misalignment sensors. The first is a brass rub block with a temperature sensor. When the belt misaligns and rubs against the brass, it heats up and the temperature probe produces an alarm, much like a bearing temperature sensor. These can be tested in the same manner as the bearing temperature sensors. Alternatively, there are force activated belt misalignment sensors that can produce an alarm immediately on a belt misalignment instead of waiting for heat generation. Force activated misalignment sensors can be tested by removing the sensor from the elevator casing and activating it by force. Some may also have a built-in test feature that can be used to test the sensor while it is mounted in place. Sensor placement should be verified visually to ensure that the location is optimum for detecting the misaligned belt.

When deciding how to test the sensors, it is important to understand the inherent risks of using simulations. Typically, simulations are within the same controller that is calculating the alarms. If there is an error in the alarm calculation, it is likely that the simulation will have the same error, which will result in a false sense of security. There have been several examples of these types of issue with simulations. One example is that a normal system will shut down the conveyor in the event of a belt running at 80% of its normal speed. However, due to an error in the programming math on the PLC, the elevator did not shut down until it was at 20% of its normal speed, or 80% underspeed, which would result in serious belt damage due to slip. The only way that this programming error could be detected would be through a true test. Another example of a common issue, as previously described with the receiving and shipping elevator scenario, is that incorrectly labelled sensors will not be identified by a simulation.




Bearing temperature sensor testing

In addition to the initial commissioning and verification of sensors, it is important to perform regular testing of the sensors at least once annually, and sometimes more regularly under heavy use operation. Sensors may get temporarily removed for machine maintenance and if they are not re-installed correctly or if they get swapped around, then this will be easily identified during regular testing. This will also identify if any software updates or bypasses have affected the control equipment protecting the conveyors. The tests should be documented so that there are records to provide to management as well as insurance companies and OSHA. This process could be assisted and greatly improved by using a system that has an integrated cloud portal that can automatically keep a digital record of the test, including the date and time that the test was performed.

In summary, a system can only be expected to perform as well as its installation and maintenance. By performing an initial commissioning and verification, the instrumentation and controls are tested to give the facility a base line. By performing regular subsequent testing and correcting any issues which are identified, the system should continue to perform and meet the facility's expectations and safety requirements for many years to come.

Brian Knapp is vice president – Electronics Div., 4B Components Ltd, Morton, IL. 4B offers a large range of elevator components. The company's electronics division specializes in level controls, intelligent sensors, and safety control systems that prevent costly downtime and minimize the risk of explosion in hazardous areas. For more information, visit www.go4b.com/usa.