

STRENGTHENING PLANT SAFETY

Derek Stuart, AMETEK Land, discusses how the correct selection of equipment and operating criteria can reduce risk in storage silos and mills.

Introduction

Coal provides around 90% of the energy for cement production worldwide. It is readily available, low cost compared to most alternatives, and offers consistent quality, making it the preferred fuel for most cement producers. Some European producers have used alternative fuels (AFs) in order to reduce CO_2 emissions, but this trend has been offset by increased coal consumption in Asia and Africa.

Risks of unwanted combustion, potentially causing injury, damage, and downtime, occur everywhere coal is handled, processed, or stored. Safe coal handling practices are designed to ensure that the fuel remains intact throughout its journey from the mine until the point at which it is ignited in the kiln. This article examines equipment selection and operating criteria for reducing risk in storage silos and in coal mills that pulverise the fuel before burning.

Spontaneous heating

Of critical importance is the problem of oxidation. All coals oxidise during storage, but sub-bituminous coals are especially prone to self-ignition. The increasing use of sub-bituminous coals means a greater risk of spontaneous heating and spontaneous combustion. Good operating procedures are designed to ensure that coal is used before it has time to self-ignite; good housekeeping ensures that any spillage of coal during transportation is identified and cleaned up.

When coal is exposed to the air, the volatile components combine with oxygen in an exothermic reaction, leading to spontaneous heating. The Arrhenius equation tells us that the rate of oxidation approximately doubles with every 10 °C increase in temperature, so a runaway condition can occur in which the coal self-ignites in a process of spontaneous combustion. In addition

to the obvious safety concerns, spontaneous heating and spontaneous combustion result in loss of material, so that coal which has been paid for is no longer available to burn in the kiln.

It takes as little as 1.4 kg of pulverised coal in 28 m^3 of air to form an explosive mixture. Since a large cement kiln burns more than 10 kg/sec. of coal, the safe burning of pulverised coal necessitates strict adherence to planned operating sequences. The greatest risk of fire occurs when the pulveriser is shut down under load, as this leaves a large amount of finely-divided fuel inside a hot mill. The large surface area of the pulverised coal and the high temperature inside the mill lead to rapid oxidation of the coal. This results in further heat buildup and the potential for a fire. If the mill is restarted without first removing the hot coal, an explosion can occur when particles are suspended and exposed to the air. Even in routine mill shutdowns, there is a danger that any residual coal left within the mill will oxidise and may explode as the mill is restarted. To prevent a coal fire, the mills can be made inert with a steam deluge when an unexpected shutdown occurs, or when there is a high risk of a coal fire.

Available detection techniques

Several techniques are available that can monitor the effects of spontaneous heating and give early warning that a dangerous condition could occur. They work by detecting one of the tell-tale signs of oxidation: either heat buildup or the emission of carbon monoxide (CO) gas. The choice of the most appropriate monitoring technique depends on both the measurement location and on the degree of risk. More sophisticated – and therefore more expensive – monitors are appropriate where low-rank coals pose an increased likelihood of spontaneous combustion.

Thermocouples are widely used to detect the heat buildup from oxidation or early-stage mill fire, but they have limited sensitivity and discrete sensors have difficulty monitoring the whole volume of the mill. It also takes time for sufficient heat to build up within the mill to give a detectable increase in temperature. Experience shows that thermocouples do not provide a reliable indication that a hazardous condition is developing.

Carbon monoxide detection is ideal for the detection of spontaneous oxidation in silos and pulverisers. Large amounts of CO are produced by the inefficient oxidation associated with spontaneous combustion. Ambient air contains a very low concentration of CO (usually well below 10 ppm), so a significantly higher concentration provides a sensitive and fast indication that unwanted oxidation is occurring. The technique can only be used in enclosed spaces, because the wind will quickly disperse any gas emissions before a measurable concentration can accumulate.

Installation location

For monitoring storage areas, the sample point should be located towards the top of the silo so that it measures the gas in the headspace above the coal. In most cases, a single sample point is sufficient because natural convection will ensure the gases in the headspace are well-mixed. Very large or highly asymmetric storage volumes may require additional sample points to ensure adequate coverage.

In mill applications, the best measurement point is usually at the exit of the classifier. The continuous flow of coal and air through the mill ensures a representative sample of the gases in the mill and the predictable flow direction allows the use of an abrasion shield to prevent excessive wear on a sample probe. Even though the inside of the classifier is a hazardous area, sample probes are simple devices with no electrical connection therefore no special precautions are needed.

Determining alarm levels

One of the biggest challenges in configuring a Millwatch system is the determination of suitable alarm levels. A CO concentration greater than 250 ppm can be seen during mill startup, but in normal operation the CO concentration is in the region of 10 ppm. Millwatch analysers offer two independent alarm points, so alarm levels can be set high during startup and lower in normal operation. Careful assessment of the alarm level is important. Obviously, it is important to ensure the alarm level is not set too high, otherwise there can be a significant time delay before the system responds to a potentially hazardous condition. However, an excessively low alarm level will lead to nuisance alarms, which will undermine the usefulness of the monitoring system.

Verifying correct operation

It is important to verify correct operation of the sensor, otherwise a negative indication can give a false sense of security. For example, a sensor can become plugged by coal dust so that it is no longer exposed to the silo atmosphere. Electrochemical sensors are compact and sensitive, but they give zero output when they fail and this means a faulty sensor will indicate a low CO concentration. In-situ sensors are compact and easy to install, but blockage is difficult to detect, and calibration checks are usually performed manually by a technician with a bottle of calibration gas. Extractive analysers require additional hardware for installation, as the sensor is mounted remotely from the sample point. However, they can detect a blocked sample probe by sensing a reduction in sample flow. They are also generally equipped with an automatic calibration mechanism.

Successful co-monitoring

HouShi power plant is a 4200 MW electricity generating plant in China's Fujian province, operated by the Huayang Group. It supplies electricity to the city of ZhangZhou and the surrounding area. There are seven electricity generating units at the site, each of which is rated for 600 MW. In 2011, the plant operators decided to add CO monitors to the five coal mills in Unit 1, supplementing their existing temperature and

fire sensors. They determined that AMETEK Land's Millwatch analysers were best suited to the task. The analysers have hundreds of installations worldwide and include the following features:

- Rugged sample probes with automatic blowback to maintain a good sample flow.
- Automatic calibration verifies correct operation of the analysers, confirming that they respond correctly to CO.
- Continuous measurement of each sample point, with no multiplexing and a response time of less than 60 sec.
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This last feature is especially important, as a hazardous condition can develop within a few minutes, and a multiplexed system sampling six measurement points will typically sample each point only once every 10 - 15 min.

The system proved its value in 2013 when the Millwatch system showed rapidly rising CO levels in the outlet of one of the coal mills. It would have taken at least 15 min. for the temperature and fire detection systems to respond and show an indication of a problem, so the Millwatch analysers allowed corrective action to be taken significantly earlier than would otherwise have been possible.

Conclusion

Installed and used properly, a CO sensor gives an early indication of spontaneous heating and combustion which strengthens plant safety. It allows the operator time to assess the scale of the problem and to decide on the appropriate remedial action. They prevent losses of fuel, avoid damage to plant and equipment, and, most importantly, reduce the risk to personnel.

About the author

Derek Stuart is the Global Product Manager – Power for Land Instruments International.