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Technical Exclusive

Spark Detection: First Line of Defense for Preventing Combustible Dust Fires and Explosions

By Jeffrey C. Nichols

According to the National Fire Protection Association (NFPA) Standard 654, the Standard for the Prevention of Fire and Dust Explosions (2013 edition), combustible dust is defined as "a finely divided combustible particulate solid that presents a flash fire hazard or explosions hazard when suspended in air or the process-specific oxidizing medium over a range of concentrations." The dust may be from organic or non-organic matter in any combination, and a dust explosion can have the same impact as a gasoline explosion. The key to avoiding a catastrophic event is to install an effective prevention technology for detecting all sparks and embers in the incipient stage in the process material flow, and extinguishing or diverting any sparks before they ignite the transported material and dust.

Spark detection and extinguishing systems are comprised of detectors, a control console, and countermeasure devices like extinguishment or high-speed abort gates. When a spark or ember enters the field of view of a detector, the detector sends a signal to the control console. The control console sets an alarm, records the event, and triggers the countermeasures. There are multiple countermeasures possible but the typical application is for the control console to activate an extinguishing device that sprays atomized water for a set period of time to extinguish the hazard without affecting production.

Detector Technology

Different types of spark detection systems have been developed offering varying degrees of protection. Two broad categories of these: sensors that detect light in the visible and invisible near infrared range and those that detect heat radiation. In the heat category are black-body radiation detectors. All bodies radiate energy proportional to their absolute temperature. As the temperature of a black body increases, it emits electromagnetic radiation at higher intensities and shorter wavelengths.

Detectors that sense only heat cannot detect sparks or embers until they reach a certain minimum temperature, and are in close proximity to the sensor. Fire prevention systems based only on heat detectors rely upon the theory that only particles above a certain temperature are dangerous, and only those particles need to be extinguished. These detectors might miss sparks that, combined with proper conditions for combustion which materialize farther downstream, may still result in a fire or explosion. The only way to be sure that a spark is not going to create ignition in the process is to detect and extinguish all sparks. Because of this, the NFPA specifies in its Standard 664 paragraph A.8.6.2.2, "The spark extinguishing system should activate every time a single spark is detected."

Industry expert, Dr. Vahid Ebadat of Chilworth Technology Inc., a firm that investigates explosions, concurs, saying, "The 'bottom-line' response to this question would be a suggestion to consider the above-quoted guidance from NFPA 664, and detect and extinguish every single spark".

The preferred technology for spark detection in most applications is to utilize detectors that are designed to detect light energy in the near infrared (IR) range, as proven in over 100,000 successful installations worldwide. This methodology is more effective at identifying possible ignition sources in the incipient stage, before combustion starts.

Spark detectors see the infrared energy emitted by a spark, and because of the properties of infrared light, it can see sparks and embers through many types of material and even reflections of embers that heat detectors cannot. Light from a spark or ember in the near infrared range can also be detected at much greater distances than heat.

Heat radiation becomes harder to detect the farther the detector is from the source. According to the Inverse Square Law:

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For point sources, intensity of the radiation varies inversely with the square of the distance from the source. Doubling the distance reduces intensity of the radiation by a factor of four, (1/4 of its original value).

Figure 1. Infrared detectors (FM 1/8 and FM 3/8) by GreCon are capable of detecting sparks in material flows up to 1200ºF using fiber optic cables. The blackbody radiation detector (DLD 1/8) is available for standard, high-temperature, and special applications. Detectors shown here include mounting adaptors.

In other words, at twice the distance from the detector, an ember must be four times as intense to be detected by a black body detector. Available black body heat detectors are limited to less than 30 in., whereas infrared light spark detectors can detect hazardous conditions reliably in large ducts and transitions much greater than 30 in.

In heavy product flow, the material inside the conveyor or duct can act as insulation and mask the heat signature from a spark or ember and thus these hazards can pass the heat detector without being detected. Black body or "hot particle" heat detectors are best suited for applications where there is ambient light present, such as drop chute transitions onto or from belt conveyors with detectors viewing through the cascading material on opposite sides of the chute. This configuration of two opposing heat detectors versus one single detector provides a far greater detection area and greatly reduces the material masking effect.

Detector Applications

Because of the wide variety of materials being transported in ducts and the varying duct shapes and dimensions involved, different types of IR spark detectors have been developed for various applications.

Low-pressure pneumatic conveying systems with ambient air temperatures use a standard IR spark detector (GreCon FM 1/8 Spark Sensor). The example shown in Figure 1 mounts onto the duct and detects sparks and embers through the material stream.

For applications involving high temperature or high pressure conveying, IR spark detectors using stainless steel clad fiber optic cables connecting it to the duct cross sectional viewing area should be used. Using fiber optic cables protects the sensor electronics from the radiant heat of the transport or conveyor from a material dryer or other heat source. The cable-equipped sensors shown in this example can detect sparks and embers in air stream temperatures up to 660°F, and 1200°F with a special adapter this exposes the lens to abrasion that wears through the lens until the sensor is compromised and its components are exposed to the environment within the duct. These conditions affect the sensor's ability to function properly and make the system unreliable over the long-term.

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– without the use of cooling air. They can also be applied to high-pressure and dense-phase transport systems where a denser material flow is normal and the material abrasion of the sensor lens may be a problem. In this case, these fiber optic cables use a hard blue sapphire lens to protect against abrasion.

In applications where ambient light is present a black body radiation detector is used. One application, a pellet mill for example, is at the outlet of a pelletizer and in a cooler to detect embers and overheated pellets. Two opposing sensors are preferred to ensure the full coverage of the material stream. For high-temperature applications a version of these sensors is fitted with fiber optic cable. The third type of black body sensor has a higher spectrum response for special applications.

Detector Mounting

The manner in which detectors are mounted on ducts also makes a difference. In the interest of achieving a maximum field of view, some black body sensors employ rounded globe type lenses that project into the duct and material flow (see Figure 2). Depending on the type and size of material,

A better way to achieve the required visibility, while reducing the exposure of the sensors to wear and tear, is to use sensors with flat lenses and mount them flush on opposite sides of the transport duct (see Figure 3 and 4) where the material flow helps keep the lenses clean. Using paired IR detectors on either side of a duct has the benefit of ensuring redundant detection from different viewing angles throughout the duct section.

Processing Plant Application

A large processing plant will use multiple spark detector pairs in different key locations. One example, the wood pellet mill shown in Figure 5 includes detectors at the output of the dryer, the hammer mill, pellet press, and cooler, as well as the conveying systems between each production process, and all dust collection systems. Atomized water extinguishment systems with plug-free nozzles are used in some areas and fire dump valves are used to remove burning materials from the process. Other countermeasures can be triggered including deluge valves, abort gates, equipment shutdown or programmable logic controller (PLC) actions. These are accomplished using advanced control consoles.

Figure 2. Detectors that protrude into ducts can be rendered ineffective by abrasion from material flow in very short periods of time. These internal components are now exposed to the conveyer's environment. Source: Industrial Fire Prevention LLC.

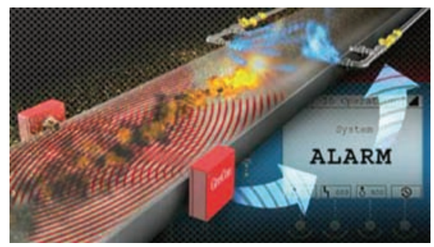

Figure 3. The optimal orientation of IR spark sensors for complete duct coverage is to place one sensor opposite another on each side of the duct, upstream of the fire extinguishing devices. Shown in the pneumatic conveying duct cutaway are infrared spark detectors. The red lines represent full view of the material traveling through the duct. Downstream of the detectors is the extinguishment system. The detector to extinguishment distance is a formula of air speed and system factors. Refer to NFPA 654 Annex C on Spark Detection.

Figure 4. IR spark detection mounted flush on duct wall with as little protrusion as possible using stainless steel adapters. The label indicates this spark detector is Factory Mutual approved.

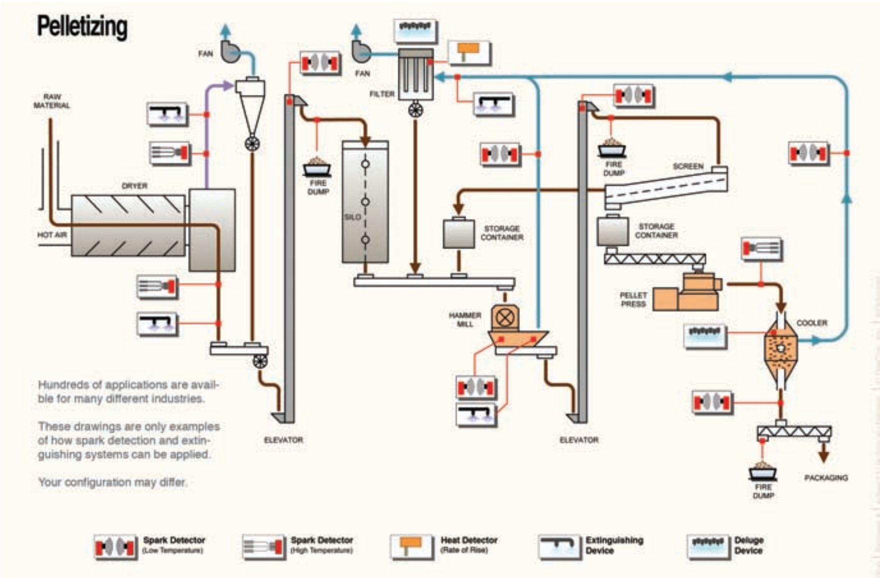

Figure 5. A large plant such as this pelletizing mill may include many IR spark detectors and other types of detectors triggering countermeasures.

Advanced multi-microprocessor control consoles can monitor and alarm on various hazardous conditions with the processing plant using various types of detection. Other possibilities include smoke detectors, rate of heat rise detectors, combustion gas detection, flame detectors along with the standard IR spark detectors and black body radiation detectors. These advanced control consoles can also trigger multiple combinations of countermeasures from multiple detection zones and can be setup for complex special configurations.

Industrial Equipment Approvals

Process industry professionals know that when a technology is Factory Mutual Approved, it has undergone extensive testing to ensure it delivers on its promise and is reliable. Fire and explosion safety equipment that is FM approved has been certified to reduce risk of property loss and as an added benefit many insurance companies provide discounted rates. When choosing any type of safety system, one should consult with the supplier to ensure that not only the correct technology is being installed, but that the equipment meets the highest industrial safety standards as well (see figure 4).

Awareness is the key to fire and explosion prevention, and the key to protecting material transport systems is in understanding the effectiveness of different spark detection technologies. With an eye to reliable safety, IR spark detectors have proven effective in providing maximum safety in helping prevent fires and explosions in the process industries.

Jeffrey C. Nichols, managing partner, Industrial Fire Prevention LLC, process safety specialist, has been helping to prevent industrial conveying and dust collection system fires and explosions since 1979. For more information, visit www.IndustrialFirePrevention.com, e-mail info@IndustrialFirePrevention.com, or call 770-266-7223.