Combustible dust hazards and explosion safety have become increasingly urgent concerns in bulk solids processing and handling plants. In this two-part article, a dust collection expert expands on Powder and Bulk Engineering’s recent coverage of these issues by providing information on how to prevent explosions in dust collection systems and how to isolate the connected bulk solids process from a dust collector explosion. Part I appeared in October.

Explosion isolation

If a deflagration occurs in your dust collector, a pressure wave and flame front will propagate through the ductwork to upstream and downstream equipment even if the dust concentration in your ductwork doesn’t exceed the dust’s MEC. The flame front is a serious hazard to anyone working near the dust capture hoods. If the ductwork’s dust concentration does exceed the MEC, the deflagration will propagate through the duct and cause pressure piling (that is, the pressure wave ahead of the flame front will add to the pressure in the connected equipment). This pressure piling can exceed the explosion protection capability of the downstream equipment — such as a cyclone — and cause it to fail. You can prevent this by using an explosion isolation device in the duct, which will confine the explosion to the collector and block it from propagating to upstream and downstream equipment. The device should be installed on the main dirty-air ducts connected to your dust collector. If you recirculate the collector exhaust back to your building, you must also isolate the exhaust airstream at the dust collector outlet (discussed in the sidebar “Special caution: For plants recirculating collector exhaust” in Part I).

Isolation devices come in two types: active and passive. An active device has a detector to sense the deflagration and electronic controls to signal an actuator to activate the device and isolate the duct. A passive device works mechanically, with little or no electronic control.

Active isolation devices. Active isolation devices, covered in Chapter 11 of NFPA 69, include dry chemical suppression devices, fast-acting mechanical valves, externally actuated float valves, and fast-acting pinch valves.

A dry chemical suppression device is the same device discussed in Part I as an explosion prevention method. In Figure 1, two dry chemical suppression devices (at right) have been installed to isolate dirty-air ducts connected to a dust collector. Using such a device to isolate a duct will stop the flame front from entering the duct but won’t isolate the pressure wave produced by the suppressed explosion ($P_{\text{reduced}}$).
A fast-acting mechanical valve, as shown in Figure 2a, is a slide-gate valve with an actuator. The actuator can be a nitrogen reservoir (shown at left in Figure 2a), compressed-air reservoir, or gas-cartridge actuator (shown at right). When the detector senses a deflagration, the controls trigger the actuator to close the valve within milliseconds after the detector sends the signal. Keep three installation cautions in mind with this valve: You must locate the valve far enough away from the dust collector to allow enough time for the valve to react and close before the explosion’s pressure wave and flame front get to it; you must strengthen the duct where the valve is installed to withstand the inertia created by the valve’s mass as the valve closes; and you must also strengthen the duct between the valve and the collector to ensure that it can resist the pressure wave. This valve stops both the pressure wave and flame front from entering the duct.

An externally actuated float valve looks like a slightly flattened sphere (the float) with guides in the duct for the float to slide along, and it operates somewhat like a ball check valve. When the valve’s detector senses a deflagration, the controls trigger an actuator to quickly push the float across the duct, closing the valve. The valve is used only on a collector’s clean-air ducts to prevent the float’s sealing surface from becoming fouled by dust. You must provide strong duct support where the valve is installed to prevent the duct from moving when the float moves. This valve stops both the pressure wave and flame front from entering the duct.

A fast-acting pinch valve, as shown in Figure 2b, is a valve with a rubber or elastomer sleeve inside the duct and a compressed-air actuator attached to the valve. When the detector senses a deflagration, the controls trigger the compressed air’s release, which closes the sleeve. You don’t need to provide additional duct reinforcement when using this valve because the sleeve’s closing action produces much less inertia than that of a mechanical or float valve. This valve can stop both the pressure wave and flame front from entering the duct, but the valve’s rubber or elastomer sleeve won’t last very long in contact with flames.

Passive isolation devices. The passive isolation devices covered in Chapter 12 of NFPA 69 include flame-front diverters, passive float valves, and mechanical chokes (rotary airlock valves). Backdraft dampers, commonly used in Europe, aren’t listed in NFPA 69 but are considered acceptable by some Authorities Having Jurisdiction (that is, the organization, office, or individual responsible for enforcing the standard or for approving explosion isolation equipment, materials, installations, or procedures).

The dirty-air duct from the process enters this expansion section at a sharp angle, forcing the dirty air to reverse approximately 180 degrees to flow toward the collector.

A flame-front diverter, as shown in Figure 3a, relieves a deflagration’s pressure wave from a specially shaped duct on the dust collector and a relief membrane (or door) to the atmosphere. The duct turns upward at the collector and has an expansion section that fits the relief membrane. The dirty-air duct from the process enters this expansion section at a sharp angle, forcing the dirty air to reverse approximately 180 degrees to flow toward the collector. The pressure wave and flame front from a dust collector deflagration will rush into the expansion section and open the relief membrane, bypassing the dirty-air duct to the process. This device is best suited to applications handling dusts with lower \( K_{St} \) values (\( K_{St} \) is the maximum rate of pressure rise normalized to a volume of 1 meter), so ask the diverter manufacturer at what \( K_{St} \) value the device has been demonstrated to ensure that it can handle your dust. Also be aware that the device may not be suited to handling an abrasive or sticky dust, which can erode or coat the relief membrane.
A **backdraft damper**, as shown in Figure 3b, operates like a check valve on the duct, with a reinforced flap that slams shut when a deflagration occurs. The raised flap at right in Figure 3b is normally lowered over the opening, and airflow from right to left through the valve partially opens the flap. When a deflagration occurs in the dust collector, the pressure wave reverses the airflow, slamming the flap shut, which blocks the pressure wave and flame front from entering the duct. The backdraft damper is built and tested to handle your dust’s maximum explosion pressure ($P_{\text{max}}$) and $K_S$ value. Install the valve on the collector’s dirty-air duct at the distance from the collector recommended by the manufacturer.

A **passive float valve**, as shown in Figure 3c, is actuated by the deflagration’s pressure wave traveling ahead of the flame front from the dust collector through the valve. The pressure difference and airflow from the pressure wave—rather than an external actuator, as in the active isolation float valve—cause the float to block the duct and stop the deflagration from entering it. Because this device can easily become fouled by dust, it’s probably best suited for use on clean-air ducts.

A rotary airlock valve at the dust collector hopper outlet can serve as a **mechanical choke**, as shown in Figure 3d, to block a flame front. For this application, the valve body and rotor should be all metal, and the valve should have at least six vanes to prevent creating a direct path for the flame front to pass through it. The valve can block the flame front as long as the installation meets one of two conditions: The material level in the hopper above the valve’s inlet flange is always equal to or greater than the valve inlet’s equivalent diameter or 1 foot deep, whichever is larger, or the valve has a small enough vane-tip-to-valve-body clearance (0.0079 inch or 2 millimeters) to quench the flame. The latter option is generally better because it allows the valve to work when the collector hopper has been fully discharged. The valve’s tight clearance stops the pressure wave from exiting the hopper, but the valve must be turned off to prevent flaming embers from passing onto the next process step.

**More NFPA 69 requirements**

Requirements for design documentation, installation, commissioning, inspection, maintenance, and record-keeping for explosion prevention and isolation equipment are also included in NFPA 69. Chapter 15 covers retroactive requirements that apply to both old and new equipment, including:

- **Inspection**: Workers trained by the manufacturer must inspect your explosion prevention or isolation equipment quarterly, in accordance with the manufacturer’s specifications. This inspection covers routine items such as checking for dust fouling on backdraft dampers, float valves, and other equipment in which the fouling can im-
pair the equipment’s operation. During inspection, workers should also verify your explosion prevention or isolation equipment’s process interlocks. These interlocks ensure two things: that the equipment is armed or operating before the process can start, and that a detected explosion both activates the explosion protection equipment and shuts down the appropriate process equipment. Annex A in NFPA 69 provides a detailed checklist for the inspection process, and you should modify the checklist to fit your installation.

You need to provide initial and annual refresher training to operating, maintenance, and supervisory personnel exposed to the equipment protected by explosion prevention and isolation devices in your plant.

- **Procedures following system activation:** If the explosion prevention or isolation equipment activates, workers should identify and correct the activation’s root cause. They should also inspect the entire process and dust collection system for damage and complete the quarterly inspection checklist to ensure that the system is unimpaired.

- **Recordkeeping:** Over the life of your process, your plant owner or operator must keep on site the explosion prevention and isolation equipment inspection records for the most recent 3-year period.

- **Personnel safety and training:** You need to provide initial and annual refresher training to operating, maintenance, and supervisory personnel exposed to the equipment protected by explosion prevention and isolation devices in your plant. The training should cover workplace hazards, the explosion prevention and isolation equipment, operating and emergency procedures, and OSHA lockout-tagout procedures.

- **Management of change:** As part of a formal “Management of Change” procedure, you should closely review any change to your materials, process, process flowrates, or procedures involving your explosion prevention or isolation equipment. You need to make an annual statement in writing declaring that no unauthorized changes were made to these items and then keep these records for the life of your process.

**Some final advice**

The information here concentrates on methods and equipment covered in NFPA 69 for protecting dust collection systems from explosions. For information on handling other explosion safety issues with dust collection systems, see NFPA 654, which is the standard for general industry, as well as the industry-specific NFPA standard that applies to your plant. Right now, OSHA is working on developing general industry regulations for handling combustible dust. That makes now a good time to analyze your dust collection system to see how it measures up to current NFPA and OSHA combustible dust standards and then do what’s necessary to make the system safe.

**References**

1. Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471; 800-244-3555, fax 617-770-0700 (www.nfpa.org).


**For further reading**

Find more information on explosion safety and dust collection systems in articles listed under “Safety” and “Dust collection and dust control” in Powder and Bulk Engineering’s comprehensive article index (in the December 2008 issue and at PBE’s Web site, www.powderbulk.com) and in books available on the Web site at the PBE Bookstore. You can also purchase copies of past PBE articles at www.powderbulk.com.

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