Meeting explosion safety requirements with flameless venting

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Flameless venting is a recently developed technology for protecting indoor equipment from dust explosions. This technology provides a ready solution for some applications where conventional explosion venting can't provide the required protection. After describing the flameless venting device and how it works, this article explains how to select a device that complies with National Fire Protection Association requirements.

Flameless venting is a relatively new dust explosion protection method for indoor equipment that combines conventional explosion venting with flame-quenching techniques. Flameless venting devices meet increasingly strict explosion safety regulations for bulk solids plants and overcome the limitations of conventional ducted explosion venting in some applications. Flameless venting devices can also be retrofitted to existing equipment installations.

The need for flameless venting

Conventional explosion venting has long been the most common method of protecting indoor process and storage vessels, enclosed conveyors, and other equipment from the effects of a dust explosion. An explosion vent is an opening in a vessel's top or side that provides pressure relief during an explosion. Ducting directs the vent discharge outside the building, protecting people indoors and preventing dust deposits outside the vessel from becoming involved in a secondary dust explosion. This ducting has a substantial effect on the pressure experienced inside the vessel during the venting process, and the vent area calculation must allow for this effect.[1]

However, in some cases, the pressure increase can be so great that an alternative protection method is required. The flameless venting device provides a ready solution for these cases by combining explosion venting and flame-quenching techniques. The device can be added to existing equipment, allowing bulk solids processors to retrofit their equipment to meet today's more stringent explosion safety regulations.

In the US, flameless venting devices must comply with the National Fire Protection Association (NFPA) standard *NFPA 68: Standard on Explosion Protection by Deflagration Venting* (2007),[2-3] which OSHA has the authority to enforce. In Europe, the devices must comply with European Standard pr EN 16009 "Flameless explosion venting devices."[4] This article concentrates on US requirements.

While the flameless venting device is used primarily on indoor equipment, it's also well-suited to outdoor equipment that's adjacent to buildings or roads, where a vented explosion's flame and pressure effects can't be safely controlled. The flameless venting device can be used in most applications handling nontoxic dry bulk materials.

How a flameless venting device works

Components. A flameless venting device, as shown in Figure 1, is a passive device that typically includes an explosion vent panel and a flame-quenching element that's inside a flanged metal frame; the frame attaches the element to the process equipment, such as a dust collector.

The element is closed at one end and open at the other, and it's bolted onto the explosion vent opening on the equipment so that its open end overlaps the opening. The flame-quenching element's frame encloses layers of particle-retaining, high-temperature stainless steel mesh or carbon steel mesh, as shown in Figure 2, or ceramic material. The flame-quenching element may be cylindrical, rectangular, or square to fit the vent opening's shape.

Figure 1

Flameless venting device (exploded view)

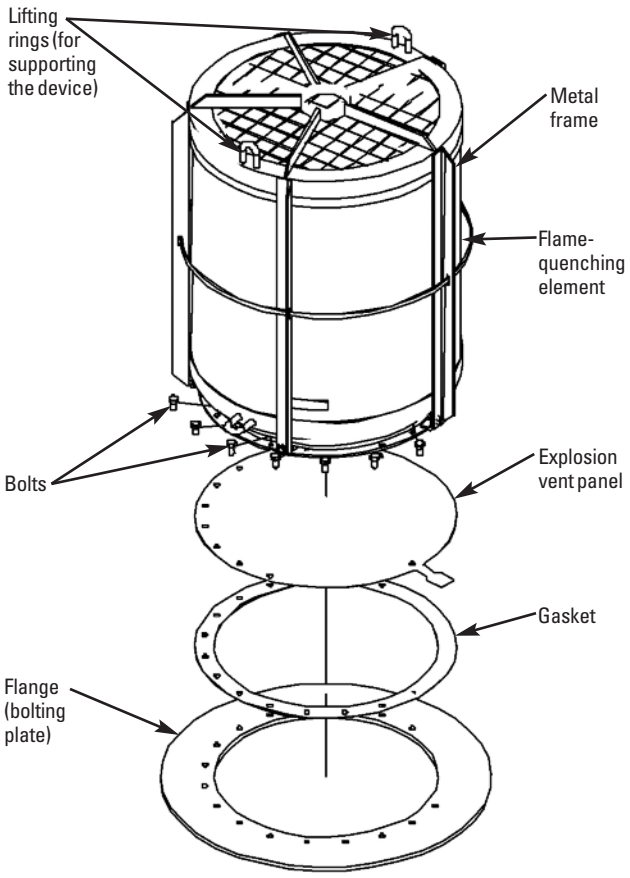
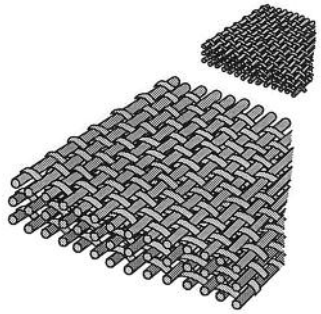


Figure 2

Layered steel mesh inside flame-quenching element



Operation. During the early stages of an explosion inside the process equipment, the explosion vent panel opens. As the explosion expands, flame and burnt and unburnt dust discharge through the open vent into the flame-quenching element. Most of the dust is retained inside the element, and the energy (heat) dissipates as it travels through and is absorbed by the steel mesh or ceramic material inside the element. This reduces the burning fuel's temperature below the fuel's ignition temperature, extinguishing the flame and preventing flame propagation beyond the device. Only a small amount of dust passes through the flame-quenching element, and post-combustion gases from the explosion are safely vented through the device into the external atmosphere around it. The flameless venting device's operation not only extinguishes the flame and retains dust, but eliminates the need for explosion vent ducting and minimizes the vent relief area required for indoor explosion venting.

Available types. Flameless venting devices of various shapes are shown in Figure 3. Many are designed to suit particular storage and process equipment such as silos, bins, hoppers, dryers, mixers, dust collectors, and cyclones, and handling equipment such as enclosed belt conveyors, screw conveyors, and bucket elevators.

NFPA 68 provides detailed guidance for calculating the flameless venting device's explosion relief area and designing the venting system to ensure that the device complies with applicable explosion safety guidelines.

Selecting the device to comply with NFPA 68

When selecting a flameless venting device, you'll need to work closely with the manufacturer to ensure that the device will provide safe explosion venting in your application. NFPA 68 provides detailed guidance for calculating the flameless venting device's explosion relief area and designing the venting system to ensure that the device complies with applicable explosion safety guidelines. The standard applies to the design, location, installation, maintenance, and use of equipment that vents deflagrations from enclosures to minimize structural and mechanical damage.

NFPA 68 addresses several key requirements for flameless venting devices (called *flame-arresting vent systems* and *particulate retention vent systems* in the standard). The standard:

- Discusses limitations and safety considerations for flameless venting devices and states that, when selecting a device, the user should consider the room's volume, how

Figure 3

Flameless venting devices of various shapes

a. Round (on a hopper)

b. Rectangular (on a bucket elevator)

c. Square (on a dust collector)

close personnel will be to the device, whether a combustible mixture may be present outside the equipment, and whether the equipment may release toxic emissions.

- States that the flameless venting device must cool explosion gases, prevent flame from emerging, and greatly reduce near-field blast effects (overpressure) outside the equipment.

- Discusses the need to consider effects of overpressure when venting equipment within a building. Even when the device completely retains flame, the area immediately surrounding it can experience overpressure and radiant energy (heat). To limit overpressure, the user must consider the expected overpressure in relation to the plant building's strength and consider adding building venting. [***Editor's note:*** Find advice on how to do this in the section "More selection advice."]

- States the need for the user to work closely with the venting device manufacturer to ensure that the previous three parameters are addressed.

Because there's no formal certification process in the US for flameless or other venting devices, you'll need documentation from the manufacturer (and any installing contractor) to ensure that the flameless venting device will satisfy NFPA 68 requirements. This includes documentation that states the device has been manufactured and installed according to NFPA 68. The manufacturer should also document the device's design according to NFPA 68 Table A.11.2 and provide a vent sizing calculation sheet and a certification that the calculations comply with NFPA 68 requirements.

Calculating the device's required vent relief area

An important part of designing a flameless venting device that complies with NFPA 68 requirements is to calculate the device's proper size — that is, its required vent relief area — for the application. This requires considering the device's overall *venting efficiency.* Venting manufacturers perform large-scale testing of their flameless venting devices to determine the overall venting efficiency correction factor for these devices in comparison with a conventional explosion vent's efficiency.[5] This is because the flame-quenching element on the flameless device restricts the flow of flame and gases from the vent opening and reduces the effective explosion-relief area compared with that of a conventional vent. This correction factor must be applied to vent area calculations to yield the required vent relief area increase for the flameless device over the conventional vent's required vent relief area.

Let's consider an example application, in which we'll determine what type and size of venting to install on a cylin-

drical hopper handling wood fiber. The hopper, which is installed indoors, requires either a conventional explosion vent with ducting to the outdoors or a flameless venting device; the flameless venting device must have FM Global approval.[6] The hopper has a 50-cubic-foot volume and length-to-diameter ratio of 1, giving the vessel a compact rather than elongated shape. The hopper has a P_{stat} (relief device [or burst panel] static opening pressure) of 1.45 psi and a P_{red} (reduced explosion pressure; that is, the maximum calculated pressure developed in the hopper during a vented explosion) of 4.5 psi. Based on material characterization testing, we've determined that the fibrous wood dust has a K_{St} (the dust's maximum rate of pressure rise normalized to a 1-cubic-meter volume) of 120 bar-m/s and a P_{max} (the dust concentration's maximum explosion pressure) of 102 psi.

Using the vent area calculations in NFPA 68 with these vessel and dust parameters, we calculate the required vent relief area for this hopper to be 1.0 square feet (144 square inches).

- To select a conventional explosion vent that can provide this required vent relief area, we use the NFPA 68 vent area calculations for this device with our vessel and dust data. The hopper's indoor location requires designing, constructing, and installing a vent duct leading to a safe flame discharge area (with a typical perimeter of about 66 feet) outside the building wall. The NFPA 68 vent area calculations for a ducted explosion requires a vent relief area of 2.54 square feet, so we select a 24-inch-diameter round vent. Installing the vent duct will also require penetrating the wall.

- To select a flameless venting device that can provide the required vent relief area in this application, we use the NFPA 68 vent area calculations for flameless venting devices with a 54.2 percent venting efficiency correction factor (determined from tests of one manufacturer's 8- to 20-inch flameless venting device[7]). This gives:

  Required flameless venting device area
  = 1.0 square feet/(54.2/100)
  = 1.85 square feet (266 square inches)

  One 20-inch flameless venting device installed on a 20-inch explosion vent panel on the hopper will supply a 2.02-square-foot vent relief area, exceeding the calculated required area of 1.85 square feet. In addition, the flameless venting device offers these practical advantages: Unlike a conventional explosion vent, the flameless venting device eliminates any need for vent ducting and, thus, any need to penetrate the building wall to vent explosion flames.

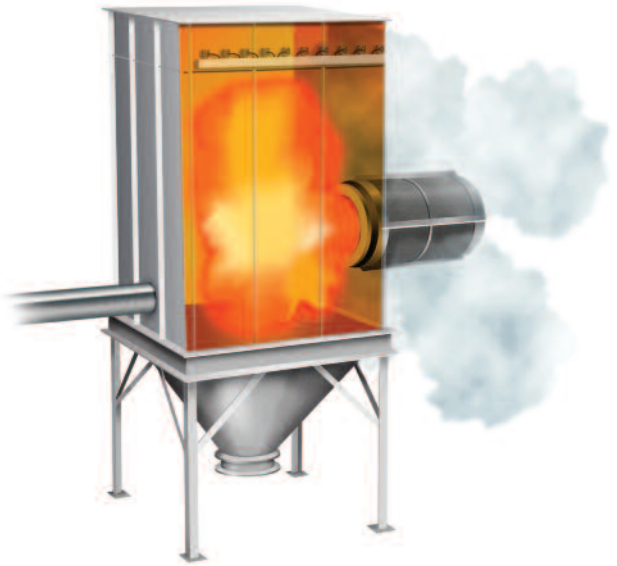
Note: The venting efficiency factor for any conventional explosion vent or flameless venting device is specific to the manufacturer and often to the application, as well. Select either type of device based on the manufacturer's recommendation.

More selection advice

Some application limits. The equipment volume that a single flameless venting device can protect is limited, so be sure that you know this limit for the device you select. Because flameless venting is a relatively new technology, manufacturers have yet to complete extensive performance testing of the device on large-volume vessels such as silos. If you're planning to use a flameless venting device on a silo or other large vessel, work closely with the manufacturer to ensure that the device is properly selected for your vessel.

If your equipment handles a fibrous dust, be aware that it has a greater tendency to clog the flame-quenching element than other dusts; for such an application, consult the manufacturer for selection guidance. The flameless venting device isn't suitable for applications handling toxic materials or metal dusts.

Approaches for limiting building overpressure. Also consider how to limit overpressure in your plant building resulting from the flameless venting device's operation, as discussed in NFPA 68. This requires determining the expected overpressure the flameless venting device will produce in relation to the building's strength and considering whether you need to add venting to the building to handle the overpressure. One practical approach is to use a volume ratio between the protected equipment and the building containing it. Typical ratios are 1:9 for a reinforced or



A flameless venting device combines conventional explosion venting with flame-quenching techniques.

vented building and 1:15 for a building not specifically reinforced. So, for example, a 200-cubic-foot storage bin with a flameless venting device would require the building to be vented or reinforced if the building's volume is less than 1,800 cubic feet. You can also use another more or less conservative approach (based on calculating the explosion's pressure increase) if the results of large-scale testing by the device manufacturer support this approach.

At installation, provide adequate support for the flameless venting device so that its weight and reaction force during venting won't damage your equipment.

Installation, inspection, and replacement advice

Because radiant heat, combustion gases, and a small amount of dust are released from the flameless venting device during an explosion, locate the device a safe distance from workers. They should work no closer than a distance equal to 2 times the device's longest side from the device discharge.

At installation, provide adequate support for the flameless venting device so that its weight and reaction force during venting won't damage your equipment. For example, some flameless venting devices are equipped with lifting rings (Figure 1) that may be attached to cables, rods, or beams to support the device.

Once the device is installed, routinely inspect the device, the explosion vent panel it covers, and the device's support mechanism according to the inspection checklist in NFPA 68 section A.11.4. Keep on file the documentation provided by the manufacturer and installing contractor that states the flameless venting device has been manufactured and installed according to NFPA 68.

If an explosion occurs in your equipment and causes the flameless venting device to operate, replace the explosion vent panel the device covers, the flame-quenching element, and the bolts and gaskets attaching the element to your equipment. **PBE**

References

1. For more information on explosion venting and designing vents, see Solids Handling and Processing Association (SHAPA) *Technical Bulletin 10: Sizing of explosion relief vents,* by Mike Ward, available from SHAPA (www.shapa.co.uk/materials-handling-public.php).
2. Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471; 800-244-3555, fax 617-770-0700 (www.nfpa.org).
3. Find more information on NFPA 68 explosion venting requirements in these recent *Powder and Bulk Engineering* articles: "Five ways new explosion venting requirements for dust collectors affect you" by Lee Morgan and Tony Supine (July 2008, pages 42-49) and "Designing your dust collection system to meet NFPA standards" by Gary Q. Johnson (Part I, December 2008, pages 53-59; Part II, January 2009, pages 89-95). For information on purchasing articles, see "For further reading."
4. For more information on European explosion safety standards, contact the author.
5. For information on recent large-scale tests conducted by Fike Corp., Blue Springs, Mo., contact the author. Find information on Fike Corp.'s earlier flameless venting device tests using explosion chambers in "Efficiency of flameless venting devices" by John E. Going and Kris Chatrathi in *Process Safety Progress,* March 2003, Vol. 22, No. 1, pages 33-41.
6. FM Global is an insurance company that performs engineering analysis of physical and financial risk to prevent or mitigate property losses to companies; the firm provides third-party FM Approval certification for products, such as venting devices, that protect property from loss.
7. FlamQuench II flameless venting device, Fike Corp., Blue Springs, Mo.

For further reading

Find more information on explosion venting in articles listed under "Safety" in *Powder and Bulk Engineering*'s comprehensive article index (in the December 2009 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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