Dust Explosion Protection System – A Food Processing Imperative

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Abstract

The devastating consequences of dust explosions are widespread and lasting, though with proper prevention and protection efforts, the risks can be reduced to an acceptable level. For food and beverage processors who deal with dust on a daily basis, the challenge is heightened but yet still manageable. This paper introduces today's explosion protection solutions, and provides guidance on how to accurately match the available techniques to typical applications.

WHITE PAPER

INTRODUCTION

Food and beverage manufacturing plants are sanitary, hygienic environments, and yet they are still prone to dusty conditions. Fine, dry products and materials such as sweeteners, starches, and flour pose a distinct fire and explosion hazard. Special attention must be paid to areas in or outside facilities where dusts are produced, processed, stored or transported, and can be lofted into the atmosphere. Otherwise, all that is needed is an ignition source with sufficient energy to cause a nightmarish event.

Explosion hazard mitigation and management begins with understanding the explosion properties of the material. When that information is not available, explosibility testing is needed. Once the material is characterized, explosion prevention and protection measures can be taken based on the intended application. Prevention is the first line of defense, whereas protection deals with the effects of explosions that do occur.

Four explosion protection techniques are used in the food processing industry: venting, flameless venting, suppression and isolation. They can be used separately or in combination depending on the application. It is important to understand the advantages and limitations of each technique in order to make the most effective explosion protection decisions.

Venting: Pressure Release

The most popular explosion protection technique by far is venting. This method is extensively described in engineering literature and standards such as National Fire Protection Association (NFPA) 68: Standard on Explosion Protection by Deflagration Venting [1] and European Norm (EN) 14491: Dust Explosion Venting Protective Systems [2]. The sanitary explosion vents used in food and beverage processing must accommodate partial vacuum conditions and a wide range of temperatures.

Venting protects a vessel from bursting by enabling pressure developed during an explosion inside the vessel to be safely released into the environment (Figure 1). A rupture diaphragm is placed on the vessel and designed to open at a static burst pressure (P_{STAT}) well below the pressure at which the vessel would be destroyed or damaged.

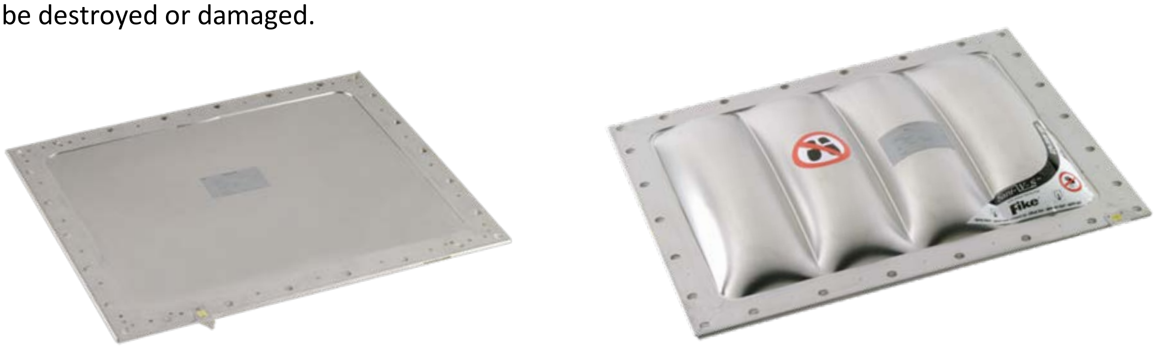

Fig. 1. Fike SaniV™ and SaniVS™ explosion vents

Key performances of a suitable vent include reliable PSTAT, fast opening and an absence of fragmentation.

Venting allows control of the pressure developed inside an enclosure, but it does not mitigate the hazards of the flame exiting from the vent (Figure 2). Because of these secondary dust explosion hazards, conventional venting is not recommended for enclosures located indoors [3].

Fig. 2. Dust explosion venting at Fike Remote Testing Facility showing venting with flame release

For indoor enclosures, vent ducts can be added to redirect the flame and pressure outside the building. This may, however, be difficult to apply effectively because adding a vent duct can increase the reduced explosion pressure inside the vented enclosure (PRED). An alternate approach is flameless venting

Flameless Venting: Pressure Release, Flame Arrest and Dust Retention.

The flameless venting technique was designed specifically to protect against dust explosions. Its purpose is threefold: to relieve pressure, quench the flame and retain the dust. In the early stage of an explosion, a vent panel opens and the dust (burnt and unburnt) is captured in the flame arrestor unit, which is composed of layers of stainless steel mesh. The flame-quenching unit may be cylindrical, rectangular or square (Figure 3).

Fig. 3. Fike EleQuench™ flame filter is designed for use on grain bucket elevator legs

Flameless venting offers a compact alternative to vent ducting with much greater venting efficiency. It also minimizes the blast, thermal radiation, and noise outside the protected equipment, and can, therefore, be used outdoors when secondary effects associated with conventional venting are a concern.

However, flameless venting does not fit all applications; a suppression system may be more suitable when there is limited space to install vents or when the processed material is toxic.

Suppression: Energy Absorption

Explosion suppression is an active technique with key advantages over conventional venting: there is no release of pressure, flame, or potentially toxic material into the environment because the explosion is dynamically contained within the enclosure. It also reduces the damage to the equipment and mitigates the potential fire hazards that can arise from an explosion.

Suppression systems typically are more expensive than vents but offer key advantages. An explosion suppression system typically consists of a pressure sensor, a control panel, and high rate discharge (HRD) suppressor(s) with appropriate dispersion nozzles. The ignition of a dust cloud within an enclosure produces a fireball which emits pressure waves. These are quickly detected by the sensor, which sends a signal to the control panel to initiate the discharge of the suppressant. Nitrogen and the suppressant agent are rapidly released into the vessel, extinguishing the fireball by reducing the temperature of the combustible material below a level necessary to sustain combustion.

Isolation: Propagation Prevention

Process equipment is very often connected to other parts of a facility by pipes or conveying systems. Any dust explosion that originates in an interconnected enclosure, even vented or suppressed, can propagate and reach other process equipment, causing extensive damage. Because the flame front will accelerate and stronger pressure effects will be produced, the resulting explosion in the secondary vessel can be much more violent than the initial event.

Explosion isolation protects against this hazard. Isolation can prevent flame propagation to a secondary enclosure, prevent pressure piling and flame jet ignition in the secondary enclosure, and prevent deflagration to detonation transition in pipes (high length to diameter ratio).

Isolation can be either passive or active. Passive systems are activated by the explosion itself and include diverters, float valves and flap valves (Figure 4). With flap valves, the pressure generated by the explosion will push a gate and close the pipe, thus preventing propagation of the flame to the protected parts of the process. Passive systems tend to be simpler and require less maintenance than active isolation systems.

Fig. 4. Fike Flap Valve ValvEx™ passive explosion isolation system

Active systems, on the other hand, require tripping by a sensor for activation. That trigger will either close a mechanical valve ahead of the flame front or inject an extinguishing agent into the pipe to stop further flame propagation. Active systems include chemical barriers, gate valves and pinch valves.

Isolation device placement is essential to its success. If the device is placed far from the ignition, the deflagration can generate high pressures in the pipes and damage the isolation device. If it is placed near the ignition, then it may not be entirely closed before the flame arrives.

Steps for Explosion Protection Selection

Choosing the appropriate explosion protection method for food and beverage processes involves answering basic application questions. They are outlined here and also illustrated in more detail in the selection flow chart below (Figure 5).

1. **Use explosion venting when** … the enclosure is outdoors.
2. **Use flameless venting when** … the enclosure is indoors and vent ducting is impractical.
3. **Use explosion suppression when** … the material is toxic, the enclosure is indoors and flameless venting is impractical, or when fire damage can be a concern.
4. **Use explosion isolation (passive or active) when** … the enclosure has interconnections.

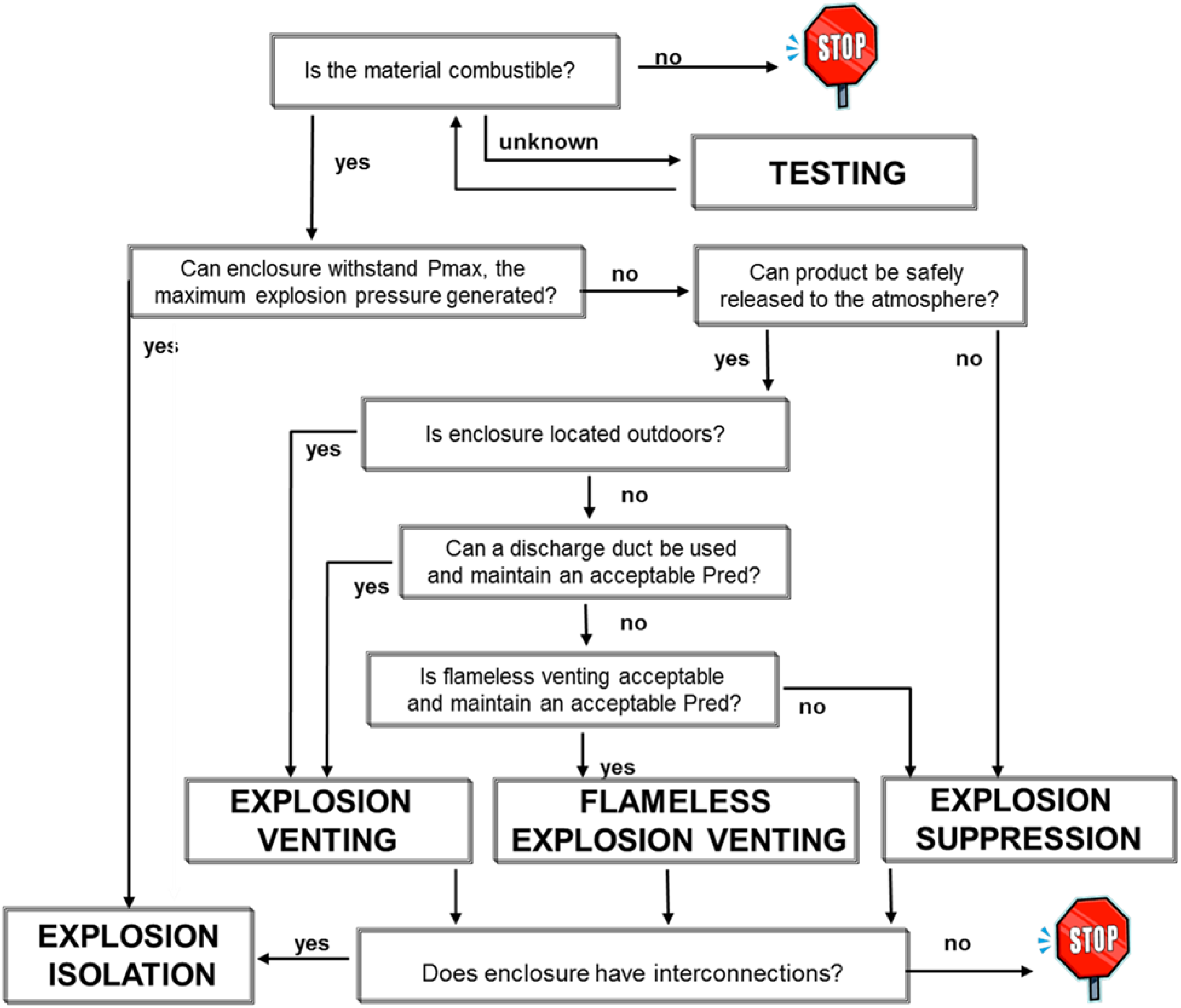

Fig. 5. Explosion protection selection chart (Fike Corporation)

Lean On the Explosion Protection Experts

Dust explosion protection is crucial to avoid what could otherwise become a catastrophic incident, costing lives, property, environmental integrity and reputational damage. Fortunately, food and beverage manufacturers have four effective methods available to address the different applications. To ensure the right decisions are made, consider working closely with an explosion protection manufacturer who can provide recommendations and suitable equipment to meet the business needs. Fike tests its explosion protection devices under realistic deflagration conditions at a large-scale to ensure full effectiveness.

About Fike Corporation

Fike Corporation is a globally recognized supplier of precision-engineered solutions for fire protection, explosion protection, overpressure protection and pressure activation. **Because so much is at stake™,** since 1945 our highly skilled workforce has designed and built solutions for Fortune 500 companies and businesses around the world that want peace of mind from experiencing consequences of serious financial loss or a devastating disaster. For more information about Fike Corporation visit www.fike.com.

References

[1] NFPA 68, Standard on explosion protection by deflagration venting (2013).
[2] EN 14491, Dust explosion venting protective systems (2006).
[3] J. Taveau, Secondary dust explosions: How to prevent them or mitigate their effects, Process Safety Progress 31 (2012) 36-50.

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