WHITE PAPER

Dust Collectors and Explosion Safety: Venting and Suppression

Explosive or potentially explosive dusts are a part of many industrial processes for which dust collection systems have to be designed to work. Ideally these systems should minimise or avoid the risk of an explosion, or ensure that in the event of an explosion the outcome can be safely controlled. In this article, we explore effective ways of venting and suppression.

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Zoning

There are two major European ATEX directives for equipment: 2014/34/EU (94/9/EC), and plant: (1999/92), the latter defining the zoning bases of safe systems. The higher the probability of an explosive concentration, the higher the level of safety required:

- Areas with a low probability of an explosive cloud, classified as zone 22.

- When a cloud can occur during normal operation the area, classified as zone 21.

- Areas where an explosive cloud is always present, or occurs frequently during normal operation, classified as zone 20.

Reducing risk of ignition by system design

Figure 1 - Dust collectors after a catastrophic explosion

From the safety perspective, the primary task is to reduce the risk of ignition. For systems with a low probability of an explosive cloud (Zone 22), elimination of the ignition sources in combination with a strictly monitored maintenance and training scheme might be sufficient, but as the consequences of an explosion are so severe it is seldom possible to reduce the risk to an acceptable level.

Thus it is necessary to design the system so that it poses no danger if and when there is an explosion. This applies to zones 20 and 21 for which malfunctions should also be taken into account; and in the case of zone 20, rare malfunctions as well. The two dominant ways to protect against catastrophic collapse are venting and/or suppression.

Venting

The most economic and reliable design of protection used most often is a pressure resistant collector body and a vent panel that opens to reduce the maximum pressure. If an explosion occurs there will be an increased pressure and a fireball inside. When the relief panel opens, the excess pressure is vented to the atmosphere. Together with the gas, there will be flames and unburnt fuel that creates a fireball outside of the vent opening.

The pressure will push flames back through the incoming pipe. In almost all cases, this needs to be further equipped with a protective system that stops the explosion from going back into the process, causing a bigger and potentially far more dangerous secondary explosion. There may also be flames travelling through the clean side of the unit if a cartridge has failed.

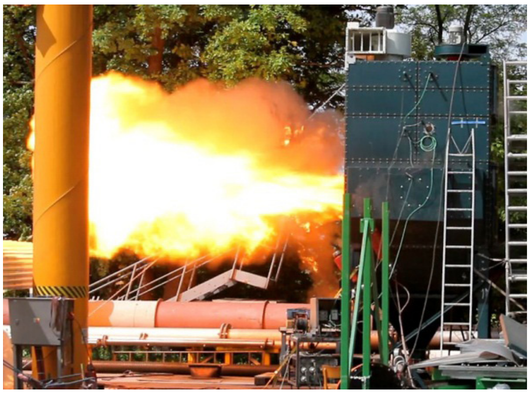

Figure 2 - A dust collector in test

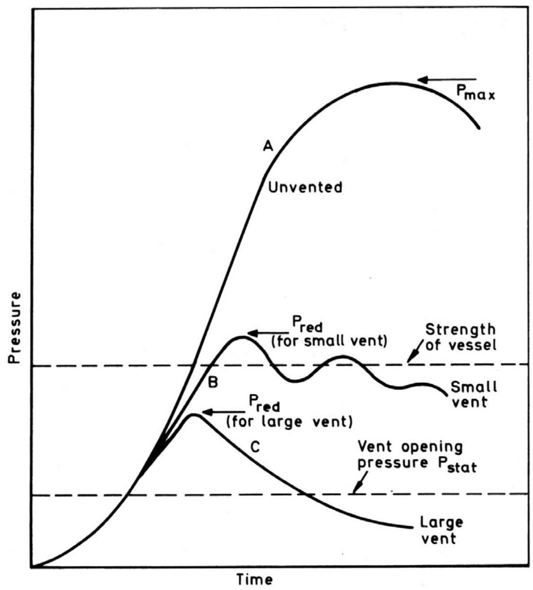

Figure 3 - Pressure during venting (Ref 1)*

Venting as a mode of protection creates several challenges. Firstly, the unit must be able to withstand the elevated pressure that occurs. This is not as high as without venting, but it can still be significant.

A common misconception is that the pressure will not increase beyond the opening pressure of the vent panel. In reality, the maximum pressure will always be higher than the opening pressure of the vent. The exact pressure in a single explosion is a very complex function of many factors, the most important of which are the dust, dust concentration, point of ignition and the geometry of the vessel/dust collector.

If the ignition occurs far from the vent or during turbulent flow conditions, the explosion will be more severe. This unpredictability is taken into account in the sizing standards for vents. These can sometimes be seen as excessive, but the nature of the problem makes it necessary to build in some margin for error. A good way to improve the accuracy is to undertake actual testing of the system.

Extensive testing has revealed that for some conditions selected units are able to go beyond the normal calculations, eg. by using longer vent ducts for some units. Testing also provides much more reliable data for vessel strength compared to computer calculation/ simulation.

When an explosion is vented, it is not only pressure and hot gases that are ejected, but unburnt fuel which causes a continued explosion on the outside (See Figure 2). The external explosion reduces the efficiency of the venting. If the dust collector is placed inside a building and the vent is connected via a vent duct, the external explosion will cause significantly reduced venting and the duct may see a similar pressure to the dust collector body. This limits the length of the duct, especially for highly explosive dusts.

The dust's explosivity is described by the KST (Bar m/s – normalized rate of pressure rise) and PMax (Bar – Maximum pressure in a closed vessel) values. This is fundamental; without knowledge of the dust properties it is not possible to apply a protection scheme with any degree of certainty.

Figure 4 - A dust collector with flame quench

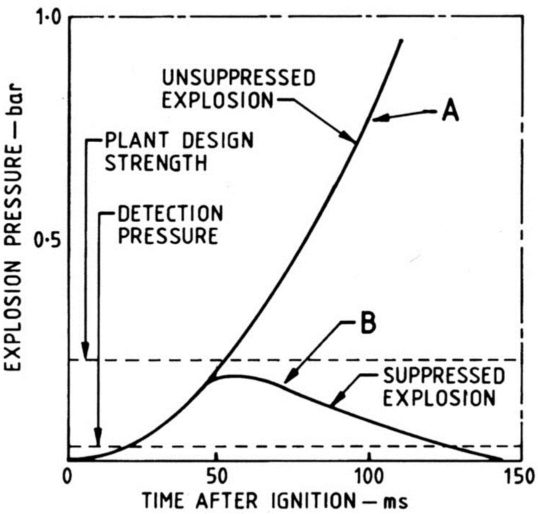

Figure 5 - Suppression and explosion pressure (Ref 1)*

When testing, it is also important to test a representative sample. What ends up in the dust collector is typically the more explosive fine fraction of dust, rather than the actual bulk product being processed. When you vent an explosion there will be a signifcant fireball expanding out from the vent. This means that you need to both mark the risk area and prevent people from entering it when the unit is in operation. Most importantly, the risk area cannot be used for storage, as the stored material can become projectiles or catch fire when there is an explosion.

Sometimes venting can be combined with a flame quench, a device that allows the pressure to pass through but cools down the material sufficiently to quench the flame. It also allows venting to be used indoors, but with certain limitations: the device cannot be used for highly explosive dusts, and because it reduces the efficiency of the venting, it increases the required vent area by about 50%.

Suppression

Suppression is the second method of securing a dust collector from the effects of an explosion. In principle, you detect the start of an explosion with a pressure detector, sometimes in combination with an infra-red detector, at which point you inject a suppression agent very rapidly. The agent used is a fire extinguishing powder adapted to the kind of dust being processed. It is vital the injected powder reaches sufficient concentration in the vessel before the explosion can fully develop.

Similar to venting, the dust properties are vital: if these change, the system may no longer be safe. The protected vessel also needs to be designed to withstand the elevated pressure that can occur.

The suppression system is managed by a central control unit, often operating several components that both suppress the explosion in the unit, and trigger mechanical or chemical barriers in incoming and outgoing ductwork.

Suppression systems have some important advantages. They can be located freely within the facility and there will be no release of product in the case of an explosion where a mechanical barrier is used. The downside is a more expensive system that needs more maintenance.


Figure 6 - A collector protected by suppression

Metal and organic dust

The effectiveness of both venting and suppression largely depends on the dust properties. Explosion safety research has shown that metal dust (mainly light metals) and organic dust with the same KST value do not always behave the same way. So it is essential to build in extra safety margins when working with exceptionally dangerous metal dusts.

Summary

Venting and suppression are the essential first steps in the design of any system for dealing with potential explosions. Following the basic steps outlined here will reduce significantly or even minimise the risk of explosions, but above all it make it much safer from the perspective of those operatives who work in the nearby environments.

Reference 1:

Dust Explosion, prevention and protection: a practical guide. Edited by John Barton

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About the author:

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