Are You Overprotected?

A rational approach exists for combustible dust explosion protection

By Dr.-Ing. J. W. Lottermann, Rembe Inc./Rembe GmbH Safety + Control;
and Eric Finley and Helen Sztarkman, Rembe Inc.

IT IS a given that dust explosion protection is expensive. While combustible dust explosions are less likely to occur than fires, when they do occur, they often are catastrophic events. This raises the issue of how much investment is necessary for appropriate protection measures.

Because such protection legally is required [1], the issue is not *whether* to provide protection, but rather it is *defining* appropriate explosion protection measures to avoid over-engineering.

NFPA STANDARDS

According to National Fire Protection Association (NFPA) 654, Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids, 2013, the employer must (1) determine and assess the combustible dust explosion risk by conducting a process hazard analysis as part of its obligation to ensure life safety, and (2) implement the "necessary and appropriate" safety measures [2].

Looking at NFPA 654, chapter 5.2.1.2, the life safety objectives with respect to an explosion hazard shall be achieved if either of the following criteria is met:

1) Ignition has been prevented, or

2) Under all explosion scenarios, no person […] is exposed to untenable conditions […] and no critical structural element of the building is damaged […].

Regardless of this performance-based design option, massive over-engineering is seen in practice. Simply stated, once companies are aware of the need for explosion safety, the "or" frequently is taken as an "and" so that the combination of both explosion prevention and explosion protection measures lead to expensive and excessive safety designs.

EXPLOSION PREVENTION VERSUS PROTECTION

In the first stages of any process hazard analysis, operators must determine the presence of combustible materials and whether they should anticipate the formation of explosive atmospheres in hazardous quantities. Although regulations and standards show preference to *avoiding* hazardous explosive atmospheres through substitute combustible materials [3], instead of using preventive safety measures, experienced operators know the practical relevance of this preferred preventive measure. For instance, a baker needs flour and sugar to bake, a power station burns coal, and wood dust is a natural by-product in chipboard factories. All these materials can cause explosive atmospheres. As

a result, the explosion hazard is a given in all of these examples when no real substitute would be safer.

If hazardous explosive atmospheres can't be prevented safely, the employer must assess the probability and duration of hazardous explosive atmospheres occurrences and the probability of the existence or the introduction of effective ignition sources. This assessment stage commonly is known as "classification" in the United States or "zoning" in the European Union (EU). [4]

But what frequently is forgotten when implementing these explosion safety measures in manufacturing processes is that the classification of hazardous locations into zones or classes also helps in providing protection priorities.

RISK-BASED, PROBABILISTIC APPROACH

Regardless of which global classification or zoning approach is used, the scope of explosion prevention measures depends on the probability of the occurrence of hazardous explosive atmospheres (zone, class and division). This probabilistic concept is based on the comparative assessment of the generally accepted residual risk (RR_{Ex}), which arises from a combination of the severity (A_S) and the probability of an explosion (P_{Ex}): [5]

$$RR_{Ex} = A_S \times P_{Ex} \qquad (1)$$

Because the probability of an explosion is characterized by the probability of a hazardous explosive atmosphere's existence ($P_{g.e.A.}$) and the probability of the occurrence of an effective ignition source ($P_{w.Z.}$),

$$P_{Ex} = P_{g.e.A.} \times \sum P_{w.Z.} \qquad (2)$$

this central requirement results:

$$RR_{Ex} = A_S \times [P_{g.e.A.} \times \sum P_{w.Z.}] \qquad (3)$$

To determine the appropriate protection, operators first must identify the hazardous locations and ignition sources in the process area. Many factors come into play, which is why a process hazard analysis is crucial when equipping a facility with explosion protection equipment. A comprehensive analysis will examine the entire facility and determine which prevention or protection techniques are required for each process instead of applying *everything* available. This is the first step in properly and efficiently controlling the combustible dust hazard present.

Next, operators should analyze the risk's severity because the severity can fluctuate depending on the situation. For instance, the explosion severity in a dust collector located in the middle of a facility is greater than the explosion severity in a dust collector located outside in an isolated area. It may be hard to determine the actual severity of an explosion taking place, so some type of protection will be required in all cases. This risk analysis provides only a way to prioritize which areas to protect first.

Taking the example of a dust collector system (Figure 1) that is protected with a flameless venting device and an explosion isolation device, operators need only to implement measures to *avoid* ignition sources, not *prevent* ignition sources. In the filter's raw gas and dirty air section, which normally is classified as hazardous Zone 20, Class II, Division 1, a rotary air lock classified in equipment category 3D (or equivalent) [6] also could be used if this rotary air lock was certified or approved to be pressure shock-resistant and flameproof.

However, a look into processing systems that

DUST COLLECTOR SYSTEM

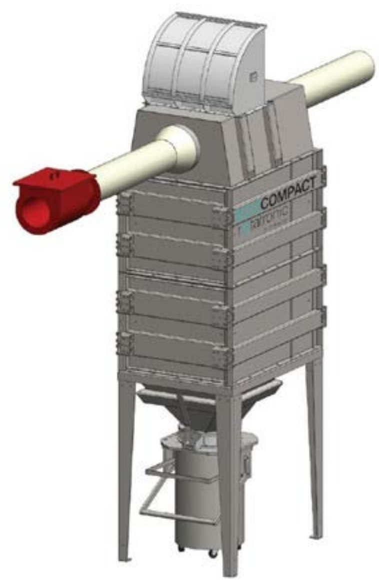

Figure 1: This type of dust collector system requires only that operators avoid ignition source, not prevent them.

are, in practice, protected shows that all stops frequently are pulled out to apply preventive measures, such as eliminating ignition sources, despite the existence of consequence-limiting measures.

With regard to the comparably low probability of ignition within the design parameters of working equipment (see, for example, EN 13463-1 introduction), such concepts become absurd. For example, a manufacturer recently applied for his equipment category 1D [6] silo discharge screws to be considered a unique selling point, even though most silos *already are protected with explosion-venting devices*. In light of the escalating costs of equipping a plant in such a manner, it is no wonder that the high cost vs. benefit of explosion safety is the first topic of discussion whenever a need is identified.

Rather, an appropriate mix of preventive and protective measures can lead to a consistent explosion safety concept. The freedom to design such an appropriate explosion protection mix already is provided in the German Technische Regeln für Gefahrstoffe (TRGS) 720/Technische Regeln für Betriebssicherheit (TRBS) 2152, [7] where the legislative authority speaks of “suitable combinations of preventative and constructive measures in accordance with expert judgement.” This interpretation is supported in the more precise definition from the European Directives 94/9/EC (ATEX 114) and 1999/92/EC (ATEX 153) [6], as well as NFPA 654, chapter 5.2.1.2. According to these regulations and standards, all necessary measures must be taken to ensure that the workplace, the work equipment and the relevant connection devices are designed, constructed, assembled, installed, maintained and operated in a way to minimize the *risk of explosions*.

In view of equation (1), above, if an explosion’s effects are limited to a nonsevere level using explosion protective measures, an acceptable residual risk arises almost independently of the probability of occurrence, with reference to the risk matrix, from the Verein Deutscher Ingenieure (VDI) series of guidelines 2263 “Dust fires and dust explosions: Hazards, assessment, protective measures; inerting” (Figure 2). This risk matrix is recognized by the professional engineering industry and tried-and-tested in operational practice. [5]

EXPLOSION PROTECTION MEASURES

Although an explosion could lead to catastrophe and death in any zone, class and division," the question of requiring a risk-oriented approach also is raised for *protective* explosion measures.

This risk-oriented approach for protective explosion measures would be the same as for preventive explosion measures in which the measures' scope, degree and reliability are aligned to the probability (frequency and duration) of a hazardous explosive atmosphere's occurrence.

Take the example of a system protected using explosion suppression but whose protective system was deactivated at the point of explosion.

A first approach to this is stated in the TRGS 721/TRBS 2152-1: The affected measures in "areas with explosion impacts exceeding the usual degree" in scope and type must be taken into account and in NFPA 654, which says that the use of specific protective systems requires a detailed Process Hazard Analysis or, in some cases, an *additional* Process Hazard Analysis.

For instance, in a plant's high-traffic areas (for example, meeting places, corridors with dense traffic, residential buildings and larger office premises) that are located in a hazardous zone, only protective systems that cannot be manipulated, deactivated or otherwise prevented from functioning should be allowed to be used.

Furthermore, with passive explosion protective systems, which normally are not installed and checked by the manufacturer, operators should undertake a visual inspection periodically to avoid misapplication or malfunction.

In this context, it becomes clear that a risk-oriented categorization of protective explosion measures also must occur with regard to the probability of the occurrence of effective ignition sources.

In comparison with preventive explosion safety measures in which an explosion is not permitted in principle, an impact-related categorization also must take place that considers the expected measure of damage.

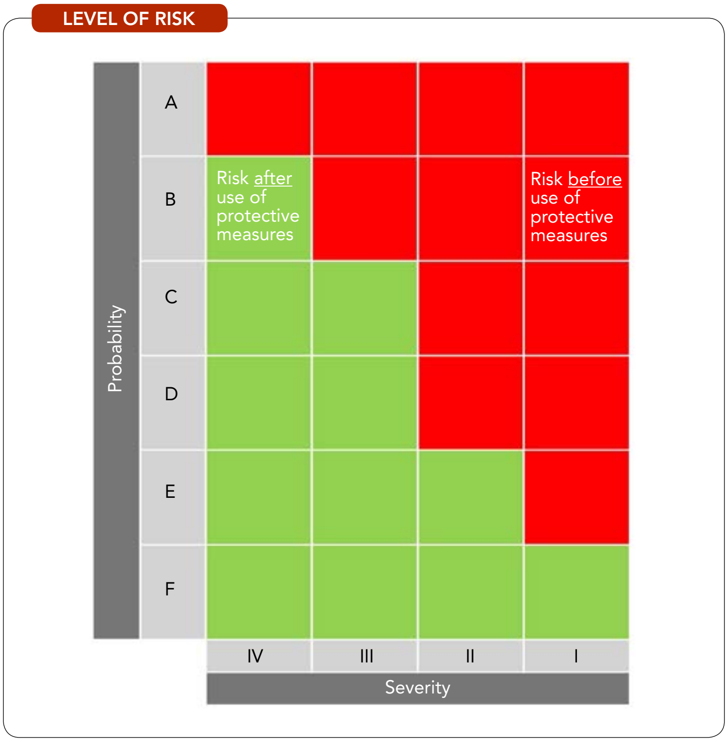

Figure 2: This risk matrix demonstrates that if an explosion's effects are limited to a nonsevere level using explosion protective measures, an acceptable residual risk arises almost independently of the probability of occurrence.

REFERENCES

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SUMMARY

The contexts of preventive and protective explosion safety measures are addressed in American and European standards and legislation. An appropriate explosion safety concept based predominantly on the use of protective measures (most frequently explosion venting in connection with explosion isolation) permits the forgoing of additional, more cost-intensive preventive measures.

If ignition sources in explosion-prone systems cannot be avoided in operational practice with sufficient safety, then a technically safe and economically reasonable combination of preventive and protective measures can be used according to professional discretion. It is the operator's responsibility to adjust the scope of these preventive safety measures, which reduce the probability of occurrence, to the operator's own requirements, resulting in a reasonable safety system that fits that particular explosion risk situation. This approach ensures the most efficient and effective explosion protection and prevention system is implemented.

DR.-ING. J. W. LOTTERMANN is a senior consultant, Explosion Safety, and global sales manager at Rembe Inc./Rembe GmbH Safety + Control. He can be reached at Johannes.Lottermann@rembe.de. **ERIC FINLEY, BS, ME**, is an engineer at Rembe Inc. He can be reached at eric.finley@rembe.us. **HELEN SZTARKMAN, JD**, is a sales manager, New Markets, at Rembe Inc. Email her at Helen.sztarkman@rembe.us.