DExToRR
Dust Explosions - Toolkit for Risk Reduction

Dust Explosions Step 4 Hazards Area Classification

Part 1 – Potential Flaws in the Procedure

Dust explosions can be deadly, delivering tragic consequences caused by what many of us consider are benign products such as sugar or aluminium dust. Dispersed into the air however, and given a source of ignition, we have seen these products level production facilities.

Having reviewed the measures designed to prevent explosive dust atmospheres from forming, I am concerned they are fundamentally flawed.

For instance, in many countries there is a legal requirement to carry out a 'Hazardous Area Classification' (HAC) where there is an expectation that an explosive atmosphere could occur. In the European Union this requirement is covered by Directive 1999/92/EC, which is frequently referred to as the ATEX 137 Directive. I will simply refer to it as the Directive for the rest of this blog.

However, as I will explain, the measures for HAC do not require a formal risk assessment or provide a basis for assessing whether the selected equipment requires further protection measures. Furthermore, it does not consider the inventory of the combustible dust, the level of confinement, the likely power of an explosion, the number of people working in the vicinity of the equipment or the location of the equipment.

That's a lot of flaws.

The Explosive Atmospheres definition is too narrow

The first flaw is that the Directive only covers explosive atmospheres within the following range:

1. Temperature –20 °C to +60 °C;
2. Pressure 80 kPa to 110 kPa; and
3. Air with a normal oxygen content, i.e.~21 %

It does not take much process knowledge to know that there are plenty of processes that operate outside this range. An explosive atmosphere only including air with ~21% oxygen is again limiting, since many processes include an oxygen concentration over a very wide range. It also ignores oxidants such as chlorine.

This limit also encourages flawed thinking since it suggests that mixtures with a concentration less than 21% are not hazardous which is not true. Mixtures of dust in air will remain explosive down to the limiting oxygen concentration which typically ranges from 5% to 15% depending on the dust. This can occur when working with reactions that generate non-combustible gases or use non-combustible solvents.

Little emphasis on replace, reduce and refine

You might expect that measures aimed at classifying hazardous areas and reducing the risk of dust explosions would require us to:

1. Replace - replace the combustible dust(s) with other dust(s) that are not combustible, or if this is not possible.

2. Reduce - reduce the inventory of the material or replace some or all of the materials with materials that are less hazardous, or if this is not possible.

3. Refine - refine the process to make it less hazardous e.g. by eliminating a dust dispersal process.

But this is not always the case. The international standard on classification of areas in relation to explosive dust atmospheres (IEC 60079-10-2) does not require us to consider the three R's. The Directive is arguably less flawed as it requires the employer to take measures to prevent the formation of explosive atmospheres. Furthermore, the UK version of the Directive incorporated into the Dangerous Substance and Explosive Atmospheres Regulations (DSEAR) places a strong emphasis on replacement and reduction but not so much on refinement. A recent flash fire at US Ink (see reference 5) shows how important the three R’s can be, since US Ink had a facility with an unnecessarily high inventory of combustible carbon black and a complex pneumatic conveying system. The US Chemical Safety Board (CSB) in its investigation report place most of their emphasis on following NFPA guidance and not on reducing the inventory of dust or refining the process to make it less hazardous. Whilst the NFPA guidance cited is based on good engineering practice, in my opinion the CSB would have given a much stronger message on risk reduction had they focused much more on the three R’s

Inside and Outside Equipment

Another weakness is the thinking required when it comes to the equipment itself. The approach to hazardous area classification was originally aimed at the selection of electrical equipment; NFPA 499 is still based on this requirement. However, there is little electrical equipment with the exception of instrumentation inside process equipment, which means that the traditional emphasis has been on the outside of equipment.

Now that non-electrical is covered by the IEC standards, and many dust handling processes including pneumatic conveying, milling, drying, and mixing can create an explosive dust cloud, it has become clear that considering the inside of equipment is as important, if not more important, than the outside.

The regulations, standards and guidance use the concept of a "source of release". The Directive refers to, "Any escape and/or release...of...combustible dusts". Similarly IEC 60079-10-1 and NFPA 499 frequently refer to a "source of release."

Although the Directive, IEC 60079-10-1 and NFPA 499 do contain references to the formation of explosive dust clouds inside equipment, none of them specifically states the need to consider the much wider concept of any dispersion that can create an explosive dust atmosphere.

In my opinion this is a fundamental flaw and a much more useful concept for HAC is "Sources of Dispersion" which covers all of the mechanisms for forming an explosive atmosphere both inside and outside equipment. "Sources of Release" include leaks for equipment joints or dust generated by open processing. "Sources of Dispersion" include these but also include dust generate by contained processes such as pneumatic conveying, milling, blending and gravity charging of hoppers.

Hazardous Area Classification Drawings

The Directive states that an explosion protection document should be produced to demonstrate which areas are classified as hazardous zones. This is usually interpreted to mean that drawings should be created to show the extent of the hazardous zones. IEC 60079-10-2 and NFPA 499 show typical hazardous zones on plan and elevation drawings.

However, since these drawings were traditionally considered to only be relevant to electrical equipment (and still are in NFPA 499) they often only show hazardous zones on the outside of equipment. This approach means that the hazardous zones inside equipment which are likely to be the most hazardous are not shown on the drawing. Without this record there is a significant risk that these classified areas will be overlooked during any future modifications.

Furthermore, IEC 60079-10-2 and NFPA 499 do not give any clear guidance on the size of zones, this seems to be a fundamental flaw. NFPA 499 does give some indicative simple calculations, but I am sure that more detailed calculations indicating the likely size of zones would help to provide more meaningful zone sizes.

Level of Ventilation

Ventilation is not formally considered in IEC 60079-10-2 (unlike the comparable gas standard). However, this is a key oversight, as ventilation has an impact in three areas. Firstly, the use of local extract ventilation reduces the quantity of dust in the extracted space so could conceivably downgrade the classification from a Zone 20 to a Zone 21 (see Figure 1). On the other hand, the extracted dust will now be concentrated in the dust collection unit where the risk of an explosion can be high.

Secondly, general ventilation can also reduce the quantity of dust in the extracted space and for small quantities of dust may prevent an explosive dust cloud forming at all. General ventilation may also be helpful with housekeeping.

Thirdly, fluctuating ventilation such as natural ventilation created by the wind may be helpful in reducing the quantity of dust in an area but it may also create explosive dust clouds where housekeeping is poor and layers of powder can be raised up into a dust cloud.

Blanket Zoning

When designing facilities, it is common practice to provide blanket zoning to allow for uncertainty and future proofing. To some extent this is encouraged by IEC 60079-10-2 and NFPA 499 because they suggest the edge of Zone 22 may be the walls of a room or other containing structure.

In my opinion, blanket zoning is not good engineering practice because it does not encourage the team carrying out the classification to give sufficient thought to reducing the risk. It also implies that it is acceptable to have operating staff working in an area where there is risk that in the event of explosion they could be engulfed in the resulting flames.

Housekeeping

Good housekeeping is perhaps the most important tool we can use to minimise the risk of dust explosions as it minimises the volume of combustible dust and the consequences of an explosion.

Poor housekeeping, however, creates layers of dust that will act as a source of easily dispersed combustible material. If dispersed by a small primary explosion this can quickly lead to a much larger secondary dust explosion. Also, dust layers that form on the top of equipment can be heated and act as a source of ignition.

IEC 60079-10-2 defines three levels of housekeeping: good, fair and poor. In the case of poor housekeeping, it suggests that this should be taken into account in the HAC. In my opinion this approach does not sit well with the rest of the HAC procedure and housekeeping would be much better addressed as part of a formal dust explosion risk assessment.

Selection of Equipment

Once a hazardous zone has been identified the next step is to select equipment that has an inherent risk of becoming a source of ignition commensurate with the zone identified. So, for example, equipment for use in a Zone 20 must have a very low risk of becoming a source of ignition. This selection procedure focuses on electrical equipment and non-electrical (generally mechanical) equipment that include their own potential source of ignition. This ignores three important sources of ignition: process sources, including static electricity; cleaning procedures; and maintenance procedures. This is another fundamental flaw.

Independence of the Probability of an Explosive Atmosphere and Ignition Source Existing

The selection of equipment (or protective measure) appropriate for a hazardous zone is based on the assumption that an event that creates an explosive atmosphere and an event that creates an ignition source are independent of each other. This is a reasonable assumption for electrical equipment but less so for mechanical equipment where a mechanical failure may cause both a dispersion of dust and a mechanical spark.

Also, it is possible that a single powder handling operation could create a dust cloud in the explosive range and electro-static discharges powerful enough to ignite the cloud. This operation may occur infrequently and persist for a short time and hence the inside of the equipment could be considered as Zone 22. However, if explosive atmosphere and ignition source occur each time the operation is carried, the risk of an explosion is unacceptably high and further protection measures will be required.

Residual Risk and Consequences

Finally, HAC is not a formal risk assessment. Having selected the equipment for the zones we have identified it does not provide a method for us to assess if the basis of safety is adequate or if further protection measures such as explosion venting are required.

Furthermore, HAC does not consider the consequences of explosion since it does not consider the inventory of the combustible dust, the level of confinement, the likely power of an explosion, the number of people working in the vicinity of the equipment or the location of the equipment.

Conclusions

Taken altogether, we can see the approach to HAC embodied in regulations and standards is fundamentally flawed. Also, they contain a very simplistic approach to equipment selection based solely on the hazardous area classification, they do not include a full assessment of all of the sources of ignition and they do not consider the consequences of an explosion.

On top of this they do not include a rigorous approach to consider the requirement to replace, reduce and refine. This means that methods of protection against dust explosion are also frequently fundamentally flawed.

I would recommend that all uses of combustible dust carry out full formal risk assessments. For full details of an approach to a formal risk assessment, readers can register for the IChemE's series of webinars on this subject here:

http://www.icheme.org/shop/Forms/dust-explosion-reg-pag.aspx

References

1.IEC 60079-10-2:2015, "Explosive Atmospheres, Part 10-2: Classification of areas – Explosive dust atmospheres.

2.NFPA 499, "Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas.

3.Directive 1999/92/EC, "on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmosphere

4.The Dangerous Substances and Explosive Atmospheres Regulations 2002

5. Chemical Safety Board, Case Study, US Ink/Sun Chemical Corporation, Ink Dust Explosion and Flash Fires in East Rutherford, New Jersey,October 9,