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Reducing the risk of dust explosion hazards

In the wake of recent tragic and highly publicized dust explosions, companies are asking, "Could that happen here?" and "What can I do to prevent such an incident at my facility?" One approach is to manage dust explosion hazards as though they were subject to OSHA's Process Safety Management (PSM) requirements (29 CFR 1910.119), even though dust hazards often are not covered under this regulation.

The PSM rule's 14 individual elements can be grouped into a three-step risk management strategy:

1. Understand your process.
2. Identify the hazards of your process.
3. Implement the means to reduce the likelihood and magnitude of the hazards.

The central pillar of PSM is the process hazard analysis (PHA) in that it brings all elements together. All of the required process information is used to analyze the hazards in the PHA. In addition, following the review of the hazards, the existing and proposed safeguards are documented in the PHA. Similarly, the control of dust explosion hazards centers on the dust hazard assessment. As with PSM, the same three steps are integral to the dust hazard assessment and form the basis for mitigation of dust explosion hazards.

Risk management for dust hazard explosions should be treated similarly to the strategy in the OSHA PSM regulation.

Understand your process

The process safety information element from PSM requires a covered process to keep current information covering the process chemistry, technology and the equipment. The physical properties of the materials handled and the potential for them to react with other materials is part of this basic information, which is key to managing the hazards. A facility that handles dust should know what they are handling along with physical properties and the potential to react, ignite and/or explode.

In a recent audit of a facility that produces inorganic water treating chemicals, the audit team observed a wide variety of packaged solids that were used in the process. When asked if any of the solids are combustible, the facility personnel answered that there are no fire hazards in the plant. As the audit continued with a walk through of the facility, a substantial supply of a cellulose-based additive was observed, which was clearly marked as a dust explosion hazard. This hazard was discovered in a review of the Material Safety Data Sheets (MSDS). The first step to control dust hazards is awareness.

The Chemical Safety Board report[1] from the investigation of the tragic dust explosion at CTA Acoustics in 2003 noted that the dust explosion hazards associated with phenolic resins were not well described in the vendor's MSDS. One of the key issues listed in the report is "Combustible Dust Hazard Awareness."

Identify the hazards

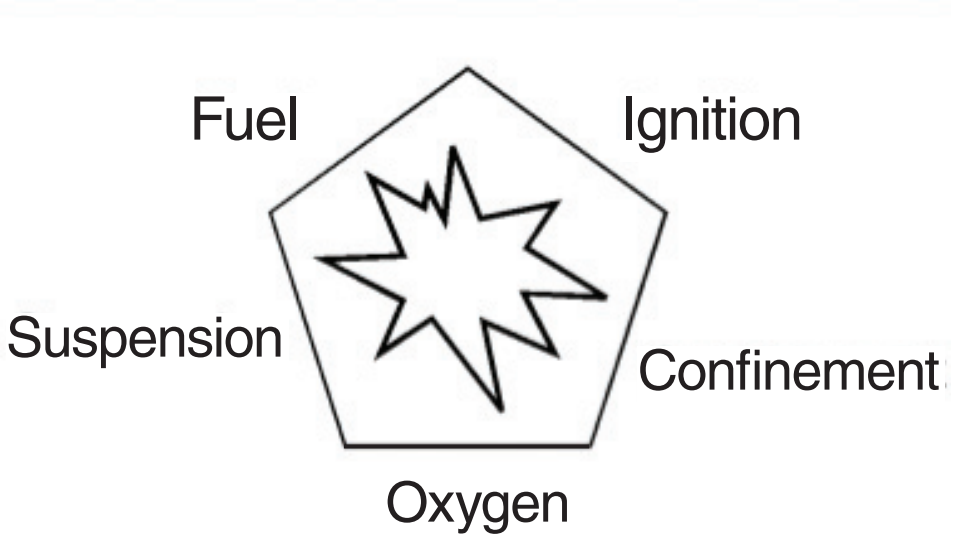
Process safety hazards are identified and analyzed in the PHA. The dust hazard assessment is the analog for management of dust hazards. The dust hazard assessment evaluates all five sides of the dust explosion pentagon.

1. Fuel: The dust hazard assessment begins with an inventory of all dust and materials that can become dust as a result of the processing steps and includes all of the information obtained in understanding the process. From a list of all dusts, combustible dusts are identified along with their physical properties. Rolf K. Eckhoff[2] identified two characteristics of dust that contribute to its importance as a fuel in a dust explosion — dust chemistry including moisture, and particle size or specific surface area. In many cases, sufficient data are not readily available (such as on MSDS) so sampling and analysis is required.

• Ignition: Sources of ignition are evaluated in the assessment and the reduction of these sources is valuable in reducing risk. However, due to the nature of combustible dust clouds, complete elimination of ignition sources is difficult at best. Some have used the phrase, "Ignition sources are free," meaning that ignition sources of sufficient energy are so prevalent that a dust explosion mitigation strategy should never rely solely on the elimination of ignition sources.

• Oxygen: While reducing the oxygen concentration below flammable limits can help reduce the risk, such a strategy is often not practical. Many solids-handling equipment and conveying systems are operated in an air environment.

• Suspension: The dust explosion requires that sufficient fine particle size dust be present and that it be well-dispersed in a suspension of an oxidizer, typically air. The dust hazard assessment, therefore, evaluates the quantity of combustible dust that can become available for an explosion and the means for the dust to be lifted into a suspension. While the suspension characteristic is not found on the traditional flammability triangle, it can easily be compared to having sufficient flammable material to be within flammable limits.



Dust explosion pentagon. Source: U.S. Chemical Safety Board

• Confinement: The ignition of a dust cloud does not depend on confinement (other than assisting in building sufficient dust concentrations), but the resulting flame speed and pressure wave created by the deflagration does. As with suspension, this is not unique to dust explosions.

Reduce the risk

The remaining PSM elements are focused on reducing the risk associated with an identified hazard scenario. For example, mechanical integrity programs, operating procedures and management of change all reduce the likelihood of an event from occurring and occasionally can reduce the magnitude of the hazard. Either result will reduce the risk. All of the risk reduction opportunities identified in the PSM rule can be applied to a dust explosion scenario to help minimize the risk.

There is one noticeable difference, however, in the control of dust hazards. The difference is housekeeping. Dust accumulations due to fugitive losses of dust from the equipment are very difficult to control at the source. Still, the most effective way to prevent a dangerous accumulation of dust is to never lose containment in the first place. For dust that does leave the process, it is essential that the equipment, including structures and buildings, be kept clean and free of accumulated dust. Note that Eckhoff[3] has illustrated that a dust accumulation of only 1 millimeter thick can result in a dust dispersion of 100 grams per meter cubed up to 5 meters high, sufficient to be in the combustible range for some materials.

A word of caution regarding housekeeping — be careful to not create a bigger problem with the solution. For example, do not use compressed air to clear the dust accumulations from equipment, thereby creating the suspension of a combustible dust that you are trying to prevent. In addition, as illustrated in the dust explosion at West Pharmaceutical Services[3], the location of the dust accumulation may not be obvious, such as layered above a suspended ceiling.

As mentioned earlier, control of ignition sources will be part of the risk mitigation strategy. Ignition sources can be minimized through proper equipment design consistent with the area electrical classification, bonding and grounding, removing or insulating heated surfaces in the area, proper hot-work permitting, etc.

Finally, the risk can be minimized through both active and passive explosion mitigation. Effective measures may include, for example, facility layout, deflagration venting, sprinkler system or specialized suppression systems.

Conclusion

Risk management for dust hazard explosions should be treated in a manner similar to the strategy laid out in the OSHA PSM regulation. Through understanding the process, identifying the hazards, and protecting against the hazards, a facility can reduce the risk of dust explosion hazard to acceptable levels.

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1. "Investigation Report, Combustible Dust Fire and Explosions (7 killed, 37 injured)," CTA Acoustics, Corbin, Kentucky, Feb. 20, 2003. U.S. Chemical Safety Board, Report No. 2003-09-I-KY, February 2005.
2. "Dust Explosions in the Process Industries," third edition, Rolf K. Eckhoff, pp. 25 to 55.
3. "CSB Investigation Digest; Dust Explosion at West Pharmaceutical Services," published April 2005.