Conducting PHAs on Combustible Dust Processes

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Abstract

Process hazard analyses (PHAs) have been conducted on chemical processes for decades. Now PHAs are being conducted on combustible dust handling processes to meet several industry standards, such as NFPA 654 and 664. Although many of the same analysis techniques can be applied, conducting effective PHAs for combustible dust processes requires some differences in approach. Due to the prescriptive nature of most of the safeguards for combustible dust handling, a Checklist methodology is far more suitable for these processes than a traditional Hazard and Operability (HAZOP) methodology. Additionally, the hazards and concerns associated with handling combustible dusts may not be as well understood. Time may need to be allotted to discuss the potential hazards. This presentation will present suggestions for leading combustible dust PHAs based on our experience with a variety of industries. It will also discuss the type of information that should be gathered before the PHA team is assembled.

PHA Requirements

PHAs have been required for processes covered by OSHA's Process Safety Management (PSM)[1] and EPA's Risk Management Plan (RMP)[2] regulations for many years. These regulations don't cover combustible dusts and OSHA doesn't currently have a standard for combustible dust handling. Instead, combustible dust safety is currently addressed by a variety of standards and publications. Some of the key references for combustible dust safety are included in the list below:

- NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities*[3]
- NFPA 484, *Standard for Combustible Metals*[4]

[1] Occupational Safety & Health Administration, 29CFR1910.119 "Process Safety Management of Highly Hazardous Chemicals," http://www.osha.gov

[2] Environmental Protection Agency, 40CFR68 "Accidental Release Prevention Requirements," http://www.epa.gov/fedrgstr/EPA-AIR/1996/June/Day-20/pr-23439.pdf

[3] National Fire Protection Association, NFPA 61, "Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities," 2008 Edition

[4] National Fire Protection Association, NFPA 484, "Standard for Combustible Metals," 2009 Edition

- NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*[5]
- NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*[6]
- OSHA *Combustible Dust National Emphasis Program* (Reissued)[7]
- OSHA Safety and Health Information Bulletin, *Combustible Dust in Industry: Preventing and Mitigating the Effects of Fire and Explosions*[8]
- CCPS's *Guidelines for Safe Handling of Powders and Bulk Solids*[9]
- Various FM Global Data Sheets

The main reference standards that OSHA defers to when conducting inspections are the NFPA standards listed above. NFPA 654, which has the broadest coverage, specifically requires that the design of fire and explosion safety provisions be based on a process hazard analysis of the facility, the process, and the associated fire or explosion hazards. NFPA 664 for wood dusts has almost the same requirement, but they refer to this review as a "process analysis" instead of a "process hazard analysis," but the intent is essentially the same. NFPA 484 has a provision in which the authority having jurisdiction (AHJ) may require a PHA in certain situations. Although NFPA 61 doesn't specifically require a PHA, the latest Report on Proposal document for this standard indicates that the committee intends to add annex material in the next revision to clarify that a PHA can be used to determine the appropriate design using a performance-based approach.

A PHA is recognized as being a good practice for documenting and improving the safety of a process. No matter which of the NFPA standards your process falls under, it is a good idea to go ahead and conduct a PHA on your process. Of course, these need to be "living" documents which are revalidated at least every five (5) years.

Methodology Selection

Unlike many chemical processes, the methods for safe handling of combustible dust tend to be very prescriptive in nature. This means that for many specific pieces of equipment, such as air-material separators (a.k.a. dust collectors) or bulk storage vessels, the safeguards which should be employed are spelled out in the relevant standards. This type of regimented guidance lends itself quite well to a Checklist methodology for a PHA. A Checklist method can act as a double-

[5] National Fire Protection Association, NFPA 664, "Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities," 2007 Edition

[6] 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," 2006 Edition

[7] OSHA Combustible National Emphasis Program (Reissued), CPL-003-00-008 (March 11, 2008)

[8] OSHA Safety and Health Information Bulletin, SHIB 07-31-2005, "Combustible Dust in Industry: Preventing and Mitigating the Effects of Fire and Explosions" (2005)

[9] Center for Chemical Process Safety, "Guidelines for Safe Handling of Powers and Bulk Solids" (2005)

check for compliance with the standard and be used to document the logic behind deviations from a prescribed safeguard.

When there is a piece of process equipment being utilized which doesn't fit into one of the categories included in the NFPA standards, then there may not be enough prescriptive suggestions for safeguards to utilize a checklist methodology. In such cases, a Brainstorming method is more appropriate. A good option here is to utilize the "What-If" methodology. A HAZOP method could also be used, but in many cases the typical process guide words are not applicable to a dust handling operation. The What-If methodology allows the leader to draw upon the knowledge and experience of the PHA team to identify and document potential hazards which could be present in the process. Additionally, it is a good practice at the end of a Checklist study section to open up the discussion and capture additional What-If scenarios that the team may come up with which are outside the scope of the Checklist questions.

Study Section Selection

Most of the NFPA standards are organized by type of equipment. Therefore, when selecting study sections it is helpful to break the process up into sections based on equipment type to match the prescriptive guidance in the NFPA standards. If there are multiple pieces of equipment within the process which perform basically the same function with the same type of dust, then these can be grouped into a single study section. Due to the nature of the equipment-based checklists, it is not a good idea to combine multiple types of equipment within the same study section. If there are pieces of equipment left which are not specifically covered in the NFPA standards, then group these logically into separate study sections which can be covered using the What-If methodology. Figure 1 and Table 1 show an example of how a process can be broken into study sections.

In this process, the bulk powder from the trucks is unloaded into the bulk silos using a positive pressure blower supplied by the delivery truck. The raw material is transferred from the bulk silos into the mixers using a negative pressure pneumatic conveying system which pulls through the second dust collector. The positive pressure pneumatic conveying lines from the truck to the bulk silos were segregated from the rest of the pneumatic conveying lines, which operate under a slight vacuum, because the safeguards will be difference between these two systems. For a similar reason, the two dust collectors were segregated out since they operate under different pressure conditions and therefore may have slightly different designs and safeguards.

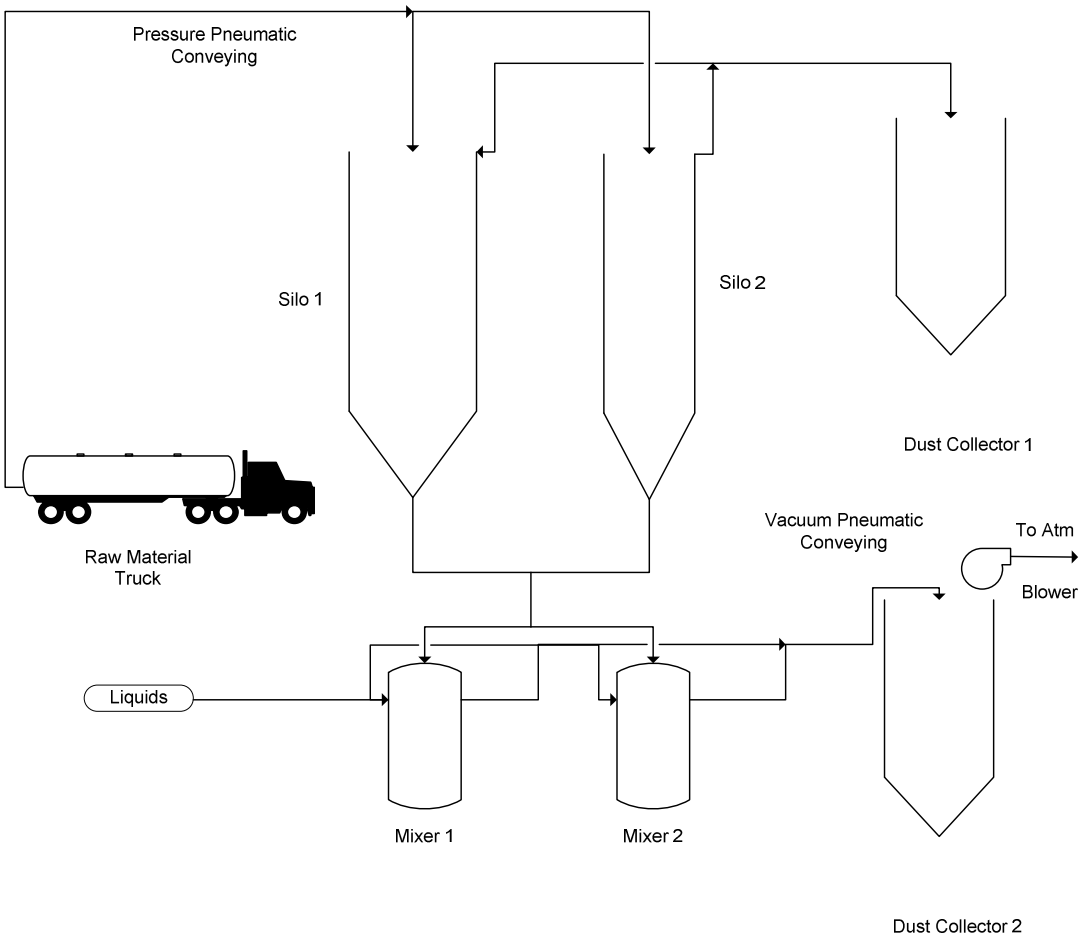

Figure 1. Simplified PFD

Table 1. Example Study Section Selection

Study Section	Methodology
Raw Material Truck Unloading	Checklist
Pneumatic Conveying (Pressure)	Checklist
Bulk Storage (Silos 1 & 2)	Checklist
Dust Collector 1	Checklist
Pneumatic Conveying (Vacuum)	Checklist
Mixers 1 & 2	What-If
Dust Collector 2	Checklist

Checklist Development

As mentioned previously, the NFPA standards are very prescriptive in nature. For each type of equipment, they list specific design features that should be utilized. A good starting point for development of a PHA checklist will be these NFPA standards. Start with the equipment-specific criteria which are listed. Next add in any general safeguards which are called for in the standard for all combustible dust handling equipment.

Don't limit yourself to these NFPA standards when developing your checklists. Instead, utilize other recognized and generally accepted good engineering practices (RAGAGEPs) which exist. Some of these include Factory Mutual (FM) Data Sheets and the Center for Chemical Process Safety (CCPS) book, *Guidelines for Safe Handling of Powders and Bulk Solids*[10].

Use all of the prescriptive safeguards for a particular piece of equipment to populate the list of questions for the PHA worksheets. Be sure to phrase the question such that a "Yes" answer indicates that the safeguard is in place and a "No" answer indicates that the safeguard is not utilized. This will provide consistency when conducting the PHA such that any scenarios in which there is a positive response to the Checklist question can be halted at that point.

If you don't want to take the time to create your own combustible dust checklists, you can save time by utilizing a PHA software package which already has such checklists developed. ioMosaic's HAZOPtimizer™ software contains multiple combustible dust checklists embedded in the software package with reference information to designate the source of the Checklist question. Table 2 provides an excerpt of a combustible dust checklist for bulk storage.

Table 2. Excerpt from Combustible Dust Bulk Storage PHA Checklist

Item	Reference
Where an explosion hazard exists and fixed vessel is > 8 ft3, are fixed bulk storage containers protected via deflagration venting, containment, oxygen exclusions or suppression?	NFPA 654 (Fixed Bulk Protection)
Are bins and tanks of noncombustible construction?	CCPS Publication 2005, Chapter 5- Silos and Hoppers
Are bins and tanks equipped with a means of isolation on the transfer systems to prevent propagation of an explosion in accordance with NFPA 69?	NFPA 654 (Isolation of Equipment)
Are explosion relief panels designed to relieve at < 30 lb/ft2 unless windstorm resistance requirements are higher?	FM 7-76 (Protection)
Is all equipment properly bonded and grounded?	NFPA 654 (Conductive Components), NFPA 77 (Bulk Storage)

[10] Center for Chemical Process Safety, "Guidelines for Safe Handling of Powders and Bulk Solids," 2005

PHA Preparation

Prior to beginning the PHA it is essential that the team understands the characteristics of the dusts being handled. During a typical process PHA, the team leader would gather the relevant material safety data sheets (MSDSs) for the materials being handled, and then at the beginning of the team meetings the group would review the key hazards presented by these materials. Unfortunately, many MSDSs do not contain specific information regarding combustible dusts so it may be necessary to conduct some testing to gather the necessary information for the powders being handled. There are two (2) key questions that should be answered prior to the commencement of the PHA:

- Is the dust combustible and how significant is the explosion risk?
- What level of ignition source is required to ignite a cloud of this dust?

The first question can be answered by conducting an explosion severity test. The results of this test include the explosion severity rating, K_{St}, of the dust and the maximum pressure reached during optimum explosion conditions, P_{max}. The second question can be answered by conducting a minimum ignition energy (MIE) test. The explosion severity test results can be used by the team to help assess the worst-possible consequences for each scenario. The MIE information can be used by the team to understand what types of ignition sources will result in an ignition of the dust cloud, thereby allowing the team to properly classify the PHA scenario in terms of likelihood. Table 3 provides information regarding the probability of ignition for various ranges of ignition energies.

Table 3. MIEs and Ignition Probabilities

Flammable Hybrid Mixture or Dust with:	Ignition Sources	Ignition Probability
MIE < 4 mJ	Almost all ignition sources, including brush discharges	Imminent
4 < MIE < 10 mJ	Most ignition sources, probably not brush discharges	Very probable
10 < MIE < 100 mJ	Some electrostatic discharges	Less probable
100 < MIE < 1,000 mJ	Only very intensive electrostatic discharges	Not probable
MIE > 1,000 mJ	Only extremely intensive electrostatic discharges (lighting)	Not probable

Since the bulk of the PHA will be conducted utilizing a Checklist methodology, it may be beneficial to conduct some research prior to the start of the PHA team meetings to verify the responses to as many of the PHA questions as possible. This information would be gathered

during a detailed field assessment prior to the start of the PHA. This would be a much more detailed walk-through than is typical for a process PHA since the objective is to verify specific, existing safeguards. This preliminary field assessment will expedite the team meetings and ensure accuracy of the responses. It may also lead to less conservative results and fewer follow-up action items because the team won't have to guess at whether each safeguard exists.

Another significant difference between process PHAs and combustible dust PHAs is that the level of supporting documentation often differs significantly. If a process PHA is being conducted because of a requirement in OSHA's PSM standard or EPA's RMP standard, then those standards also require a certain amount of process safety information to be available. Since there is no equivalent standard for combustible dust, in many cases, back-up information such as P&IDs or PFDs may be missing or incorrect. If this information is not available, then alternative information must be located or developed prior to the start of the PHA to provide the team with a clear understanding of the process and equipment being reviewed.

PHA Introduction

At the beginning of any PHA, the leader should provide some basic education to the team members regarding the PHA methodology and ground rules for the team. In some cases, this training can be very abbreviated if most of the team members have participated in a previous PHA.

Since the practice of conducting a PHA on a combustible dust process is relatively new, this background training will be especially important since many of the members may be new to the PHA process. In addition, I often find that many of the team members may not be aware of the hazards posed by combustible dusts in general. In these instances, it is essential to provide some basic training to the team members regarding the hazards of combustible dusts. A good starting point is to explain the combustible dust explosion pentagon, shown in Figure 2. It is also beneficial to discuss the hazards of fugitive dusts and the potential for catastrophic, secondary dust explosions. If there is time, some of the videos or reports from the U.S. Chemical Safety and Hazard Investigation Board (CSB) can be a good source of training material for the team.

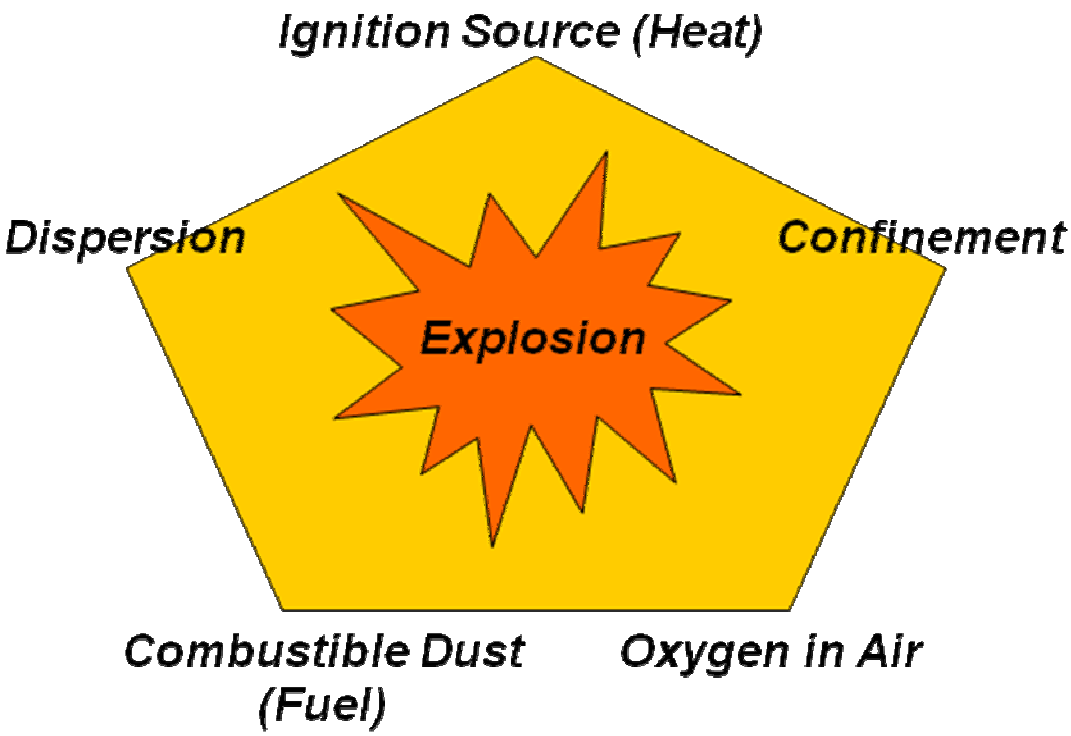

Figure 2. Combustible Dust Explosion Pentagon

Conclusion

As with chemical processes, a comprehensive PHA is an ideal way to understand and document the hazards associated with a combustible dust process. The basics of the PHA process are equally applicable to dust processes, but the choice of methodology and boundaries for the study sections may be slightly different for combustible dust processes as compared to a chemical process. The first step in preventing incidents is to identify hazards. Applying vetted PHA principles to combustible dust handling areas is a great place to start.