WHITE PAPER

Dust Hazard Analysis for Simple Dust Collection Systems

Combustible dusts are a recognized hazard for industrial facilities everywhere, and performing a hazard analysis is the best way to evaluate your risk of an explosion. This white paper will focus on smaller factories involved in basic processes that generate combustible dusts collected by simple dust collectors. It will introduce the 2016 *NFPA 652: Standard on the Fundamentals of Combustible Dust* and its new Dust Hazard Analysis methodology which is geared toward these more basic applications. It will examine how to perform a hazard analysis, how to maintain documents, and what to expect from OSHA as it enforces NFPA combustible dust standards.

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AIR POLLUTION CONTROL

By Mike Walters

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Combustible dusts in the workplace are now a recognized hazard that can't be ignored by industrial facility owners, managers and workers. Combustible dust deflagrations and explosions have caused numerous losses of life and catastrophic property damage in multiple industries ranging from pharmaceutical plants to sugar factories. Recent major incidents[1] have garnered the attention of the Occupational Safety & Health Administration (OSHA)[2], and currently OSHA has put dust at the top of its list of inspection items during an audit.

Combustible dusts are a recognized hazard for all types of industrial facilities, and a hazard analysis is the best way to evaluate your risk of an explosion.

In 2008, OSHA reissued directive CPL 03-00-008, Combustible Dust National Emphasis Program (NEP), providing instructions to inspectors on how to recognize combustible dust hazards. The National Fire Protection Association (NFPA)[3] publishes multiple standards addressing how to mitigate or reduce hazards associated with combustible dusts. OSHA uses these standards to enforce combustible dust violations. *NFPA 652: Standard on the Fundamentals of Combustible Dust* (2016 edition) was released in October 2015 to complement the OSHA NEP. The NFPA committee recognized the widespread lack of understanding of combustible dust hazards in industry and determined that a combustible dust standard was needed to promote awareness of the problem.

NFPA 652 is now the starting point for defining a combustible dust and its hazards. Its purpose is to clarify the relationship between the shared standards and the industry-specific standards such as NFPA 484 for metals, NFPA 664 for wood, NFPA 655 for sulfur, and NFPA 61 for agricultural and food processing. These standards require that a facility processing or handling combustible dust perform a hazard analysis and risk assessment for each operation that handles combustible dust. NFPA 652 introduces the term Dust Hazard Analysis (DHA) to differentiate this analysis from the more complex Process Hazard Analysis (PHA) required by OSHA for the chemical process industry. The intent is to inform users of the standard that different methods of hazard analysis can meet the standard.

A hazard analysis, regardless of type, is the first thing the OSHA inspector will ask for if he or she discovers combustible dust in your facility. Failure to provide this information will result in the first citation. Many books have been written on this subject geared toward large chemical and other facilities who have extensive safety management personnel. This white paper focuses on the smaller factories engaged in processes that generate a combustible dust collected by a simple dust collector. This white paper will examine dust hazard analysis and risk assessment components, who should perform them, what type of analysis should be performed and how to maintain documents.

Table 1. Stages of a Process Assessment

Process Stage	Objectives
Design	Determine explosibility of dust Determine if an industry-specific standard applies (e.g., NFPA 484 for metals) Review location of dust collector with respect to safety and occupancy Review location of isolation devices Look for ignition sources in process or external to the process Evaluate storage of combustible dusts
Engineering	Identify where combustible dust clouds could form Identify where spills may occur Identify if and where dust can build up in the system Identify ignition sources Determine the best controls Determine what equipment should be interlocked and shutdown during an event Evaluate complexity of controls and their effect on reliability of the system
Startup	Confirm as-built is as-designed Is dust being contained within the system or are there leaks? Look for hazards associated with adjacent equipment and traffic around process
Operation	Are any hazards associated with routine operation? Use operational experience to update previous hazard evaluations Are there hazards when the process is out of service?
Change	Does the change increase any hazards in the system? Does the change require employee training?
Decommissioning	Have all combustible materials been removed? Can a combustible dust cloud be created during teardown?

What is a hazard analysis?

Process hazard analysis has many synonyms; review, evaluation, study, assessment, and survey, to name a few. It is a tool used to improve safety by identifying hazards. In our case, we will focus on combustible dust hazards and dust collection systems. The analysis should start at the design phase of a project and follow the process to the end of its lifespan with periodic reviews and updates. **Table 1** lists some examples of the hazard assessment objectives for various stages of the process lifetime.

Types of analysis

There are multiple techniques or types of hazard analysis procedures. The Center for Chemical Process Safety publishes a *Guidelines for Hazard Evaluation Procedures*[4] which covers simple and complex systems and techniques if you require further detail on this subject. The following is a list of available techniques that can be used that are covered in this guide with examples.

- Preliminary Hazard Analysis
- Safety Review
- Relative Ranking
- Checklist Analysis
- What-if Analysis
- What-if Checklist Analysis
- Hazard and Operability Study
- Failure Modes and Effects Analysis
- Fault Tree Analysis
- Event Tree Analysis
- Cause-Consequence Analysis

What type of analysis should I perform?

For a dust collection system, the checklist or what-if checklist analysis could be sufficient. You will have to decide if your process complexity warrants the use of a more structured technique. Things to consider would be material composition and toxicity, location to public places, exposure of employees and risks to other processes. In many cases, the safety manager will be familiar with one or more types of analysis and that will drive the choice of which method to use.

As described above, the new NFPA 652 combustible dust standard provides a detailed guide for a hazard analysis on a dust collection system in its appendix. It introduces Dust Hazard Analysis in order to avoid confusion with OSHA regulations requiring a Process Hazard Analysis. It is not the intent of the NFPA standards to force manufacturers to undergo strict hazard analysis procedures that are required for industries like refineries and chemical manufacturers.

NFPA 652 also contains retroactive requirements for a DHA. Now, all existing systems are required to have a DHA and the time limit to perform this analysis is three years from the date of issuance of the standard, October 2015. This is one of the most important changes to NFPA standards in recent history. Previously, you did not have to perform a hazard analysis on existing systems unless they were modified in a manner that exceeded 25 percent of their initial installation cost.

Who should perform the analysis?

Typically, the complexity of the system determines who and how many should participate in the hazard analysis. The *Guidelines for Hazard Evaluation Procedures* provides guidance on this aspect of the analysis. In many cases with nuisance dust collection systems, one person familiar with the process can prepare a hazard analysis. In other cases, help will be required to expand the knowledge base available to the analysis. It is important that an experienced person competent in the type of analysis and the process participate in the analysis. Sometimes equipment operators should be pulled into the team. The people on the front line operating and maintaining the equipment will often have valuable insights into not only the hazards present but possibly simple fixes for recurring malfunctions that might cause a hazardous condition, thereby alleviating the hazard.

Equipment operators will often have valuable insights into the hazards present and possible fixes for recurring problems.

Hazards specific to combustible dust and dust collection systems

Dust Flash Fire:

A fire that spreads rapidly by means of a flame front through a diffuse fuel, such as dust, gas, or the vapors of an ignitable liquid, without the production of damaging pressure. [921, 2011][5]

Dust Flash Fire Hazard Area

An area where combustible dust accumulation on exposed or concealed surfaces, external to equipment or containers, can result in personnel injury from thermal dose during a dust deflagration, as well as any areas where a dust cloud of a hazardous concentration exists.[5]

Dust Explosion Hazard Area

A room or building volume where an unvented deflagration of the entrainable dust mass can result in a pressure exceeding the strength of the weakest structural element not intended to fail.

The following is a list of hazards associated with combustible dusts and dust collection systems.

- Finely divided combustible dusts can pose flash fire hazards and explosion hazards in the right concentrations and conditions.
- Deflagrations and explosions can travel upstream and downstream through the ducting, if not isolated, posing a fire hazard, pressure wave hazard, and noxious gases hazard.
- Dust build-up on floors, elevated surfaces and hidden areas can contribute to a secondary explosion.
- Dust build-up inside of ducting due to deficient filter performance or poor design would contribute to the propagation of flame or pressure through the duct and into the factory.
- Ignition sources in the form of open flames, electrostatic charging, lift truck activity, moving chains, and rotating equipment with bearings and hot surfaces can pose hazards.
- Metal dusts can have high rates of pressure rise and pressure maximums during a deflagration, causing an improperly designed collector to explode and produce shrapnel.
- Metal dusts can be reactive with other dust oxides and liquids such as water and produce explosive gases that are highly ignitable.
- Metal dust fires are more difficult to extinguish and can be worsened with improper extinguishing agents.

This explosion has been staged to determine how well the dust collector will hold up if a combustible dust event should occur.

Components of a hazard analysis for a facility handling combustible dusts are listed below. All of these components should be considered during a process hazard analysis.

Presence of materials that can be combustible when finely divided

Most if not all materials that burn will be combustible and possibly explosive in the form of a finely divided powder. If your process consumes raw materials and cuts, machines, shapes or alters them in a manner that creates dust, you could have a combustible dust hazard when this dust accumulates in the factory. Some examples of materials that can be combustible when finely divided include but are not limited to cosmetics, coal, dyes, grains, dry foods, metals, pharmaceuticals, plastics, rubber, printer toner, soaps, textiles, wood and paper.

NFPA 654: Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing and Handling of Combustible Particulate Solids provides guidelines for determining how much combustible dust poses a hazard. It identifies thin layer limits and volume limits for thin layers and accumulated volumes of dust. The most common rule is the layer depth criteria, which states that a non-separated layer 1/32” deep on floors and elevated surfaces that amounts to over five percent of the building floor space or 1000 sq ft, whichever is less, meets the fire and explosion hazard criteria. Everyone involved in a hazard analysis should be familiar with all the governing NFPA standards. The list of governing documents can be found in NFPA 652 and 654.

Processes which use, consume or produce combustible dusts

Examples of processes that use combustible dust include powder metal part manufacturing, pharmaceutical presses and coaters, food processing, chemical manufacturing, energy production, plastic manufacturing, refining and wood product manufacturing.

Examples of processes that consume combustible dusts include energy production and chemical reactions.

Processes that produce combustible dusts include grinding, milling, conveying, machining, casting, shaping, cutting, mining and mixing.

Open and hidden areas where combustible dusts may build up

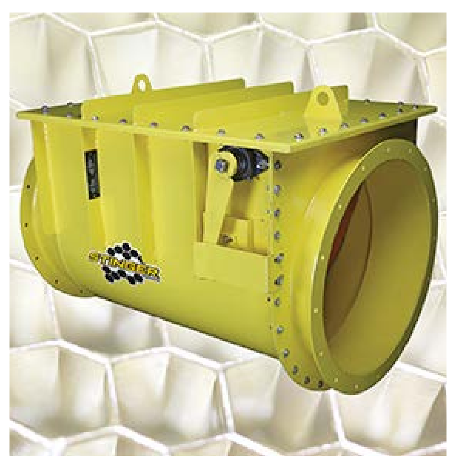
The analysis should inspect open areas and hidden areas around the process that accumulate dust and the source of the dust should be determined and controlled if possible. These areas should include floors, horizontal and vertical surfaces, ledges, roof members and drop ceilings to name a few.

Means by which dust may be dispersed in the air

If combustible dust is present during normal operations or during an upset, the analysis should identify means that would disperse the dust into a combustible cloud. Examples of means that would disperse dormant dust include a primary dust explosion, cleaning with brooms or compressed air, fans, wind, spills and equipment malfunctions.

An explosion vent relieves pressure to minimize damage in the event of a dust collector explosion.

A flameless venting device, installed over an explosion vent, extinguishes the flame front, allowing venting to be accomplished indoors.



An explosion isolation valve prevents a deflagration in a dust collector from traveling back down the inlet pipe into the workspace.

Presence of potential ignition sources

It is very difficult to identify the source of ignition after a dust deflagration event. Examples of known ignition sources include sparks from moving equipment, improperly controlled hot work, rotating machinery failure such as bearing and motors, electrical malfunctions, open flames and static electricity discharge.

Risk Analysis and Controls

A risk analysis helps determine the level of risk that is acceptable and the devices or methods used to achieve that level of risk. The intent is to achieve the Life Safety Goal as defined by NFPA:

The life safety goals are considered achieved if:
(1) Ignition has been prevented.
(2) Under all fire scenarios, no person, other than those in the immediate proximity of the ignition, is exposed to untenable conditions due to the fire, and no critical structural element of the building is damaged to the extent that it can no longer support its design load during the period of time necessary to effect complete evacuation of the occupants.[6]

It is important to realize that NFPA understands that hazards cannot be completely eliminated and some level of risk of loss to life and property cannot be prevented.

Table 2 summarizes the hazards and the available controls to reduce the level of risk from these hazards.

The controls need to be compatible with the combustible dust. Most metal dusts are reactive with water, so automatic sprinkler systems are prohibited on metal dust applications unless your hazard analysis demonstrates and documents that the dust is not reactive with water.

Table 2: Dust Collector Hazards and Controls

Hazard	Controls	
Fire *Multiple controls may be provided*	Automatic sprinklers CO2 suppression Argon suppression Fan interlock	Fire gate on inlet Fire gate on outlet Fire alarm - smoke detector Fire alarm - thermal switch
Explosion	Deflagration venting Chemical suppression	Dilution with noncombustible dust Oxidant concentration reduction
Flame and pressure upstream of the collector	Passive isolation damper Passive float valve Actuated float valve	Fast-acting mechanical valve Chemical barrier
Flame downstream of the collector	Flame arresting device	
Flame and pressure downstream of Collector	Actuated float valve Fast-acting mechanical valve Chemical barrier	

Some controls are common sense and good practice. A fan interlock with the dust collector deflagration control device that shuts down the fan will significantly reduce fire damage to the collector and could make the difference between scrapping the collector or re-using it.

What does the analysis look like?

One method to document a hazard analysis could be done in a spreadsheet similar to the one in Table 3. This table is an example created from a specific scenario and illustrates a simple way to document a hazard analysis. It does not represent or depict all possible controls for the hazards listed, nor does it depict all possible hazards that could be associated with your dust collector and process. A complete hazard analysis would include process machinery associated with the production of the dust, along with hazards external to the dust collection system. History has shown that many incidents with dust collection system fires and deflagrations result from a fire outside the collection system producing flames or sparks that are sucked into the system.

Table 3: Combustible Dust Hazard Assessment Worksheet

If oxidants are present other than oxygen in air, follow OSHA regulation 29 CFR1910.119 process hazard analysis requirements.
Zone Class: See instructions for Zone Classifications included in this worksheet and NFPA 70
National Electrical Code - Article 506 and the excerpts from that standard included with this document.

Area	Description	Hazard	Zone	Action/Control
1	Dust collector	Explosion and Fire Hazards	20 20 20 20 20 20	Deflagration venting to a safe area Deflagration vent sensor to shut down process Flow switch in sprinkler line to shut down process Integrated safety monitoring filter/ flame front arrestor Internal automatic sprinklers Fire retardant filter media
		Process continues after a fire or deflagration feeding fuel and oxygen to the fire	20 20 20	Deflagration vent sensor interlocked with process to shut it down Flow switch in sprinkler line interlocks with process to shut it down Activation switch on explosion isolation valve interlocks with process to shut it down
2	Inlet duct	Flame and pressure propagation upstream	22	Flow operated flap valve (explosion isolation valve)
3	Outlet duct	Flame propagation downstream Pressure propagation downstream	22 22	Integrated safety monitoring filter certified to stop flame fronts Building can handle the effects of the pressure wave
4	Hopper discharge	Flame and pressure propagate to hopper discharge system	20	Close clearance rotary choke (airlock)
5	Return duct to building	Smoke and/or burning debris enters building	22	Diverter valve interlocked to divert airflow outside when process is shut down
		Leaking filters cause dust to build up in building creating fire and explosion hazards	20	Pressure drop monitored on secondary safety monitoring filters. Leak detection through high DP shuts down process

You can add as many columns to this worksheet as needed to identify aspects of your system, and additional rows for each individual section of pipe and process equipment. The analysis should classify locations as not a hazard, maybe a hazard, or deflagration hazard. The questions that you ask for each segment of the system are:

1. Is the particulate explosible in this segment?
2. Is the particulate suspended in air?
3. Is the concentration dense enough to support a deflagration?
4. Is there an ignition source strong enough to ignite the dust cloud?
5. Is there any hazard management in place?

Some segments of the system could require multiple rows of analysis. This is OK. Be systematic and concise, and don't be afraid to modify the document collection sheet to fit your needs. Ultimately you want to identify the hazards and select suitable controls. Each control should be listed and vendor documentation should be collected on the specifics of the control. Consult appendix B of NFPA 652 for further guidance on performing a dust hazard analysis.

Documentation

The hazard analysis and risk assessment for the process must be maintained for the life of the process and reviewed every five years or whenever something in the process changes. These documents, along with a long list of other documents in NFPA 654 and other governing standards, are to be kept on file and available to OSHA upon request. The list of documents is beyond the scope of this paper but they include items such as calculations, process design and layout, control equipment specifications, training requirements and inspection records.

NFPA 652: Additional considerations

Some additional highlights of the new NFPA 652 standard as related to dust collection include:

- One of the first steps noted in Table 1 is to determine whether an NFPA industry-specific standard applies to the application, such as the standards listed previously for metals, woodworking, food processing, etc. What happens if a provision in the applicable standard is in conflict with NFPA 652? In these instances, the requirement set forth in the industry-specific standard should take precedence.
- As noted, existing facilities are now required to conduct a DHA that must be completed no later than three years from publication of NFPA 652, i.e. by October 2018. However, facilities are expected to demonstrate reasonable progress toward this goal over the three-year time span. Waiting until the final weeks to initiate an analysis is not a recommended strategy and could result in an OSHA citation.
- NFPA 652 states that facilities must provide a program for inspection, testing and maintenance of safety-critical systems including dust control equipment and fire and explosion protection and prevention equipment. Equipment operators, maintenance personnel and others who could be exposed to the hazard must be trained in dust hazard awareness and job-specific safeguards prior to taking responsibility for a process.

Conclusions

Combustible dust hazards are being taken very seriously due to events of the last decade. OSHA has been slow to react to the combustible dust emphasis program, but they are progressively training their officers and adding to the inspection force. Companies that do not take these hazards seriously will face punitive fines and unrealistic dates to achieve compliance. The author hopes that this paper impresses the importance and necessity to address combustible dust hazards in the workplace and stay ahead of the negative consequences that failing to do this would create. It is the responsibility of the facility owners and operators to become familiar with the governing NFPA standards for combustible dust and comply with the protections prescribed in these standards.

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References

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[3] National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169; www.nfpa.org: NFPA Standards 61, 91, 68, 69, 484, 652, 654, 664

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[5] NFPA 654: Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids

[6] NFPA 654: Chapter 4.6