

Dust hazards analysis for simple dust collection systems

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Performing a dust hazards analysis is the best way to evaluate your plant's risk for a dust explosion. This article introduces the new NFPA 652 standard and explains how to perform and document a dust hazards analysis, focusing on smaller, basic manufacturing plants with simple dust collection systems. The article also explains what to expect from OSHA as the agency enforces NFPA combustible dust standards.

Combustible dusts in the workplace are now a recognized hazard that industrial plant owners, managers, and workers can't ignore. Combustible dust deflagrations and explosions have caused numerous fatalities and catastrophic property damage in industries ranging from pharmaceutical production to sugar refining, and recent major incidents¹ have garnered the attention of OSHA, which has put dust at the top of its list of items to inspect during a safety audit.

In 2008, OSHA reissued directive CPL 03-00-008, "Combustible Dust National Emphasis Program" (NEP),² providing instructions to inspectors for how to recognize combustible dust hazards. The NFPA has published multiple standards addressing how to mitigate or reduce combustible dust hazards in specific industries, including NFPA 484 for metals, NFPA 664 for wood, NFPA 655 for sulfur, and NFPA 61 for agricultural and food processing.³

OSHA uses these standards to enforce combustible dust violations.

NFPA 652

In October 2015, NFPA released *NFPA 652: Standard on the Fundamentals of Combustible Dust* (2016 edition) to complement the OSHA NEP. NFPA 652 is now the starting point for defining a combustible dust and the related hazards. The NFPA committee recognized industry's widespread lack of understanding of combustible dust hazards and determined that a combustible dust standard was needed to promote awareness of the problem and clarify the relationship between shared and industry-specific standards.

NFPA's industry-specific standards require a facility processing or handling combustible dust to perform a hazards analysis and risk assessment for each operation handling the dust. NFPA 652 provides a detailed guide for conducting a hazards analysis on a dust collection system in the appendix. The standard introduces the term *dust hazards analysis* (DHA) to differentiate this analysis from the more complex *process hazards analysis* (PHA) required by OSHA for industries such as oil refining and chemical processing. The intent is to inform users that different methods of hazards analysis can meet the standard and avoid confusion with OSHA's regulations requiring a PHA. It's important to note, however, that if NFPA 652 conflicts with a provision in an applicable industry-specific standard, the requirement set forth in the industry-specific standard should take precedence.

Many books have been written on hazard analysis procedures geared toward large chemical and other

facilities employing extensive safety-management personnel. In this article, I'll focus on smaller plants and identify hazards specific to combustible dust and simple dust collection systems. I'll examine a DHA's objectives, the different types of analysis to choose from, who should perform the analysis, and what to consider when conducting a DHA. I'll also describe how a risk assessment can help reduce your plant's level of risk from a dust explosion and explain how to maintain the necessary documentation for an OSHA inspection.

Combustible dust and dust collection system hazards

Hazards associated with combustible dusts and dust collection systems include the following:

- Finely divided combustible dusts can pose flash fire and explosion hazards in the right concentrations and conditions.
- Ignition sources such as open flames, electrostatic discharge, lift truck activity, moving chains, hot surfaces, and rotating equipment with bearings can ignite accumulated or airborne dust, causing a deflagration.
- Deflagrations and explosions can travel upstream and downstream through a dust collector's ducting if not isolated, posing fire, pressure-wave, and noxious-gas hazards.
- Dust buildup on floors, elevated surfaces, and in hidden areas can be disturbed by a primary explosion, become airborne, and contribute to a secondary explosion.
- Dust buildup inside ducting due to deficient filter performance or poor design can contribute to flame or pressure propagation through the duct and into the workspace.
- Metal dusts can have high rates of pressure rise and pressure maximums during a deflagration, causing an improperly designed dust 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 the use of improper extinguishing agents.



Masks protect these sculptors from breathing in the airborne dust around them, but an ignition source could cause the dust to ignite, resulting in a flash fire or explosion.

DHA objectives

A DHA is a tool used to improve plant safety by identifying the specific combustible dust hazards associated with a process. The analysis should start during the process's design phase and continue with periodic reviews and updates during the life of the process and through the process's decommissioning. A DHA will have specific objectives during each stage in a process's life cycle, as shown in Table I.

Types of analysis

There are multiple techniques or types of hazard analysis procedures you can use for a DHA. The Center for Chemical Process Safety publishes *Guidelines for Hazard Evaluation Procedures*,⁴ which covers simple and complex systems and techniques with examples if you require further detail on this subject. The techniques covered in the guide include:

- 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

For a dust collection system, the checklist or what-if/checklist analysis is typically sufficient. You'll have to decide if your process complexity warrants using a more structured technique. Things to consider are your material's composition and toxicity, proximity to public spaces, worker exposure, and risks to other processes. In many cases, the company's safety manager may be familiar with one or more of these analysis types, and that will drive the choice of which method to use.

Table 1

Stages of a dust hazards analysis

Process stage	Objectives
Design	<ul style="list-style-type: none"> • Determine explosibility of dust • Determine if an industry-specific standard applies • Review dust collector location with respect to safety and occupancy • Review location of isolation devices • Look for potential ignition sources in process or external to the process • Evaluate storage of combustible dusts
Engineering	<ul style="list-style-type: none"> • 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 shut down during an ignition event • Evaluate the complexity of the controls and its effect on the system's reliability
Startup	<ul style="list-style-type: none"> • Confirm that system as-built is as-designed • Identify any leaks where dust is escaping the system • Look for hazards associated with adjacent equipment and traffic around the process
Operation	<ul style="list-style-type: none"> • Identify any hazards associated with routine operation • Use operational experience to update previous hazard evaluations • Identify hazards created when the process is out of service
Change	<ul style="list-style-type: none"> • Identify hazards created or increased by the change • Determine whether the change requires worker training
Decommissioning	<ul style="list-style-type: none"> • Ensure that all combustible materials have been removed • Ensure that a combustible dust cloud isn't created during teardown

Who should perform the analysis

The complexity of the system will typically determine who and how many should participate in the DHA. *Guidelines for Hazard Evaluation Procedures*, mentioned in the previous section, provides guidance on this aspect of the analysis. In many cases with nuisance dust collection systems, a single person familiar with the process can prepare a DHA. In other cases, this person may require help to expand the knowledge base available for the analysis.

Whoever conducts the DHA should be experienced and competent in the type of analysis chosen and in the process being analyzed. Sometimes equipment operators should be pulled onto the team; the people operating and maintaining equipment often have valuable insights not only into the system's hazards but also into potential simple fixes for recurring malfunctions that might create a hazardous condition.

In any case, everyone involved in a DHA should be familiar with all the governing NFPA standards. The list of governing documents can be found in NFPA 652 and in *NFPA 654: Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing and Handling of Combustible Particulate Solids*.

Factors to consider when conducting a DHA

When conducting a DHA for a facility handling combustible dusts, you should consider the following:

Presence of combustible dusts. If your process cuts, machines, shapes, or alters raw materials in a manner that creates dust, you could have a combustible dust hazard. Most if not all materials that burn as a solid will be combustible and possibly explosive as a dust. Examples of materials that can be combustible when finely divided



A critical component of a DHA is to identify potential ignition sources. Equipment operators often have valuable insights into a process's hazards and possible solutions.

include but aren't limited to cosmetics, coal, dyes, grains, dry foods, metals, pharmaceuticals, plastics, rubber, printer toner, soaps, textiles, wood, and paper.

NFPA 654 provides guidelines for determining how much combustible dust poses a hazard. The standard identifies limits for thin layers and accumulated volumes of dust. The most common rule is the layer depth criteria, which states that a nonseparated layer $\frac{1}{32}$ -inch deep on floors and elevated surfaces that amounts to more than 5 percent of the building floor space or 1,000 square feet, whichever is less, meets the fire and explosion hazard criteria.

Processes that use, consume, or produce combustible dusts.

The DHA should examine each process that uses, consumes, or produces combustible dust. 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. 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.

Areas where dust accumulates. The analysis should inspect both open and hidden areas around the process where dust accumulates, determine the source of the dust, and identify control measures if possible. These areas include floors, horizontal and sloped surfaces, ledges, roof members, and dropped ceilings, to name a few.

Means by which dust may be dispersed into the air. If combustible dust is present during normal operations or during an upset, the analysis should identify means that might disperse the accumulated dust into a combustible cloud. Examples include a primary dust explosion, cleaning with brooms or compressed air, fans, wind, spills, and equipment malfunctions.

Potential ignition sources. The source of ignition is often very difficult to identify after a dust deflagration event, and history has shown that many combustible dust incidents result from a fire outside the dust collection system whose flames or sparks are sucked into the system. The DHA should attempt to identify any potential ignition sources both inside and outside the process. Examples of known ignition sources include sparks from moving equipment, improperly controlled hot work, rotating machinery failure such as bearings and motors, electrical malfunctions, open flames, and static electricity discharge.

Risk assessment and controls

While a DHA identifies potential combustible dust hazards associated with a process, a risk assessment helps determine the process's acceptable level of risk to workers

and which control devices or methods must be implemented to achieve that level of risk. The NFPA recognizes that all hazards can't be completely eliminated and that some level of risk will always be present. The intent of a risk assessment is to achieve the life safety goal as defined in NFPA 654. The life safety goal is considered to be 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.⁵

Table II summarizes the hazards associated with a typical dust collector and the controls available to reduce the risk level from these hazards. [**Editor's note:** For more information about the controls listed in the table, see "For further reading" at the end of this article.]

All controls must be compatible with your application's combustible dust. Most metal dusts are reactive with water, for example, so automatic sprinkler systems are prohibited for metal dust applications unless your DHA demonstrates and documents that the dust isn't reactive with water. Some controls are just common sense and good practice. For example, an interlock that shuts down the fan in the event of an ignition in your dust collector will significantly reduce fire damage to the collector and could make the difference between having to scrap the collector and being able to reuse it.

Documentation

A hazards analysis, regardless of type, is the first thing an OSHA inspector will ask for if he or she discovers combustible dust during an inspection, and failure to provide this information will result in a citation. One simple method to document a DHA is with a spreadsheet similar to the example in Table III. This table was created from a specific scenario and doesn't depict all possible controls for the hazards listed or all possible hazards that could be associated with your dust collector and process. A complete DHA would include the process equipment producing the dust along with any other hazards external to the dust collection system.

You can add an additional row to this worksheet for each individual section of pipe and piece of process equipment, and you can add as many columns as needed to identify aspects of your system. For example, an additional column could contain notes pertaining to the risk assessment, such as why you chose a particular control, or other supporting information to help the authority having jurisdiction determine whether the controls are acceptable.

Table II**Dust collector hazards and controls**

Hazard	Controls (Multiple controls may be provided)
Fire	Automatic sprinklers CO ₂ 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 from the collector	Passive isolation damper Passive float valve Actuated float valve Fast-acting mechanical valve Chemical barrier
Flame downstream from the collector	Flame-arresting device
Flame and pressure downstream from collector	Actuated float valve Fast-acting mechanical valve Chemical barrier

The analysis should classify each system segment as “not a hazard,” “possible hazard,” or “deflagration hazard.” In Table III this is represented by the “Zone” column, which uses the hazardous location zones defined in *NFPA 70: National Electrical Code*. Zone 20 indicates a location in which a hazardous quantity of combustible dust is continuously present or present for long periods of time during normal operation; Zone 21 indicates a location in which a hazardous quantity of combustible dust is occasionally present during normal operation; and Zone 22 indicates a location in which a hazardous quantity of combustible dust is not likely to be present during normal operation.⁶

For each system segment, you should ask the following questions:

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

Some segments may require multiple rows of analysis. This is OK. Be systematic and concise, and don't be afraid

Table III**Dust hazards analysis worksheet^a**

Area	Description	Hazard	Zone	Action or control
1	Dust collector	Explosion and fire hazards	20	Deflagration venting to a safe area
			20	Deflagration vent sensor to shut down process
			20	Flow switch in sprinkler line to shut down process
			20	Integrated safety monitoring filter-flame front arrestor
			20	Internal automatic sprinklers
			20	Fire retardant filter media
		Process continues after a fire or deflagration feeding fuel and oxygen to the fire	20	Deflagration vent sensor interlocked with process to shut it down
			20	Flow switch in sprinkler line interlocks with process to shut it down
2	Inlet duct	Flame and pressure propagation upstream	22	Activation switch on explosion isolation valve interlocks with process to shut it down
		Flame propagation downstream	22	Flow-operated flap valve (explosion isolation valve)
3	Outlet duct	Pressure propagation downstream	22	Integrated safety monitoring filter certified to stop flame fronts
			22	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

Note:^a If oxidants are present other than oxygen in air, follow OSHA regulation 29 CFR 1910.119 process hazard analysis requirements.

to modify the worksheet to fit your needs. Ultimately you want to identify all hazards and select suitable controls. You should list each control and collect vendor documentation on each control's specifics.

The DHA and risk assessment documentation 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 full list of documents is beyond the scope of this article, but it includes items such as calculations, process design and layout, control equipment specifications, training requirements, and inspection records.

Additional considerations

Under NFPA 652, existing facilities are now required to complete a DHA no later than 3 years from the standard's publication, for a completion date of October 2018. This is one of the most important changes to NFPA standards in recent history. Previously, a company didn't have to perform a hazards analysis on an existing system unless the system was modified in a manner that exceeded 25 percent of the system's initial installation cost. Importantly, while the DHA doesn't need to be completed until October 2018, companies are expected to demonstrate reasonable progress toward this goal over the 3-year time span. Waiting until the final weeks to initiate an analysis is not a recommended strategy and could result in an OSHA citation.



As shown in this demonstration, a properly vented dust collector directs flames and pressure safely away from the workspace and allows the collector to be reused after an explosion.

NFPA 652 also 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.

While OSHA has been slow to react to the combustible dust emphasis program, the agency is progressively training officers and adding to its inspection force. The responsibility for complying with governing NFPA standards lies with facility owners and operators, and companies that don't take combustible dust hazards seriously will face punitive fines and little time to achieve compliance.

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References

1. US Chemical Safety and Hazard Investigation Board (CSB), 2175 K. Street, NW, Suite 400, Washington, DC 20037; www.csb.gov; Video "Combustible Dust, An Insidious Hazard."
2. Available at www.osha.gov.
3. NFPA standards are available at www.nfpa.org.
4. Available at www.aiche.org/ccps/resources/publications.
5. NFPA 654: Chapter 4.6.1.
6. NFPA 70: Article 506.

For further reading

Find more information on this topic in articles listed under "Dust collection and dust control" and "Explosion/fire protection" in *Powder and Bulk Engineering's* article index in the December 2015 issue or the Article Archive on PBE's website, www.powderbulk.com. (All articles listed in the archive are available for free download to registered users.)

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