Combustible Dust Hazard Analysis and NFPA Standards

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Reasons that Employers Are Still Caught Unaware.

- Employers do not realize that they have combustible dust issues.
- Past guidance, including from OEMs, may be wrong or circumstances may have changed – reliance on others is not a defense.
- Fire departments and state and local regulators may not be educated on combustible dust hazards.
- Combustible dust may accumulate over many years before it becomes a potential explosion problem or an incident occurs.
- The five necessary elements of a dust explosion may not have been present before recent changes.
- Contractors and maintenance departments may not have considered the effects of one change on combustible dust issues - no management of change process.
- Manufacturers/Contractors may not have adhered to NFPA standards at the time.
Employers May be Vulnerable and then Respond Incorrectly.

- There is confusion about the roles of NFPA Standards and about NFPA 652.
- The first step of a Process or Dust Hazard Analysis is often underutilized or badly done.
  - Focused on by new NFPA 652.
  - If you don’t conduct a Dust Analysis to justify your actions, OSHA will use a Checklist-approach and shape the discussion.
- There are many approaches to Abatement/Compliance.
- Compliance takes longer than expected and presents interim legal exposure.
- Employers overlook Repeat and Willful OSHA exposure.
- Experts and Counsel have important roles.
Examples of Applicable OSHA Standards


- 1910.132(a) PPE/protective clothing in flash fire areas
- 1910.146 Permit confined spaces
- 1910.119 PSM, where dust is a highly hazardous chemical
- 1910.33-37 Means of egress
- 1910.38 Emergency Action Plans (EAP)
- 1910.156 Fire Brigades
- 1910.157 Portable fire Extinguishers
OSHA Cites Most Combustible Dust Hazards Under It’s “General Duty Clause” Approach

In the absence of specific standards, OSHA relies on Section 5(a)(1) of the OSHAct:

“Each employer…shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious harm to his employees.”

OSHA must prove:

• that a serious hazard is recognized by the employer's industry or the employer; and
• there is a feasible and useful method for abating the hazard.

What shows “Recognition?”

• Does the “industry” recognize the hazard and by extension, the responses/abatements?
• Consensus standards are not automatically accepted as recognized by the industry.
• OSHA cites for hazards, not specific abatements.
• Employers may also follow consensus standards as best practices but argue that all or parts of standards are not legally citable.
Examples of Common OSHA Citations.

- Dust collectors or air material separators were located inside building without proper explosion protection.
- Air from dust collectors was recycled back into building.
- Lack of explosion isolation between equipment.
- Lack of bonding or grounding of equipment.
- Duct work from the dust collection system to other areas of the plant were not constructed of metal.
- Housekeeping, dust accumulation, and cleaning methods.
- Lack of Employee Training.
- Need for classified electrical system and powered industrial trucks.
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Introduction

- Combustible dust is a major hazard in the solids handling industries.
- Today we will discuss:
  - Basics of Combustible Dust
  - NFPA standards
  - Conducting a Dust Hazard Analysis
What do we mean when we talk about combustible dust?

- Combustible Dust is a “particulate solid that presents a fire hazard when suspended in air ... regardless of size or shape.” - NFPA

- Layman’s terms: if it can burn, and it hangs in air (even briefly), it is likely a combustible dust.

- Combustible Dust can be: dry food, plastics, wood, rubber, textiles, pesticides, pharmaceuticals, dyes, coal, and metals, among many other substances.
Decrease in Particle Size

• The rate of combustion of a material depends on particle size, and smaller particles have increased burning rates.

• Normally slow burning material can create flash fires if particles are sufficiently small and suspended in air.
Definitions – Hazards of Combustible Dust

• **FIRE**: The rapid oxidation of a material in the chemical process of combustion, releasing heat, light, and various reaction products.

• **DEFLAGRATION**: Propagation of a combustion zone at a velocity that is less than the speed of sound in the un-reacted medium. (From NFPA 654)

• **EXPLOSION**: An explosion is a rapid increase in volume and release of energy in an extreme manner, usually with the generation of high temperatures and the release of gases.

*Image from US Chemical Safety Board*
Fire Triangle

- Oxygen
- Heat
- Fuel
Deflagrations

• For a free-air deflagration to occur, four conditions must be met:
  ❖ Small combustible particles are present (fuel)
  ❖ The particles are suspended in the air in sufficient quantity
  ❖ Available oxygen
  ❖ Ignition source (energy)

• Having all four conditions come together simultaneously is relatively rare in most facilities.

• However, if rooms or pieces of equipment have the potential for dust concentrations to reach the MEC, then a deflagration hazard exists.
Suspension of a Dust Cloud

For a deflagration to occur, the dust cloud must be suspended in a sufficient density – the Minimum Explosion Concentration (MEC).

- Insufficient Concentration
- Sufficient Concentration
Deflagrations

- Deflagrations release energy in the form of heat very rapidly.

- This heat increases the air temperature and causes the air and combustion gases to rapidly expand.

- As this expansion occurs, local pressure gradients develop. The pressure gradient (i.e. pressure wave) propagates with the deflagration.
Dust Explosions

- Explosion hazards exist when all four conditions needed for a deflagration can occur within an enclosure – whether it is a room, building, container, or piece of equipment.

- Most dust explosions originate inside pieces of equipment or containers. Fires and Explosions often occur in the following types of:
  - Dust Collectors (account for over 50% of incidents)
  - Silos / Bins
  - Dryers / Ovens
  - Conveyors / Elevators
Explosion Pentagon

- Oxygen
- Dispersion of Dust Cloud
- Fuel
- Containment of Dust Cloud
- Ignition Source
Containment of Dust Cloud

The dust cloud must be contained for an explosion to occur.
When you have a confined dust cloud, all that is missing is an ignition source (assuming oxygen is present).
Process Equipment Explosion

Diagram:
- Clean Air Side
- Exhaust
- Inflow
- High Dust Concentration
Process Equipment Explosion
Process Equipment Explosion
Process Equipment Explosion
Process Equipment Explosion

Baghouse Ruptures
Explosion Chain Reactions

- Industrial dust explosions can create a chain-reaction resulting in more explosions and flash fires.

- Flame fronts can travel through ductwork from equipment to equipment, or pressure waves can disturb settled dust creating a hazardous atmosphere throughout a building.

- These SECONDARY EXPLOSIONS are often the most damaging.
Deflagration Propagation
Deflagration Propagation
Deflagration Propagation
Greatest Hazard of Combustible Dust

- Dust can accumulate on surfaces, with the smallest particle sizes accumulating in hard to reach places (overhead surfaces), often unnoticed.

- Primary explosions can dislodge the accumulated dust, and create a much larger, SECONDARY EXPLOSION.
Several standards exist to prevent dust fires and explosions.

In the USA, the National Fire Protection Association (NFPA) maintains standards associated with combustible dust.

Several of these standards were recently updated, or are being updated in 2019.
About NFPA

• The National Fire Protection Association (NFPA) is charged with creating standards for fire prevention.

• NFPA has no enforcement power of their own.

• Authorities Having Jurisdiction (AHJs) often reference NFPA standards in their own regulations.

• Compliance falls on facilities more than equipment manufacturers.
Current NFPA Standards

The below standards can apply to Particulate Handling facilities:

- NFPA 652 – Fundamentals of Combustible Dust
- NFPA 61 – Agricultural and Food Processing Facilities
- NFPA 654 – Prevention of Fire and Dust Explosions from Combustible Particulate Solids (General)
- NFPA 664 – Wood Processing and Woodworking Facilities
- NFPA 68 – Standard for Explosion Protection by Venting
Applying the Standards

- NFPA 652 is an overarching standard that applies to all facilities with combustible dust.
- NFPA 61, 654, 664 and others are “Commodity Specific” standards.
- Start with 652, and then use the commodity standards for specific equipment and to be more consistent with industry standards.
- When there are differences in 652 and the commodity standard, NFPA allows the user to choose either standard.
- NFPA has a long-term goal to combine all standards into 652.
Major Requirements of the Standards

• Establishes facility layout / building requirements for fire protection and life safety.
• Require facilities to obtain combustion properties of materials.
• Must conduct Dust Hazard Analysis prior to installing new equipment, and within 5 years for existing equipment.
• Have “Prescriptive Requirements” for equipment.
• Specifies Management System requirements for operation of the plant.
Recent Changes to 652 and Others

• Specific dates for completing the Dust Hazard Analysis (DHA) for existing equipment are being added to the standards. E.g. Sept. 7, 2020 for 652.
• DHAs must be reviewed and updated every 5 years.
• NFPA 61, 654, and 664 are being reorganized to align with NFPA 652.
• Exemptions are being applied to explosion protection for smaller pieces of equipment (less than 8 ft³ / 0.2 m³).
• Significant updates on the details for housekeeping.
• Removed exemptions for isolation of small diameter ducts.
Assessing the Hazards

- The potential for dust fires and explosions varies from facility to facility, and process to process.

- To determine the presence and extent of hazards for a specific process, a Dust Hazard Analysis (DHA) must be performed.

- NFPA 652 – Standard on the Fundamentals of Combustible Dust – has specific requirements for conducting DHAs:
  - Existing facilities must complete DHAs for all processes by Sept. 7, 2020 (NFPA 652, 2019)
  - For new processes or processes undergoing modification, DHA must be done as part of the project.
  - DHAs must be performed or led by a qualified person.
  - DHAs must be reviewed and updated every 5 years.
What is a Dust Hazard Analysis (DHA)?

A DHA is a systematic review of the process to:

• Identify where fires and explosions can occur,
• Identify the potential causes and consequences,
• Determine if existing and proposed safeguards are sufficient.

Drawing from a Combustible Dust Hazard Analysis
Steps in a DHA?

1. Evaluate the material being handled at each stage of the process,
2. List the processes and equipment that handle particulates,
3. Identify equipment and areas where fire, deflagration, or explosion hazards exist,
4. Identify potential ignition sources,
5. Discuss fire and explosion scenarios (consequences),
6. Review safeguards in place to mitigate the hazards,
7. Evaluate the level of risk.
Evaluate Material Properties

- The first step is relatively obvious: identify all potential dusts HANDLED and GENERATED at the facility.
- Review SDS for the materials and contact the vendors for any additional data.
- Review textbooks, online databases and NFPA standards.
- If unknown, conduct laboratory testing.
Itemize all pieces of equipment, paying special attention to:

• Bins, tanks, and silos
• Hammermills, pulverizers, grinders,
• Dryers and ovens,
• Dust collectors,
• Conveyors, screw augers, and bucket elevators,
• Sifters, screens, and classifiers.

An Example Process
(Source: NFPA 652 – Standard on the Fundamentals of Combustible Dust)
For each piece of equipment, determine if a fire or explosion hazard exist:

• Look at the material properties to determine if it can easily burn,
• Determine if a dust cloud will exist in the process equipment during normal operation, or if an upset condition can create a dust cloud.

Evaluate fire or explosion hazards in the building:

• Identify areas where dust accumulation is likely,
• Pay special attention to hidden or rarely visited areas,
Ignition sources can include:

- Process Heat
- Friction
- Hot Work
- Mechanical Energy

Also look for:
- Electrical Sparks and Arcing
- Static Electricity
- Radiant Heat (hot surfaces)
- Open flames
- Powered Industrial Trucks
- Smoking
Once you have identified where fires and/or explosions can occur, you need to develop “What-If” scenarios.

Points to consider:

• What engineering controls (safeguards) are in place to mitigate the hazard, and what additional controls could be added?
• What types of equipment and occupancies are near the location of the hazard?
• What pieces of equipment are connected via ducts or conveyors to units where an explosion hazard exist?
• What is the potential chain of events that could occur?
The Risk of a specific fire or explosion hazard is based on the Likelihood and Severity of an event.

The likelihood should consider:
- The potential for an ignitable dust cloud,
- Presence of an ignition source,
- All operating modes (normal, abnormal, start-up, shut-down).

Severity should consider:
- Potential harm to employees,
- Impact to business, i.e. downtime,
- Existing safeguards to reduce harm.

A Risk Matrix can be used to determine if the level of risk is acceptable. If not, additional controls are needed.
The completed risk matrix will identify the areas and equipment that are at unacceptable levels of risk.

Recommendations designed to reduce the likelihood and/or severity of fires and explosions should be developed for everything that is unacceptable.

The priority of the recommendations should be based on a balance of which items present the greatest risk and which recommendations are most feasible.
CTI is available to assist clients with the following services:

- Combustible Dust Hazard Analysis
- Dust Sampling and Analysis
- NFPA and OSHA Compliance Review
- Explosion Protection Design and Selection
- Hazardous (Classified) Location Determination
Contact Information

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