



Combustible Dust Hazards

Central Ohio ASSE/Central Ohio CHMM

March 18, 2016

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Topics

- Background
- What is combustible dust?
- What are the hazards of combustible dusts?
- Severity
- Dust, Fire and Explosive Pentagon
- Regulations
- Hazard Assessments
- Prevention and Mitigation of Combustible Dust events

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Background

- First documented dust explosion
 - 1785
 - Bakery
 - Turin, Italy
 - Cause
 - Lamp → Flour dust
 - No fatalities

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Background

- 1985-2005
 - 119 Deaths
 - 718 Injured
- 1996-2005
 - 106 Explosions
- 2006-2008
 - 82 Explosions
- 2008-2012
 - 50 accidents
 - 29 fatalities
 - 161 injuries

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1981, Grain Elevator, Corpus Christi, TX

- 9 Fatalities
- 20-30 Injuries
- >\$30 Million Damages

- Causes
 - Smoldering grain
 - Milo Dust

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2008, Imperial Sugar, Port Wentworth, GA

- 14 Deaths
- 36 Injuries

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The Problem

- Unaware of the dust explosion potential
- Failed to recognize the seriousness of dust explosion hazards
- Information was not contained on MSDS
 - 41% of reviewed MSDS did not contain information about combustible dust hazards
 - 59% most of the information was not adequately stated

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The Problem

- Less than 1/32" combustible dust is needed in suspension to be explosive.
- The thickness of a dime (~1/16") is twice the amount needed to be deadly.

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What is Combustible Dust? - OSHA

- **Combustible dust** is defined as a solid material composed of distinct particles or pieces, regardless of size, shape, or chemical composition, which presents a fire or deflagration hazard when suspended in air or some other oxidizing medium over a range of concentrations.

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What is Combustible Dust? – NFPA 654

- "Any finely divided solid material that is 420 microns or smaller in diameter (material passing a U.S. No. 40 Standard Sieve) and presents a fire or explosion hazard when dispersed and ignited in air."
- A combustible particulate solid that presents a fire or deflagration hazard when suspended in air or other oxidizing media over a range of concentrations regardless of particulate size or shape. (NFPA – 2006 ed.)

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What Is Combustible Dust?

- The simple definition – any fine material that is able to catch fire and explode when mixed with air.

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Where Is Combustible Dust?

- Agricultural
- Carbonaceous
- Chemical
- Metal
- Plastic

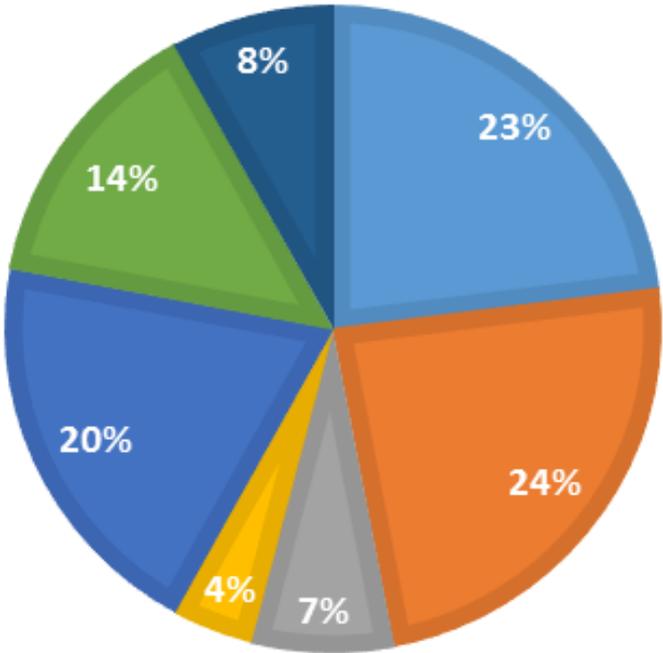
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Types of Dust Causing Combustible Incidents

TYPES OF DUST RESULTING IN INCIDENTS

■ Food ■ Wood ■ Other ■ Inorganic ■ Metals ■ Plastic ■ Coal



Source – FM Global

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Where Is Combustible Dust?

- Wood Processing
 - Paper
 - Furniture
- Textiles
- Pharmaceuticals
- Food
- Agriculture
- Metal Processing
- Tire and Rubber
- Chemicals

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Combustible Dust Producing Operations

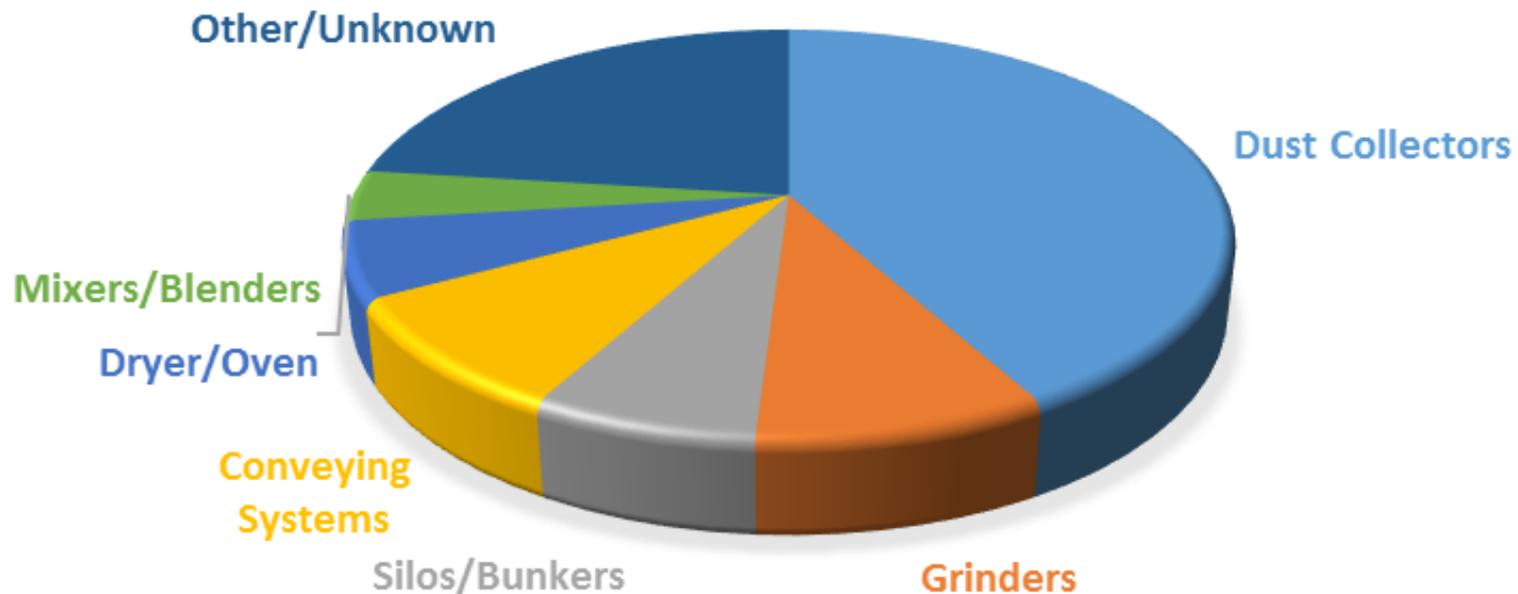
- Material
 - Abrasive Blasting
 - Cutting
 - Grinding
 - Polishing
 - Crushing
- Dry Material
 - Conveying
 - Mixing
 - Sifting
 - Screening
- Buildup dried residue from wet materials

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Equipment Involved in Dust Explosions

EQUIPMENT INVOLVED IN DUST EXPLOSIONS



Source – FM Global

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Dust Explosion Conditions

- Combustible
- Dry
- Sustain the Fire – Release of high heat
- Small particle size – Spread the flame
- Capable of being suspended in air
- Concentration to cause an explosion (MEC)
- Ignition source near dust suspension
- Sufficient oxygen
- Confinement to build pressure

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Dust Explosion Conditions

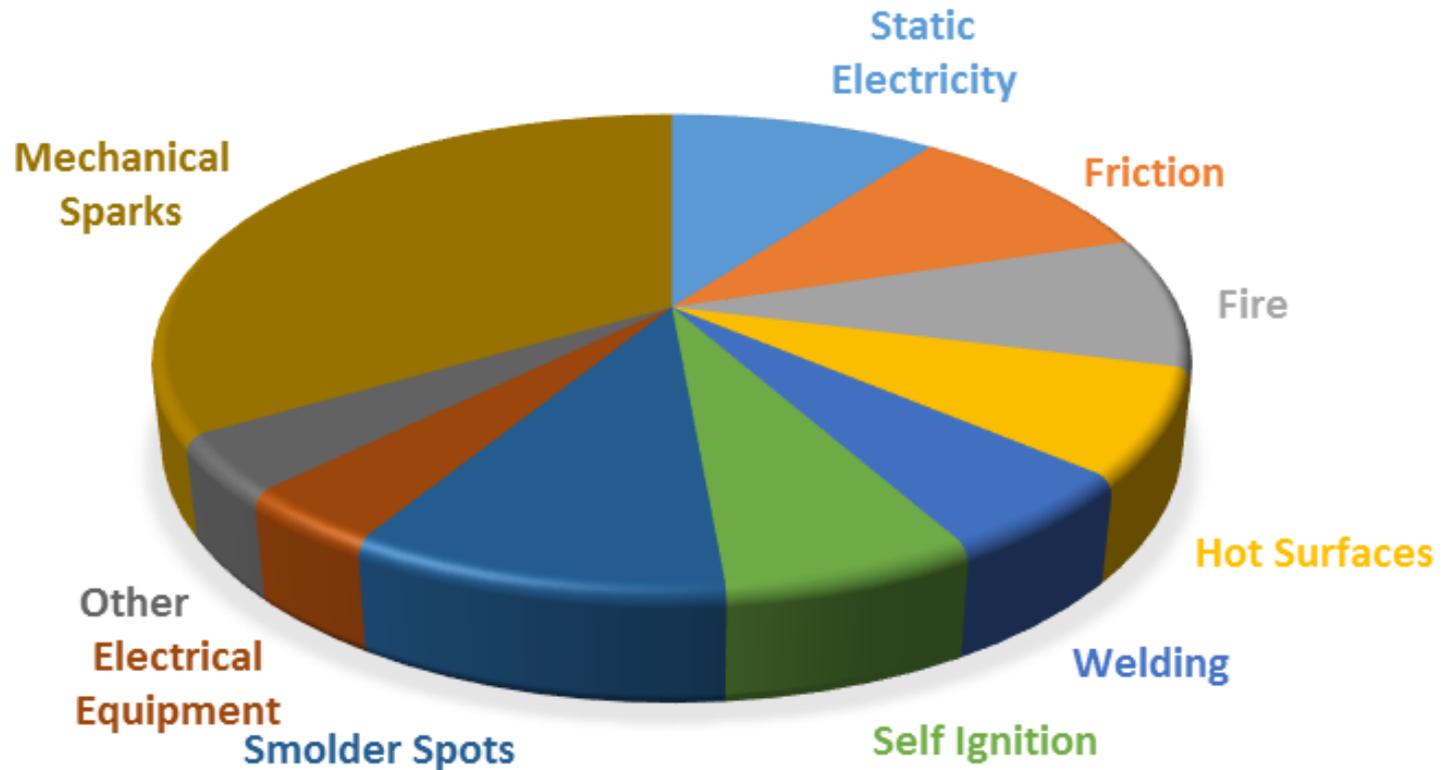
- Check SDS for material
- Moisture content
- Materials may change while being processed

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Ignition Sources of Dust Explosions

DUST EXPLOSION IGNITION SOURCES

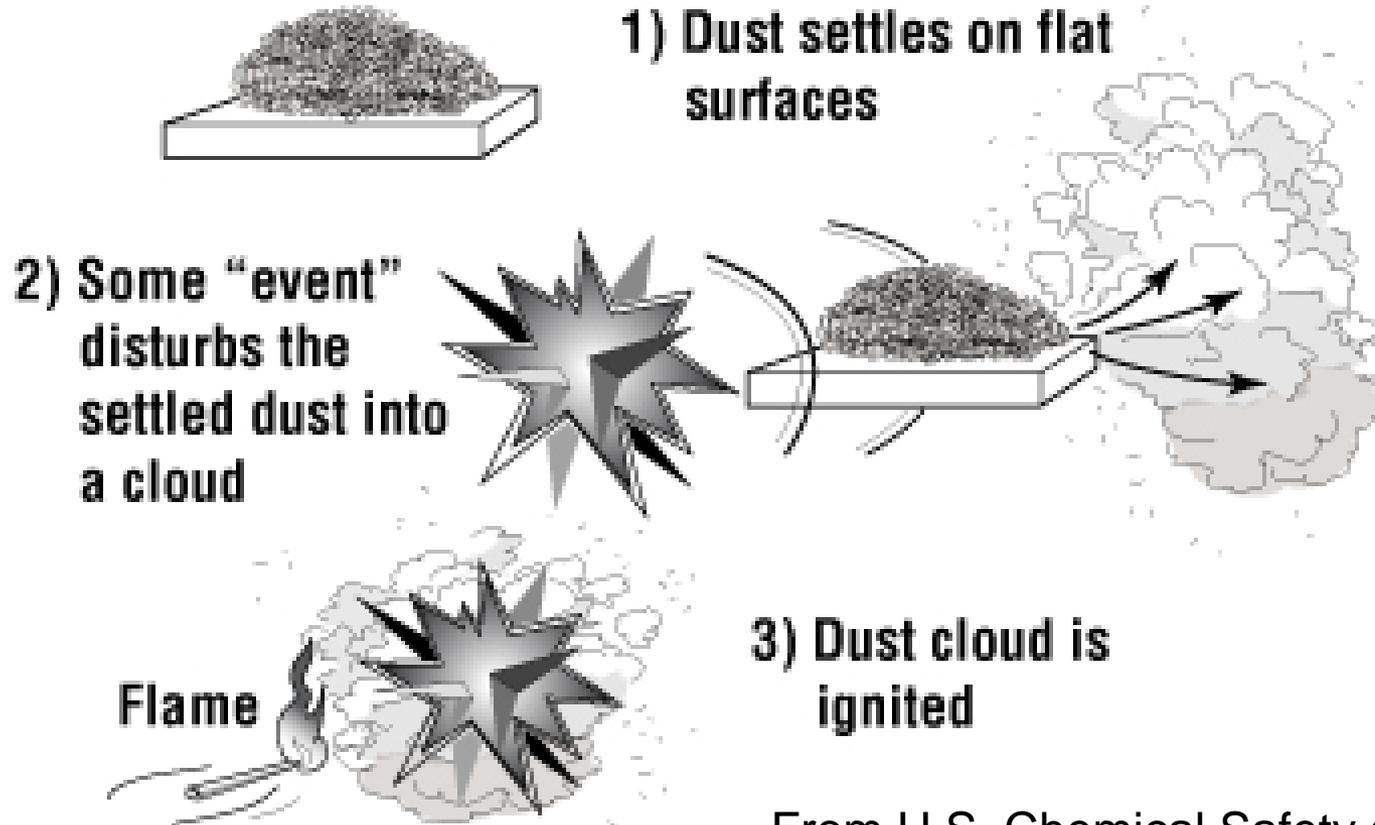


Source – Stahl, *Dust Explosion Protection*

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Combustible Dust Explosion



From U.S. Chemical Safety and Hazard Investigation Board.

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Dust Explosion Pentagon

- Combustible Dust – Fuel Source
- Heat – Ignition Source
- Oxygen in Air – Oxidizer
- Dispersion of Dust Particles
 - Sufficient Quantity
 - Sufficient Concentration
- Confinement of Dust Cloud

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Primary and Secondary Explosions

- Initial (Primary) Explosion
 - Shake loose accumulated dust
 - Damage containment system
 - Dust becomes airborne
- Secondary Explosion
 - Ignition of dust created by primary explosion

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A Dust Explosion Event in MSec.

Event	Elapsed Time
• Primary Deflagration Inside Process Equipment	20
• Shockwave Caused by Primary Deflagration	25
• Bldg Surface Reflects Shockwaves; Accumulated Dust into Suspension	37
• Dust Clouds formed in Air by Shockwaves	62
• Source of Ignition Created by Primary Deflagration Breaking out of the Equipment Enclosure	80
• Ignition of Secondary Deflagration	130
• Propagation of Secondary Deflagration Through Dust Clouds	200

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Deflagration

- An exothermic reaction, such as the extremely rapid oxidation of a flammable dust or vapor in air, in which the reaction progresses through the unburned material at a rate less than the velocity of sound. A deflagration can have an explosive effect.

– Section 2702 of the *International Fire Code* (IFC)

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Particle Size Exceptions

- Larger particles can still deflagrate
 - Abrade → Smaller particles
- Particles agglomerate then separate into smaller particles

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Video



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Combustible Dust Measurements

- K_{st} Dust Deflagration Index, relative explosive severity compared to other dusts.
- MEC, The Minimum Explosive Concentration, measures the minimum amount of dust dispersed in air required to spread an explosion.
(Analogous to LFL/LEL)
- MIE, The Minimum Ignition Temperature, which predicts, the ease and likelihood of ignition of a dispersed dust cloud
- Dust Layer

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Dust Explosiveness

K_{st} Values for Different Dust Types

Dust Explosion Class*	K_{st} (bar.m/s)	Characteristic*	Typical Material**
St 0	0	No Explosion	Silica
St 1	> 0 <= 200	Weak Explosion	Charcoal, Powdered Milk, Sugar, Sulfur, Zinc
St 2	>200 <=300	Strong Explosion	Cellulose, Poly Methyl Acrylate, Wood Flour
St 3	< 300	Very Strong Explosion	Aluminium, Anthraquione, Magnesium

The actual explosion class depends on the sample and may vary due to characteristics such as moisture content, shape and particle size.

* OSHA CPL 03-00-008 – Combustible Dust Emphasis Program.

** NFPA 68, Standard on Explosion Prevention by Deflagration Venting.

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OSHA Regs. Related to Combustible Dust

- 1910.22 Housekeeping
- 1910.269 Electric Power Generation, Transmission and Distribution (Coal Handling)
- 1910.272 Grain Handling Facilities
- 1910.307 Hazardous Locations
- 1910.1200 Hazard Communication

- Combustible Dust National Emphasis Program
- Safety & Health Information Bulletin 07-31-2005
 - Combustible Dust in Industry

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OSHA's Response

- Combustible Dust National Emphasis Program (NEP)
 - October 18, 2007
 - Inspect facilities that generate or handle combustible dusts that pose a deflagration/explosion or other fire hazard
 - 64 Types of Industries

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OSHA Regs. Related to Combustible Dust

- General Duty Clause, Section 5(a)(1)
 - Airborne fugitive dust
 - Excessive dust
 - Ungrounded ducts and ventilation systems
 - Prevention of deflagration not provided in dust collection system
 - Interior dust prevention systems

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OSHA Regs. Related to Combustible Dust

- 1910.22 General Requirements – Housekeeping
- 1910.38 Emergency Action Plan
- 1910.39 Fire Prevention Plan
- 1910.157 Portable Fire Extinguishers
- 1910.165 Employee Alarm Systems
- 1910.94 Ventilation
- 1910.119 Process Safety Management
- 1910.132 Personal Protective Equipment
- 1910.176 Material Handling and Storage

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OSHA Regs. Related to Combustible Dust, Cont'd

- 1910.178 Industrial Forklifts
- 1910.263 Bakery Equipment
- 1910.265 Sawmill Operations
- 1910.272 Grain Handling Facilities
- 1910.307 Hazardous Locations
- 1910.1200 Hazard Communication

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OAC 1301:7-7-13

- Sources of Ignition
- Housekeeping
- Explosion Protection Standards – authorizes the fire code official to enforce (NFPA) to prevent and control dust explosions

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OAC 1301:7-7-13/NFPA

Standard	Subject
NFPA 61 as listed in rule 1301:7-7-47 of the Administrative Code	Agriculture and food products
NFPA 69 as listed in rule 1301:7-7-47 of the Administrative Code	Explosion prevention
NFPA 70 as listed in rule 1301:7-7-47 of the Administrative Code	National Electrical Code
NFPA 85 as listed in rule 1301:7-7-47 of the Administrative Code	Boiler and combustion systems hazards
NFPA 120 as listed in rule 1301:7-7-47 of the Administrative Code	Coal preparation plants
NFPA 484 as listed in rule 1301:7-7-47 of the Administrative Code	Combustible metals, metal powders and metal dusts
NFPA 654 as listed in rule 1301:7-7-47 of the Administrative Code	Manufacturing, processing and handling of combustible particulate solids
NFPA 655 as listed in rule 1301:7-7-47 of the Administrative Code	Prevention of sulfur fires and explosions
NFPA 664 as listed in rule 1301:7-7-47 of the Administrative Code	Prevention of fires and explosions in wood processing and woodworking facilities

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2014, Portage Precision Polymers, Ravenna, OH

- Serious Violation
- Workers were exposed to the combustible dust while working in the facility.
- Possible explosive hazard

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Prevention – Hazard Assessment

- Identify materials and processes that could generate dust
- Determine how those dusts may become dispersed in air
- Identify potential ignition sources
- Identify duct accumulation areas (open and “hidden”)
- Identify where special electrical equipment must be used

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Prevention – Hazard Assessment

- Review SDSs
 - SDSs are required to determine hazards
 - Many SDSs do not include explosibility
 - A hazard evaluation is required to be conducted to consider all discernible hazards.
 - This includes explosibility.

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Prevention – Hazard Assessment

- Conduct internal and external audits
- Encourage employees to engage in preventative measures to eliminate dust explosions
- Train employees on how to recognize potential dust combustibility hazards
- Identify explosion hazards through JHAs

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Prevention - Housekeeping

- Ensure that facility is as dust free as possible
- Develop, implement and maintain a written housekeeping program
- Consistently inspect potential accumulation areas, especially “hidden” areas
 - Have a regular schedule for “dust” cleaning
 - Ensure that equipment is safe to be used
 - Vacuums rated Class II Div 1
 - Ensure that dust is removed from the area

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Prevention - Housekeeping

- Use cleaning methods that do not generate dust clouds.
- Clean outside air source shall be obtained for comfort heating equipment

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Prevention – Ignition Sources

- Hazardous Area Classification depends on the following:
 - The properties of the liquids, gases, flammable vapors or gases, or combustible dusts that may be present
 - The likelihood that a combustible concentration or quantity is present
- Combustible dust is classified as Class II

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Prevention – Ignition Sources

- **Group E** – Atmospheres contain combustible metal dusts
- **Group F** – Atmospheres contain carbon dusts that have greater than 8% entrapped volatiles or have been sensitized by other materials so that they present an explosion hazard
- **Group G** – Atmospheres contain combustible dusts not included in Group E or F.

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Prevention – Ignition Sources

- Electrical Equipment
 - Class II, Div 1 and 2 rated
 - Should not generate mechanical sparks and/or friction
 - No open flames
 - No welding, cutting or grinding without a Hot Work Permit
 - Minimize the use of tools and vehicles
 - Eliminate potential static electricity generation
 - Ensure proper bonding and grounding

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Prevention – Engineering Controls

- Clean and change filter bags on dust collectors no less than what is recommended by the manufacturer.
- Clean out dust cyclone holding bins at regularly scheduled intervals no less than what is recommended by the manufacturer.
- Limit and control potential ignition sources.

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Prevention – Engineering Controls

- Install dust control systems such as filters and cyclones.
- Provide a clean, outside air source for comfort heating equipment

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Prevention - Fire

- Implement a fire prevention and control plan.
- Ensure that combustible dust is covered in the facility fire prevention plan
 - Sources
 - Mitigation/Prevention
 - Firefighting equipment

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Prevention - Fire

- Ensure that fire protection equipment is inspected and in good repair.
- Ensure that bonding and grounding is practiced.

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Prevention - Explosion

- Containment
 - Withstand the pressure without rupture
- Explosion Isolation
 - Prevents the explosion from propagating to other equipment
- Explosion Suppression
 - Detect the buildup of pressure
 - Apply suppression
- Explosion Vents
 - Prevent buildup of excessive pressure
 - Location is important

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Questions

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