How to Use Process Hazard Analysis (PHA) to Reduce Combustible Dust Explosion Risk

Presenters:
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& Adam Kane: Pharmaceutical OEM sales at Camfil APC
Focus of This Presentation

• Requirements of PHAs in NFPA 654
• Definition
• Methodologies
• How to conduct, document and follow up on a Process Hazard Analysis (PHA)
  1. Is the dust combustible
  2. How much dust presents a hazard
  3. Risk Evaluation Method
  4. Processes that use/consume/produce combustible dust
  5. Areas where combustible dust can accumulate
  6. Hidden areas where combustible dust can accumulate
  7. Means by which combustible dust may disperse
  8. Ignition Sources
Process Hazard Analysis

Why have a PHA?

OSHA requires all employers to adequately perform a hazard analysis as defined in NFPA 654.
Process Hazard Analysis

Section 4.0 NFPA 654

- **Required** for all processes that have a fire hazard.
- Documentation *must* be kept for the **life** of the process.
- If process involves combustible dust then you **must** document:
  - Allowable dust layer thickness
  - Maximum allowed surface area
  - Minimum PPE
- Update every 5 years

**OSHA is taking this document very seriously!**
Process Hazard Analysis

NFPA 654

4.2.1* The design of the fire and explosion safety provisions shall be based on a process hazard analysis of the facility, the process, and the associated fire or explosion hazards.

3.2.5 Shall. Indicates a mandatory requirement.
What is a PHA?

**A PHA is defined as:**

A systematic effort designed to identify and analyze hazards associated with the processing or handling of highly hazardous materials; and

A method to provide information which will help workers and employers in making decisions that will improve safety.

CAMFIL APC’s OFFICIAL POSITION ON PROCESS HAZARD ANALYSIS

If a customer does not want to follow the Process Hazard Analysis and Risk Assessment requirements of NFPA then we will adhere strictly to the prescribed controls in the standards.
Hazard Analysis Methodologies

https://www.osha.gov/SLTC/etools/safetyhealth/mod4_tools_methodologies.html

WHAT - IF Checklist: The what - if checklist is a broadly-based hazard assessment technique that combines the creative thinking of a selected team of specialists with the methodical focus of a prepared checklist.

Hazard and Operability Study (HAZOP): HAZOP is a formally structured method of systematically investigating each element of a system for all of the ways in which important parameters can deviate from the intended design conditions to create hazards and operability problems.

Failure Mode and Effect Analysis (FMEA): The failure mode and effect analysis is a methodical study of component failures. This review starts with a diagram of the process that includes all components which could fail and conceivably affect the safety of the process.

Fault Tree Analysis: A fault tree analysis is a quantitative assessment of all of the undesirable outcomes, such as a toxic gas release or explosion, which could result from a specific initiating event. It begins with a graphic representation (using logic symbols) of all possible sequences of events that could result in an incident. The resulting diagram looks like a tree with many branches — each branch listing the sequential events (failures) for different independent paths to the top event.
OSHA Citation

Occupational Safety & Health Administration  We Can Help

Inspection: [Redacted]

Inspection Information - Office: Cleveland

ID: 312944151  Report ID: [Redacted]  Open Date: 01/20/2006

Establishment:

SIC: 3303/Aluminum Foundries
NAICS: 331312/Aluminum Foundries [except Die-Casting]

Scope: Complete  Advanced Notice: N
Ownership: Private

Safety/Health: Safety

Emphasis: Lead/Inorganic Contaminants

Date of Violation: 01/20/2006

Violation Summary

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Section 5(a)(1) of the Occupational Safety and Health Act of 1970: The employer did not furnish employment and a place of employment which were free from recognized hazards that were causing or likely to cause death or serious physical harm to employees in that employees were exposed to fire/explosion hazards from aluminum dust: a. The dust collector for the Goff 6 Tumble Blast machine was attached to the machine and inside the building. b. The dust collector for the Goff 6 Tumble Blast methods to correct these hazards include the following: 1. Conduct a process hazard analysis by an individual knowledgeable about explosive metal dusts and comply with applicable standards issued by the National Fire Protection Association (NFPA) 484-2009, Standard for Combustible Metals; 2. Move the dust collector outside of the building. 3. Cover the box that sits under the Boff 6 Tumble Blast to avoid creation of airborne fugitive dust.
OSHA Fines Ga. Company $55k for Combustible Dust Violations

Thursday, February 10th, 2011

OSHA has fined Georgia’s ProTech Environmental South Inc. – which does business under the name U.S. Erosion Control Products Inc. – over $55,000 following an inspection that revealed nearly 50 violations, the most serious of them involving worker exposure to combustible dust. The penalty comes as part of a continued effort by OSHA since 2007 to eliminate the deaths of workers in close contact with combustible dust.

From Occupational Health & Safety:

After receiving a complaint, OSHA began an inspection in August 2010 at the company’s site in Willacoochee, Ga. Serious citations were issued for violations that included exposing workers to explosion hazards resulting from inadequate dust control, exposing workers to dust without respiratory protection, failing to clean up thick dust accumulations, using unapproved electrical equipment and forklifts in locations that may include flammable or combustible materials, absence of a fire extinguisher in a straw storage area, and fire extinguishers missing from their mounts.

“Combustible dust is a major safety and health hazard, and employers must recognize and correct hazards that expose their employees to death or serious physical harm,” said Robert Vazzi, OSHA’s area director in Savannah.
Organic Dust Fire and Explosion 2003: North Carolina (6 killed, 38 injured)

Citations:

Hazard assessment;
Hazard communication; and
Engineering management.
Process Hazard Analysis

Organic Dust Fire and Explosion 2003: Kentucky (7 killed, 37 injured)

Citations:

CTA ACCOUSTICS
Citations:
Hazard assessment;
Hazard communication;
Maintenance procedures;
Building design; and,
Investigation of previous fires.
Process Hazard Analysis

Organic Dust Fire and Explosion 1999: Massachusetts (3 killed, 9 injured):

Citations:
Housekeeping to control dust accumulations;
Ventilation system design; Maintenance of ovens; and,
Equipment safety devices.

Springfield, Massachusetts
February 25, 1999
March 13, 2013

US Labor Department's OSHA cites New England Wood Pellet LLC for fire and combustible dust hazards at 2 New York manufacturing plants - $47,710

Aug 7, 2011

US Department of Labor’s OSHA cites Alabama manufacturer for combustible dust and other hazards; proposes nearly $55,000 in fines
Hazard Assessment: **Facility Analysis Components:**

- Materials that can be combustible when finely divided
Process Hazard Analysis

Materials that can be combustible when finely divided

- Cosmetics
- Coal
- Dyes
- Grain
- Dry foods
- Metal
- Pharmaceuticals
- Plastic and rubber
- Printer toner
- Soaps
- Textiles
- Wood and paper
6.1.1.3* Dust flash fire or dust explosion hazard areas shall additionally be determined in accordance with any one of the following four methods:
(1) Layer depth criterion method in 6.1.3
(2) Mass method A in 6.1.4
(3) Mass method B in 6.1.5
(4) Risk evaluation method in 6.1.6

6.1.1.4 Each of the methods in 6.1.3, 6.1.4, 6.1.5, and 6.1.6 shall be deemed to provide equivalent levels of safety.
(1) Layer depth criterion method in 6.1.3

6.1.3.1 The layer depth criterion, which is \( \frac{1}{32} \) in. (0.8 mm), shall be permitted to be increased according to the following equation for materials with bulk density less than 75 lb/ft\(^3\) (1200 kg/m\(^3\)):

\[
LD \text{ (in.)} = \frac{\left( \frac{1}{32} \text{ in.} \right) \left( 75 \frac{\text{lb}}{\text{ft}^3} \right)}{BD}
\]

where:
- \( LD \) = layer depth (in.)
- \( BD \) = Bulk density (lb/ft\(^3\))
6.1.3.2* A dust explosion hazard and dust flash fire hazard shall be deemed to exist in any building or room where any of the following conditions exists:

(1) The total area of non-separated dust accumulations exceeding the layer depth criterion is greater than 5 percent of the footprint area
Process Hazard Analysis

6.1.3.1 -5 Percent limit

10000 sq ft open room or building
5% limitation is 500 sq ft.

600 sq ft room
30 sq ft Limit
Is This A Hazard Area?
(1) Layer depth criterion method in 6.1.3

6.1.3.2* A dust explosion hazard and dust flash fire hazard shall be deemed to exist in any building or room where any of the following conditions exists:
(1) The total area of non-separated dust accumulations exceeding the layer depth criterion is greater than 5 percent of the footprint area
(2) The area of any single non-separated dust accumulation exceeding the layer depth criterion is greater than 1000 ft² (92.9 m²)
Process Hazard Analysis

(1) Layer depth criterion method in 6.1.3

(2) The area of any single non-separated dust accumulation exceeding the layer depth criterion is greater than 1000 ft² (92.9 m²)

A space 25 ft x 40 ft covered with dust in any plant regardless of size of the factory is a hazard.

Note: this is about the size of most home shops!
(1) Layer depth criterion method in 6.1.3

6.1.3.2* A dust explosion hazard and dust flash fire hazard shall be deemed to exist in any building or room where any of the following conditions exists:

(1) The total area of non-separated dust accumulations exceeding the layer depth criterion is greater than 5 percent of the footprint area
(2) The area of any single non-separated dust accumulation exceeding the layer depth criterion is greater than 1000 ft² (92.9 m²)
(3) The total volume of non-separated dust accumulations is greater than the layer depth criterion multiplied by 5 percent of the footprint area
Process Hazard Analysis

(1) Layer depth criterion method in 6.1.3

(3) The total volume of non-separated dust accumulations is greater than the layer depth criterion multiplied by 5 percent of the footprint area

Total volume = depth x area

For the 10,000 sf plant:
1/32 in x 500 sf/12 = 1.3 cubic ft (13” cubic box, 10 gal)
(1) Layer depth criterion method in 6.1.3

6.1.3.2* A dust explosion hazard and dust flash fire hazard shall be deemed to exist in any building or room where any of the following conditions exists:
(1) The total area of non-separated dust accumulations exceeding the layer depth criterion is greater than 5 percent of the footprint area
(2) The area of any single non-separated dust accumulation exceeding the layer depth criterion is greater than 1000 ft² (92.9 m²)
(3) The total volume of non-separated dust accumulations is greater than the layer depth criterion multiplied by 5 percent of the footprint area
(4) The total volume of any single non-separated dust accumulation is greater than the layer depth criterion multiplied by 1000 ft² (92.9 m²)
(1) Layer depth criterion method in 6.1.3

(4) The total volume of any single non-separated dust accumulation is greater than the layer depth criterion multiplied by 1000 ft² (92.9 m²)

This equates too 2.6 cubic feet or 20 gallons
6.1.3.2 – 1000 sq ft limit

If the plant foot print is greater than 20,000 sf then the dust accumulation is limited to 1000 sf (32 ft x 32 ft)
(2) Mass method A in 6.1.4

6.1.4.1 The threshold dust mass establishing a building or room as a dust explosion hazard area, $M_{\text{basic-exp}}$, shall be determined by the following equation:

$$M_{\text{basic-exp}} = 0.004 \cdot A_{\text{floor}} \cdot H$$

where:

- $M_{\text{basic-exp}}$ = threshold dust mass (kg) based on building damage criterion
- $A_{\text{floor}}$ = lesser of enclosure floor area (m$^2$) or 2000 m$^2$
- $H$ = lesser of enclosure ceiling height (m) or 12 m
(2) Mass method A in 6.1.4

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<th>sq ft</th>
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<td>2323</td>
<td>2000 m^2</td>
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<tr>
<td>Height</td>
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<td>12</td>
<td>12 m</td>
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<tr>
<td>Volume</td>
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<td>24000 m^3</td>
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<tr>
<td>x .004</td>
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<td>Volume</td>
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<td>2.8 cu ft</td>
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(2) Mass method A in 6.1.4

6.1.4.2 The threshold dust mass establishing a building or room as a dust flash fire hazard area, $M_{\text{basic-fire}}$, shall be determined by the following equation:

$$M_{\text{basic-fire}} = 0.02 \cdot A_{\text{floor}}$$

where:

- $M_{\text{basic-fire}} = \text{threshold dust mass (kg) based on personnel fire exposure criterion}$
- $A_{\text{floor}} = \text{lesser of enclosure floor area (m}^2\text{) or 2000 m}^2$
- $\frac{H}{H} = \text{lesser of enclosure ceiling height (m) or 12 m}$
(2) Mass method A in 6.1.4

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(3) Mass method B in 6.1.5

6.1.5.1* The threshold dust mass establishing a building or room as a dust explosion hazard area, $M_{exp}$, shall be determined by the following equation:

$$M_{exp} = \left[ \frac{P_{s}}{DLF} \right] \left[ \frac{C_{w}}{P_{max}} \right] A_{floor} \frac{H}{\eta_d}$$

where:
- $M_{exp}$ = threshold dust mass (kg) based on building damage criterion,
- $P_{s}$ = enclosure strength evaluated based on static pressure calculations for the weakest building structural element not intended to vent or fail (bar g) per NFPA 68
- $DLF$ = dynamic load factor, the ratio of maximum dynamic deflection to static deflection per NFPA 68
- $C_{w}$ = worst-case dust concentration (kg/m$^3$) at which the maximum rate-of-pressure-rise results in tests conducted per ASTM E 1225
- $P_{max}$ = maximum pressure (bar g) developed in ASTM E 1225 tests with the accumulated dust sample
- $A_{floor}$ = enclosure floor area (m$^2$)
- $H$ = enclosure ceiling height (m)
- $\eta_d$ = entrainment fraction = 0.25

We are not going here
(4) Risk evaluation method in 6.1.6

6.1.6* Risk Evaluation Method. A documented risk evaluation acceptable to the AHJ shall be permitted to be conducted to determine whether or where a dust explosion hazard or dust flash fire hazard area exists.

A.6.1.6 The risk evaluation method in 6.1.6 supplements the process hazard analysis required in Chapter 4. It is intended to focus on material properties and inherent design features of the equipment and the facility necessary to determine the extent of the hazard areas.
Hazard Assessment: Facility Analysis Components:

• Materials that can be combustible when finely divided

• Processes which use, consume, or produce combustible dusts
Processes which use combustible dusts

- Powder metal part mfg
- Pharmaceutical presses
- Food Processing
- Chemical mfg
- Energy production
- Plastics mfg
- Refining
- Pressed wood products
Process Hazard Analysis

Processes which consume combustible dusts

- Energy production
- Chemical reactions
Process Hazard Analysis

Processes which produce combustible dusts

• Grinding/milling
• Conveying
• Machining
• Casting
• Shaping/cutting
• Mining
• Mixing
Hazard Assessment: Facility Analysis Components:

• Materials that can be combustible when finely divided
• Processes which use, consume, or produce combustible dusts
• Open areas where combustible dusts may build up
Open areas where combustible dusts may build up:

Floors

Imperial Sugar
Open areas where combustible dusts may build up:

- Electrical components

Imperial Sugar
Open areas where combustible dusts may build up:

- Elevated surfaces and ledges

- Accumulations on surfaces throughout the area including ledges, guardrails, structural I-beams, electrical conduit, screw conveyor cover, duct work, and top of the feed elevator tank.

- Accumulations on the 2nd & 3rd floors.

Imperial Sugar
Open areas where combustible dusts may build up:

Mechanical equipment and walls

Imperial Sugar

- ½ to 1-inch accumulations on mechanical equipment, electric motors, duct work, and horizontal and vertical surfaces.

- 3 to 48-inch accumulations on workroom floors.
Open areas where combustible dusts may build up:

Mechanical equipment and walls

Imperial Sugar
Process Hazard Analysis

Hazard Assessment: Facility Analysis Components:

- Materials that can be combustible when finely divided
- Processes which use, consume, or produce combustible dusts
- Open areas where combustible dusts may build up
- Hidden areas where combustible dusts may accumulate
Process Hazard Analysis

Hidden areas where combustible dusts may accumulate

• Drop ceilings
• Bucket Elevators
• Machinery
• Ducting
• Elevated surfaces
• Under equipment
• Between equipment and walls
• Any place out of site
Process Hazard Analysis

Hazard Assessment: Facility Analysis Components:

• Materials that can be combustible when finely divided
• Processes which use, consume, or produce combustible dusts
• Open areas where combustible dusts may build up
• Hidden areas where combustible dusts may accumulate
• Means by which dust may be dispersed in the air
Means by which dust may be dispersed in the air

- Primary dust explosion
- Cleaning with brooms or compressed air
- Fans
- Wind
- Spills
- Equipment malfunction
Process Hazard Analysis

Hazard Assessment: Facility Analysis Components:

• Materials that can be combustible when finely divided
• Processes which use, consume, or produce combustible dusts
• Open areas where combustible dusts may build up
• Hidden areas where combustible dusts may accumulate
• Means by which dust may be dispersed in the air

• Potential ignition sources
Process Hazard Analysis

Potential ignition sources
Examples of Ignitions Sources

Sparks
Process Hazard Analysis

Examples of Ignition Sources

Sparks

Hot work
Process Hazard Analysis

Examples of Ignition Sources

- Sparks
- Hot work
- Bearings

Clean air solutions
Process Hazard Analysis

Examples of Ignitions Sources

- Sparks
- Hot work
- Machinery
- Bearings

Clean air solutions
Process Hazard Analysis

Examples of Ignitions Sources

- Sparks
- Hot work
- Electrical
- Machinery

Clean air solutions
Process Hazard Analysis

Examples of Ignitions Sources

- Sparks
- Hot work
- Electrical Open Flame
- Machinery

Clean air solutions
Process Hazard Analysis

Examples of Ignition Sources

- Sparks
- Hot work
- Electrical
- Open flame
- Static discharge
- Bearings
Process Hazard Analysis

Date: 5/20/13
Process: Powder Paint System
Dust: Combustible Powder Paint

This document identifies hazards present in the powder paint system and its dust collection system at the Camfil APC factory in Jonesboro Arkansas and recommends the controls required to mitigate these hazards. The individual controls will require additional documentation of their design and implementation that should accompany this hazard analysis.

Process Description

The powder paint system consists of a paint booth with auto and manual spray systems, a wash down booth, a dry off oven, a cure oven and an overhead conveying chain. Parts are hung on the line, washed, dried, painted, cured with heat and removed. A dust collector and two cyclones aspirate the paint booth to prevent dust escape and build up on outside surfaces. All dust collected by the cyclones is re-used in the system. Dust collected by the dust collector is waste. The paint booth, dust collector
What Did We Learn?

OSHA enforces combustible dust hazards through the general duty clause and NFPA standards.

NFPA has no power

Lack of hazard analysis is a primary citation from OSHA

COMPONENTS OF A HAZARD ANALYSIS

Presence of combustible dust

Processes that use, consume or create combustible dust

Open and hidden areas where dust can build up

Means of dispersion

Means of ignition

Layer depth criteria
Time for a Break - Questions
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