Combustible Dust Safety: NFPA 652 and other Relevant Standards

Minnesota Safety Council
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Dedication

• To Tammy Miser who lost her brother Shawn to a combustible dust explosion. Using the emotions of her loss, she and others went on to found USMWF United Support and Memorial for Work Place Fatalities.
Objectives

Attendees Will:

• Comprehend the elements of combustible dust deflagrations and explosions and the speed they occur.

• Be able to identify NFPA and other resources to identify and evaluate combustible dust risks.

• Be able to identify NFPA resources on how to properly control combustible dusts.
Why is this important

- Large losses
  - Multiple lives
  - Entire plants

- Most cited General Duty Violation nationwide
  - National Emphasis Program
  - Training class for CSHOs every year
Major Incidents

- Several Explosions triggered Emphasis Program
  - Feb. 7, 2008 Imperial Sugar Refinery, 13 killed 42 injured

- Feb. 2, 2009 WE Energies, Oak Creek Coal Plant, 5 injured. 20 + similar coal dust explosions in last 15-18 years.
- KY
- Ocean Nutrition
- Others
Combustible Dust

- A finely divided combustible particulate solid that presents a flash fire... or explosion hazard when suspended in the air or the process-specific oxidizing medium over a range of concentrations (NFPA 652, 3.3.5)
Where are Combustible Dusts?
Exemptions from Compliance

- Storage or use of consumer quantities in residence or offices
- Retail storage in original packaging
- Warehousing of materials that cannot come into contact with other combustible dusts
- Storage and use in agricultural buildings for on-premises use
Combustible Dust Explosion Pentagon

- Ignition Source
- Dispersion
- Confinement
- Combustible Dust
- Oxygen in Air
- Deflagration EXPLOSION FIRE
- Dust + Ignition + O2 = Fire
- Above + Dispersion = Flash Fire
- All 5 = Deflagration or Explosion
Combustible Dust Pentagon
Continued

- Ignition Sources
  - ANY SPARK
  - Non-Intrinsically Safe Machines
  - Auto ignition at weak points in collection systems

- Dispersion
  - Sawing or cutting
  - Milling
  - Mixing
Combustible Dust Pentagon Continued

- Confinement
  - Ventilation Tubing
- Bag Houses
- Other Collection Devices
- Confined Spaces Incl. PRCS
The “Typical” Explosion Event

Initial Internal Deflagration

Process Equipment

Time, msec.

0 25 50 75 100 125 150 175 200 225 250 300 325
The “Typical” Explosion Event

Initial Internal Deflagration

Shock Wave

Process Equipment
The "Typical" Explosion Event

- Initial Internal Deflagration
- Elastic Rebound Shock Waves

Timeline:
- 0 sec
- 25 sec
- 50 sec
- 75 sec
- 100 sec
- 125 sec
- 150 sec
- 175 sec
- 200 sec
- 225 sec
- 250 sec
- 300 sec
- 325 sec

Process Equipment
The “Typical” Explosion Event

Initial Internal Deflagration

Dust clouds caused by Elastic Rebound

Process Equipment

Time, msec.
The “Typical” Explosion Event

- Containment Failure from Initial Deflagration
- Dust Clouds Caused by Elastic Rebound

![Diagram showing process equipment and time in milliseconds]

- Process Equipment
- Time, msec.
The “Typical” Explosion Event

Dust Clouds Caused by Elastic Rebound

Process Equipment

Secondary Deflagration Initiated

Time, msec.

0 25 50 75 100 125 150 175 200 225 250 300 325
The “Typical” Explosion Event

Process Equipment

Secondary Deflagration Propagates through Interior

Time, msec.

0 25 50 75 100 125 150 175 200 225 250 300 325
The “Typical” Explosion Event

Secondary Deflagration Vents from Structure

Time, msec.
The “Typical” Explosion Event

Secondary Deflagration Causes Collapse and Residual Fires

Time, msec.
IDENTIFICATION AND EVALUATION OF COMBUSTIBILITY OF DUST
Is our Dust Combustible?

- NFPA 652 Table A.5.2.2 (pp. 32 – 43)
  - Agricultural
  - Carbonaceous, organic or biological
  - Metals and alloys (aluminum, magnesium)
  - Plastics incl. PVC and phenolic resins

- If not listed or different concentrations may need to test
  - Limited # of labs
  - Expense ($5K - $10K/sample)
Dust Hazard Analysis (DHA)

- A systematic review to identify and evaluate the potential fire, flash fire or explosion hazards associated with the presence of one or more combustible particulate solids in a process or facility.
  - Combustibility and explosibility hazards of material
  - Fire, flash fire and explosion hazards
  - Management of those hazards
  - Information and training to affected employees
Combustibility/Explosivity

- Combustibility – Same as UN/DOT Test
- Explosibility
  - ASTM E1226
  - ASTM E1515
  - Sieved to 75 µM or smaller
Sampling for Comb/Exp.

- Must Document
  - Location of fine particulates
  - Identification of samples
  - Collection and preservation of samples
  - Communication with lab
  - COC and other documentation
  - Safe sampling and shipping procedures

- Allowed to use worst-case scenario
DUST HAZARD ANALYSIS

(DHAs)
When and By Whom

- Must be done
  - New construction
  - Remodel = > 25% or more of original cost
  - For existing facilities by 2022

- Qualified Person
Methodology

- Must identify and evaluate process or facility areas where fire, flash fire or explosion can exist
- Evaluate the material
- Evaluate the process systems
  - Unintended transport of combustible dust
  - Potential fugitive dust emissions
  - Potential propagation and deflagration between parts of process
**DHA Methods**

- Must account for all possible
  - oxidizing atmospheres
  - credible ignition sources
  - Suspension mechanisms

- **MUST SPECIFY THRESHOLD ACCUMULATION OF DUST TO TRIGGER HOUSEKEEPING**
  - Regular operation including maintenance
  - Upset condition
Characteristics of Dust

- Material: Metals, organics,
- Size: Proportion that is 500 µm or less (size 40 sieve)
- MIE: Minimum Ignition Energy
- MEC: Minimum Explosable Concentration
- $K_{st}$: Rate of Pressure Rise (dP/dt)
- $P_{max}$: Maximum Explosive Pressure
Additional Requirements

- NFPA 484 for Metal particulates
- NFPA 61 for Agricultural and Food Particulates
- NFPA 664 for Wood (Saw)Dust
- NFPA 655 for Sulfur containing solids
- NFPA 654 for Everything Else
DUST CONTROL PLANS
Control Plans

- Performance Based
  - Qualified Person
  - Lack of incident is not basis for decisions
  - NFPA 652 Chapter 6

- Prescriptive
  - NFPA 652 Chapters 7-10
Choices for Control - Performance

- Done by qualified person(s)
- Documented
- Maintenance of designed features
- All models must be fully documented
- Goal is to assure life safety:
  - Assuring ignition prevented
  - Only those in immediate vicinity can be impacted by
  - Critical structure reliability until evacuation from area
Performance Continued

- Design scenarios must include fire and explosion

- Must retain prescriptive elements for:
  - Housekeeping
  - PPE
  - Management systems
Structural Controls

- Dust-tight seals around all penetrations or points where accumulation can occur
- Blow out walls
- Venting
- Separation (location) 35 ft. minimum
- Segregation (barriers)
- Detachment
Equipment Design

- Class II Division 1 or 2 electrical systems
- All internal air movement must be greater than velocity required to keep dust airborne

- Operating requirements for:
  - Pneumatic Equipment
  - Air-Material Separators (Bag houses, cyclones, etc.)
  - Central vacuum systems
  - PIVs
HOUSEKEEPING
Housekeeping
Secondary Energy Sources

- OSHA: 1/32 to 1/8 in. dust over 1000 ft² or 5% of surface
- Depth depends on material
- ALL Locations
Housekeeping Administration

- Goal: Keep fugitive dust accumulations below threshold for fire, flash fire or explosion
- Plan must be documented and audited
- Required for every CD location
- Planned and unplanned cleaning
- Training and information for all involved
Allowed equipment

- Brooms
- Shovels
- Brushes
- Scoops
Specific Methods

- **Water**
  - Requirements in NFPA 484 for wet cleaning of metals where water can oxidize (start fire) with metal

- **Compressed air**
  - Must vacuum, sweep or wash down accessible areas
  - Must be under 30 PSI
  - Class II, Division 2 wiring
  - Ignition sources/residual heat removed
  - Completely cleaned
  - Metals have additional requirements
JSA/JHA/PPE Assessments

- NFPA requirements
  - FR Garments if necessary
  - If selected, must meet all NFPA standards
  - Limitations of PPE

- Can be rolled into OSHA full hazard assessments if they cover the hazard fully.
Production Dust Control

- Continuous suction or other equally effective means MUST be used if CD is liberated during normal operation

- Air Material Separator or other capture systems must be compliant with those requirements.

- Fans must be rated for the environment
Equipment Protection Choices

- Oxidant Concentration reduction
- Venting to a safe location
- If process can be made dust tight it must be
- If process cannot be made dust tight must have AMS
Written procedures

- Startup
- Sequence of operations
- Shutdown (not necessary for emergency shutdown)
- Cleaning
Exhaust Systems
Scrubbers

- Must interlock to shut down if flow rate of scrubbing media too low
- Scrubbing medium cannot be flammable/combustible
- Will not allow combustible cloud to form
- Non-flammable reactions between medium and material
- Exhaust air must be discharged
  - MN State OSHA requirement unless variance granted
Baghouses

- Must be protected to same extent as process
- Cannot create explosive or combustible atmosphere
MANAGEMENT SYSTEMS

INCLUDING TRAINING TOO!!!
Procedures

- Must be written
- Must prevent fire, deflagration and explosions
- Operating, Maintenance and Repair
Inspection testing and Maintenance

- Operations and maintenance manuals if applicable
- Inspect
  - Fire and explosion apparatus
  - Dust control equipment
  - Housekeeping
  - Potential ignition sources
  - Electrical equipment
  - Process changes*
  - Lubrication
More I, T and M

- Must have fix it date for each finding
- Timing is performance based
Training

- All employees and contractors in area must be trained to awareness level
- Job specific
- Done prior to taking responsibility
- Hazards and controls must be covered
- Retraining
  - NFPA does not specify timeline
  - OSHA requires when employees indicate the need
EAP/ERP

- Must be documented including capabilities of response
- Reviewed and validated at least annually
Incident Investigation

- Timely completion
- Recommendations must have end dates
- Implementation reviewed with affected personnel
MANAGEMENT OF CHANGE
Must document changes

- Materials
- Job tasks
- Technology
- Equipment
- Procedures
- Facilities
Must include in MOC

- Basis for change(s)
- Safety and health implications
- Temporary or permanent, duration if temporary
- Modifications to procedures
- Training requirements
- Authorization requirements
- Test results, if conducted
Document Retention

- Training
- Equipment inspection, testing and maintenance
- Incident investigations
- DHA
- Process technology information
- MOC documentation
- EAP/ERP
- Contractor documents
Purpose

This Safety and Health Information Bulletin (SBIB) highlights:
- Hazards associated with combustible dust;
- Work practices and guidelines that reduce the potential for a combustible dust explosion, or that reduce the danger to employees if such an explosion occurs; and,
- Training to protect employees from these hazards.

Background

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

In February 1999, a deadly fire and explosion occurred in a foundry in Massachusetts. The Occupational Safety and Health Administration (OSHA) and state and local officials conducted a joint investigation of this incident. The joint investigation report indicated that a fire originated in a shell molding machine from an unknown source and then extended into the ventilation system ducts by feeding on heavy deposits of phenol formaldehyde resin dust. A small primary explosion occurred within the ductwork, dislodging dust that had settled on the exterior of the ducts. The ensuing dust cloud provided fuel for a secondary explosion which was powerful enough to lift the roof and cause wall failures.

Causal factors listed in the joint investigation report included inadequacies in the following areas:
- Housekeeping to control dust accumulations;
- Ventilation systems design;
- Maintenance of ovens; and,
- Equipment safety devices.
Ventilation Standards

- NFPA 68 Standard on Explosion Protection by Deflagration Venting
- NFPA 69 Standard on Explosion Prevention Systems