Conducting a NFPA 652 Dust Hazard Analysis (DHA): Practical Tips & Approaches

Pulp & Paper Safety Association
Safety & Health Conference
June 18, 2018

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Outline for Today’s Discussion:

• Introduction
• Combustible Dust Basics
  • Assessing Flash Fire & Explosion Dust Hazards
  • What Makes a Dust Become a Combustible Hazard?
• Data & Information for Combustible Dust Classification
• Conducting a NFPA Dust Hazard Analysis (DHA)
• New (and Old) Requirements in IFC (2018)
• Changes in NFPA 652 (2019)
• Introduce the Table of References
• Discussion & Questions
DEKRA Process Safety: Serving as a Trusted Safety Advisor

- Integrated Solutions Provider
  - Process Safety Consulting, Engineering and Laboratory Testing
  - Combustible Dust Testing & Analysis
  - Data Management & Analytics
  - Organizational Safety
  - Organizational Reliability (Human Error & Fatigue)

For more information:
www.dekra-process-safety.com
Combustible Dust Hazard Basics
Conditions for a Combustible Dust Fire or Dust Explosion
Secondary Explosions Present Additional Risks

1. PRIMARY EXPLOSION
   - DUST LAYER

2. BLAST WAVE
   - DUST CLOUD FORMED

3. SECONDARY EXPLOSION
Comestible Dust Fire or Dust Explosion?

Remove the CONFINEMENT Leg ➔ Flash Fire
Remove the SUSPENSION Leg ➔ “Regular” Fire
Remove any other Leg ➔ NO Explosion or Fire!
Assessing Combustible Dust Hazards

Cost Effectively Collecting Proper Data
### Examples of Combustible Materials

Focus is on particles < 500 microns (35 mesh)

<table>
<thead>
<tr>
<th>Agricultural Products</th>
<th>Cottonseed</th>
<th>Soybean dust</th>
<th>Chemical Dusts</th>
<th>Epoxy resin</th>
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</thead>
<tbody>
<tr>
<td>Egg white</td>
<td>Garic powder</td>
<td>Spice dust</td>
<td>Adipic acid</td>
<td>Melamine resin</td>
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<tr>
<td>Milk, powdered</td>
<td>Gluten</td>
<td>Spice powder</td>
<td>Anthraquinone</td>
<td>Melamine, molded</td>
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<tr>
<td>Milk, nonfat, dry</td>
<td>Grass dust</td>
<td>Sugar (10x)</td>
<td>Ascorbic acid</td>
<td>(phenol-cellulose)</td>
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<tr>
<td>Soy flour</td>
<td>Green coffee</td>
<td>Sunflower</td>
<td>Calcium acetate</td>
<td>Melamine, molded</td>
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<tr>
<td>Starch, corn</td>
<td>Hops (malted)</td>
<td>Sunflower seed dust</td>
<td>Calcium stearate</td>
<td>(wood flour and</td>
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<tr>
<td>Starch, rice</td>
<td>Lemon peel dust</td>
<td>Tea</td>
<td>Carboxy-methylcellulose</td>
<td>mineral filled phenol-</td>
</tr>
<tr>
<td>Starch, wheat</td>
<td>Lemon pulp</td>
<td>Tobacco blend</td>
<td>Dextrin</td>
<td>formaldehyde)</td>
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<tr>
<td>Sugar</td>
<td>Linseed</td>
<td>Tomato</td>
<td>Lactose</td>
<td>(poly) Methyl acrylate</td>
</tr>
<tr>
<td>Sugar, milk</td>
<td>Locust bean gum</td>
<td>Walnut dust</td>
<td>Lead stearate</td>
<td>(poly) Methyl acrylate,</td>
</tr>
<tr>
<td>Sugar, beet</td>
<td>Malt</td>
<td>Wheat flour</td>
<td>Methyl-cellulose</td>
<td>emulsion polymer</td>
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<tr>
<td>Tapioca</td>
<td>Oat flour</td>
<td>Wheat grain dust</td>
<td>Paraformaldehyde</td>
<td>Phenolic resin</td>
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<tr>
<td>Whey</td>
<td>Oat grain dust</td>
<td>Wheat starch</td>
<td>Sodium ascorbate</td>
<td>(poly) Propylene</td>
</tr>
<tr>
<td>Wood flour</td>
<td>Olive pellets</td>
<td>Xanthan gum</td>
<td>Sodium stearate</td>
<td>Terpene-phenol resin</td>
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<tr>
<td><strong>Agricultural Dusts</strong></td>
<td>Onion powder</td>
<td><strong>Carbonaceous Dusts</strong></td>
<td>Sulfur</td>
<td>Urea-formaldehyde/</td>
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<tr>
<td>Alfalfa</td>
<td>Parsley (dehydrated)</td>
<td>Charcoal, activated</td>
<td><strong>Metal Dusts</strong></td>
<td>cellulose, molded</td>
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<tr>
<td>Apple</td>
<td>Peach</td>
<td>Charcoal, wood</td>
<td>Aluminum</td>
<td>(poly) Vinyl acetate/</td>
</tr>
<tr>
<td>Beet root</td>
<td>Peanut meal and skins</td>
<td>Coal, bituminous</td>
<td>Bronze</td>
<td>ethylene copolymer</td>
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<tr>
<td>Carrageen</td>
<td>Peat</td>
<td>Coke, petroleum</td>
<td>Iron carbonyl</td>
<td>(poly) Vinyl alcohol</td>
</tr>
<tr>
<td>Carrot</td>
<td>Potato</td>
<td>Lampblack</td>
<td>Magnesium</td>
<td>(poly) Vinyl butyral</td>
</tr>
<tr>
<td>Cocoa bean dust</td>
<td>Potato flour</td>
<td>Lignite</td>
<td>Zinc</td>
<td>(poly) Vinyl chloride/</td>
</tr>
<tr>
<td>Cocoa powder</td>
<td>Potato starch</td>
<td>Peat, 22%H₂O</td>
<td><strong>Plastic Dusts</strong></td>
<td>ethylene/vinyl</td>
</tr>
<tr>
<td>Coconut shell dust</td>
<td>Raw yucca seed dust</td>
<td>Soct, pine</td>
<td>(poly) Acrylamide</td>
<td>acetylene suspension</td>
</tr>
<tr>
<td>Coffee dust</td>
<td>Rice dust</td>
<td>Cellulose</td>
<td>(poly) Acrylonitrile</td>
<td>copolymer</td>
</tr>
<tr>
<td>Corn meal</td>
<td>Rice flour</td>
<td>Cellulose pulp</td>
<td>(poly) Ethylene</td>
<td>(poly) Vinyl chloride/</td>
</tr>
<tr>
<td>Cornstarch</td>
<td>Rice starch</td>
<td>Cork</td>
<td>(low-pressure process)</td>
<td>vinyl acetylene</td>
</tr>
<tr>
<td>Cotton</td>
<td>Rye flour</td>
<td>Corn</td>
<td></td>
<td>emulsion</td>
</tr>
<tr>
<td></td>
<td>Semolina</td>
<td></td>
<td></td>
<td>copolymer</td>
</tr>
</tbody>
</table>

Source: OSHA Combustible Dust Poster
Combustibility / Explosibility of Dusts

• Determination of combustibility or explosibility shall be permitted to be based on the following:

  • **Historical facility data or published data that are deemed to be representative of current materials & process conditions**
  
  • Laboratory analysis of **representative** samples
    • Permitted to test a sample sieved to <75μm
    • Permitted to test the as-received sample
    • Permitted to assume a material is explosible, forgoing the laboratory analysis

• Absence of previous incidents shall not be used as basis for deeming a particulate non-combustible or non-explosible

**Note:**

• Test results strongly influenced by particle size, moisture content, presence of contaminants

• Be sure test results are representative for your material!
## Typical Combustible Dust Tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Hazard Evaluated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Go/No Go Test (ASTM E1226)</td>
<td>Does the Dust Explode? (with a High Energy Ignition Source)</td>
</tr>
<tr>
<td>Minimum Ignition Energy (MIE)</td>
<td>The energy required to ignite a dust cloud under fairly ideal conditions.</td>
</tr>
<tr>
<td>Minimum Explosible Concentration (MEC)</td>
<td>The minimum amount of dust (dispersed in air) for an explosion.</td>
</tr>
<tr>
<td>Maximum Pressure Rise (Pmax) and Max Rate of Pressure Rise (Kst)</td>
<td>Dust Explosion Pressure Factors for Design of Containment and Relief Systems</td>
</tr>
<tr>
<td>Minimum Ignition Temperature (MIT) for Clouds and Layer</td>
<td>Used for Electrical Area Classification and for Dust Analysis if handled at Elevated Temperatures</td>
</tr>
<tr>
<td>Limiting Oxygen Concentration</td>
<td>Ignition prevention below what level of oxygen (used for inerting system design)</td>
</tr>
<tr>
<td>Electrostatic Chargeability</td>
<td>Determines How Easily a Material Develops and Retains Charge</td>
</tr>
</tbody>
</table>
Strategy for Dust Explosion Testing & Implications for Basis of Safety

3. Dust Explosion Screening
   - Can the dust form a cloud?

4. Dust Explosion Screening
   - Group Go/NoGo classification

5. Ignition Sensitivity
   - MIE (both IEC methods)
   - MIT
   - MIT Layer

6. Flammable Limits
   - LOC
   - MEC

7. Explosion Severity
   - Pmax
   - Kst

Basis Of Safety
- Avoidance of ignition sources
- Avoidance of flammable atmospheres
- Inerting
- Containment
- Explosion venting
- Explosion suppression

Source:
DEKRA Process Safety
SAFETY GUIDE:
A strategic guide to characterization and understanding Handling Dusts and Powders Safely
An Overview of Dust Hazard Analysis (DHA)

Establishing a Basis of Safety
Hazard Management: Prevention & Mitigation

Basis of Safety

- Avoidance of flammable atmospheres
- Elimination of ignition sources
- Provision against consequences of ignition
Managing Combustible Dust Fire and Explosion Hazards Requires…

Detailed knowledge of:

• Combustible material properties
• Process equipment
• Operating conditions
• Maintenance practices
• Existing controls (safeguards)
• and More…

• These are Generally Collected and Analyzed through a Dust Hazard Analysis (DHA), using NFPA 652
NFPA 652 Compliance Requirements: A Framework for Dust Hazard Management

• Owner/operator of facility with potentially combustible dust shall be responsible for:
  • Determining combustibility and explosibility hazards of materials (Chapter 5)
  • Conducting a Dust Hazard Analysis (DHA) - Identifying and assessing fire, flash fire, and explosion hazards (Chapter 7)
  • Managing identified fire, flash fire, and explosion hazards
    • Prescriptive Approach (Chapters 5, 7, 8, 9)
    • It shall be permitted to use performance-based alternative designs for a building, equipment, ignition source control, and explosion protection in lieu of prescriptive requirements in Chapter 8 (Chapter 6)
  • Establishing Safety Management Systems (Chapter 9)
Conducting a Dust Hazard Analysis (DHA): Methodology

- Identification and evaluation where Fire, Flash Fire, and Explosion Hazards Exist
- When these Hazards Exist, Identification and Evaluation of Specific Fire and Deflagration Scenarios:
  - Identification of Safe Operating Ranges
  - Identification of Safeguards that are in place
    - Mitigation and Prevention Measures in Chapter 8
    - Aligned with Recognized and Generally Accepted Good Engineering Practices (RAGAGEP)
- Recommendation of additional safeguards when warranted, including plan for implementation
Conducting a Dust Hazard Analysis (DHA): Evaluation

• **Process Systems**
  • When Combustible Dust is Present:
    • Oxidizing Atmosphere
    • Credible Ignition Sources
    • Suspension
  • Evaluation of Dust & Deflagration Propagation between Units

• **Building and Building Components**
  • Prevention of Fugitive Emissions
  • Dust Collection
  • Housekeeping
    • Hazardous Area (Electrical) Classification
    • NFPA 499, Tables A 6.3.2(a) and A 6.3.2(b)
Control of Combustible Dust Atmospheres (Control of Fugitive Emissions)

- Equipment should be maintained and operated in a manner that minimizes the escape of dust.
- Continuous local exhaust ventilation should be provided for processes where combustible dust is liberated in normal operation so as to minimize the escape of dust.
  - The dust should be conveyed to dust collectors.
- Regular cleaning frequencies should be established for floors and horizontal surfaces, such as ducts, pipes, hoods, ledges, and beams, to minimize dust accumulations within operating areas of the facility (1/32 inch; 0.8 mm – with adjustments).
  - Warning Indicators that your Dust Accumulations are too large:
    - Can you tell the color of the surface below the dust?
    - Can you write your name in the dust?
The Important Role of Dust Collectors

• Prevents Dust Accumulations
  • Collection & Removal of Fugitive Dusts
  • Controls Fugitive Dust Accumulations

• Key Design Considerations
  • Adequate Air Transport Velocity in Ductwork
    • Need to Prevent Dust Settling & Accumulation
  • Proper Design (and Direction) of Explosion Venting
  • Typically Installed Outdoors
  • Specific design features required to recirculate air
  • Never Store Dust in the Hopper
NFPA 652 (Chapter 9): Management Systems

- Operating Procedures & Practices
- Inspection, Testing, & Maintenance
- Training & Hazard Awareness
- Management of Contractors
- Emergency Planning & Response
- Incident Investigation
- Management of Change
- Documentation Retention
- Management System Review
- Employee Participation
Implications of International Fire Code (2018) on Combustible Dust Operations
Sources of Requirements for Managing Combustible Dust

- OSHA
  - CPL 00-03-08 – Combustible Dust NEP

- Non-Regulatory Requirements
  - Insurance Company Standards (e.g. FM Global)
  - NFPA Codes & Standards

- Building & Fire Codes
  - Typically Adopted at Local & State Level
  - Applied for Issuance of Building Permits
  - Routine Inspections
  - Post-Incident
Regulatory Landscape: International Fire Code

What is an Occupancy Classification?

• A classification of buildings and structures that manages the use and occupancy
• To provide a rationale criteria that is relative to fire hazard and life safety considerations
• Implications on Building Construction, Size, & Layout

• Typical Classifications
  • Group F: Factory Industrial
  • Group S: Moderate- and Low-Hazard Storage
  • Group H: High Hazard

• **Group H Occupancy Classification**
  - Uses Tables in Chapter 50, Section 5003
  - General Rule based on “Exempt Amounts” for Storage & Use.
    - Amounts Greater than these levels become Group H
  - Adjustments allowed for Sprinkler Protection

• **Combustible Dust Classification (2012)**
  - No “Exempt Amounts”
  - Dust Manufactured or Used in a Fashion Presenting a Fire or Explosion Hazard (Table 5003.1.1(1))
    - Occupancy Group H2 Classification
  - Engineering Evaluation in Section 104.7.2 is required to quantitatively document risk analysis to **not** classify as Group H2
Chapter 22: Combustible Dust-Producing Operations

• Existing Requirements
  • Forced air or similar methods shall not be used to remove dust from surfaces
    • More stringent than existing NFPA requirements
  • Operational permits required for operations producing combustible dusts, such as flour mills and grain elevators

• New Requirements in 2018 Edition
  • Dust Hazard Analysis Required (NFPA 652)
    • 3 Year Implementation Cycle
  • Explosion Protection per NFPA Industry- or Commodity- Specific Standards
Introducing NPFA 652 (2019)
NFPA 652 (2019): Updates & Changes

- Issued as Consent Document (April 2018)
- Changes to DHA Timelines
  - DHA must be completed for Existing Processes by Sept 7, 2020
    - 2 Year Extension from NFPA 652 (2016)
    - 5 Year Revalidation Schedule
- Coordination with other NFPA Dust Standards
  - 2020 Edition of NFPA 654 proposes same Deadline
  - 2020 Editions of NFPA 61 and 664 have not yet had First Draft Meetings
- Rearrangement of Chapter 8 & Chapter 9
  - Hazard Management: Mitigation & Prevention
  - Management Systems
References

Sources of Recognized and Generally Accepted Good Engineering Practices (RAGAGEP)
References (with Free Access)

- National Fire Protection Association (NFPA)
  - NFPA 68 (2018), Explosion Protection by Deflagration Venting
  - NFPA 69 (2014), Standard on Explosion Prevention Systems
  - NFPA 61 (2017), Dusts in Agricultural and Food Processing Facilities
  - NFPA 484 (2015), Standard for Combustible Metals
  - NFPA 655 (2017), Standard for Prevention of Sulfur Fires and Explosions
  - NFPA 664 (2017), Dusts in Wood Processing and Woodworking Facilities
References (with Free Access)

- **OSHA Dust Resources**
  - OSHA Combustible Dust National Emphasis Program
  - Firefighting Precautions at Facilities with Combustible Dust
- **FM Global**
- **United Kingdom Health & Safety Executive**
  - Safe handling of combustible dusts: Precautions against explosions
- **DEKRA Process Safety**
  - **SAFETY GUIDE**: A strategic guide to characterization and understanding Handling Dusts and Powders Safely
Thank you for Participating in Today’s Presentation

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Mike.Snyder@dekra.com

609-799-4449
DEKRA Process Safety
We help our clients to adapt PSM to their needs & to build internal PS competence

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<th>Consulting</th>
<th>Laboratory Testing</th>
<th>Competence Development</th>
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<tr>
<td><strong>Process Safety Engineering</strong></td>
<td>- Combustible Dust Fire &amp; Explosion</td>
<td>- Courses Covering all Key Aspects of Process Safety</td>
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<tr>
<td>- Dust Flash Fire &amp; Explosion Hazards</td>
<td>- Gas &amp; Vapor Flammability</td>
<td>- Continuing Education Units (CEU’s)</td>
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<td>- Electrostatic Hazards</td>
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<td>- Gap Analysis</td>
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<td>- Process Hazard Analysis</td>
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<td>- Quantitative Risk Assessments</td>
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