IMPLEMENTING COMBUSTIBLE DUST PROCEDURES

Gary Q. Johnson, P.E.
Workplace Exposure Solutions
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Agenda - Procedures
- Organizational Issues
- Housekeeping
- Ignition Source Control
- Hazard Communication Training
  - Administrative Procedures
  - Personal Protective Equipment
- Equipment Maintenance
- Management of Change
- Emergency Procedures & Incident Reporting

Key Elements: Implementing a Combustible Dust Program
- Build Organizational Ownership?

Procedures
- Hazard assessment
- Dust testing
- Flame resistant clothing
- Operator training
- Housekeeping
- Ignition source control
- Equipment maintenance
- Firefighting, emergency
- Management of Change
- Compliance audits

Equipment
- Designs that meet regulatory requirements
- Class II electrical equipment?
- Static grounding, bonding
- Hot surfaces, friction?
- Dust collection systems
- Vacuum cleaning
- Explosion prevention, protection, isolation
- Damage limiting construction

Building Organizational Ownership?
- Convincing management and operators that:
  - A dust explosion or dust fire could happen here
  - Regulatory enforcement is active now
  - The problem won’t go away
- Charter company resources to:
  - Conduct Gap Analysis to characterize hazards and mitigation strategies
  - Implement combustible dust procedures
  - Engineer equipment changes to mitigate risk
  - Put resources in place to sustain results
Can a combustible dust explosion occur here?
Major Catastrophes, Common Materials

- 1995 – Malden Mills – nylon fiber
- 1999 – Jahn Foundry – foundry molding compound
- 1999 – Ford River Rouge – coal dust
- 2002 – Rouse Polymeric – rubber
- 2003 – West Pharma. – polyethylene dust
- 2003 – CTA Acoustics – ceiling tiles
- 2003 – Hayes Lemnerts – aluminum wheels
- 2008 – Imperial Sugar – household sugar

Dust Explosion Pentagon

Dusty Environments Can Become:
Fuel for Dust Clouds with Density > MEC

Pneumatic conveying system leak like dust cloud from compressed air blow down - cannot see 3-4 feet thru cloud

Housekeeping

- The hazards associated with cleaning
- Safe cleanup methods
  - Manual
  - Vacuum cleaning
  - Housekeeping procedures
- Contractor cleanup
- Summary

Cleanup Dust Explosion Scenario

- Overhead settled dust – create dense dust cloud > MEC during cleaning
- Static electrical spark – hose to building structure – ignite this dense dust cloud (other ignition sources possible – hot surface, flame)
- Exploding cloud dislodges other settled dust to propagate deflagration
- Expanding deflagration gases destroy building

Back to the Dust Explosion Pentagon: Multiple Strategies to Reduce Cleanup Risk

- Heat or ignition source: prevent static electricity, sparks
- Combustible dust (fuel): prevent accumulation – housekeeping
- Dispersion of dust particles: prevent dust layer getting airborne – clean up method?
- Oxidizer (oxygen in air): reduce O₂ with inert gas (asphyxiation hazard?)
- Confinement of dust cloud: building & equipment designed to safely contain or vent
Cleanup Methods

- Safe conditions for compressed air blow down
- Sweeping
- Water wash down
- Vacuum cleaning
  - Portable vacuum cleaners (PVC)
  - Central vacuum cleaning systems (CVC)

Safe compressed air blow down
NFPA 654: Section 8.2

- Vacuum all accessible dust – vacuum cleaners listed for use in Class II locations
- De-energize any electrical equipment not rated for Class II locations
- Cool any hot surfaces capable of igniting dust cloud
- Use 15 psi steam or compressed air
- Vacuum up remaining dust

Safe sweeping

- Sweep gently to minimize airborne dust
- Natural bristles (no synthetic)
- Aluminum or conductive polymer dust pans

Water wash down – what pressure?

- Fog or mist wets dust
  - Hard spray "pumps air" pumped air column create dust cloud?
Water wash down versus dry?

**Advantages**
- Increases conductivity of dust layer – reduce static electricity
- If done right, minimizes combustible dust cloud

**Disadvantages**
- Safe way - wet down first, then spray down
- Trickle down mess – widespread cleanup
- Where does residue end up and can that area be cleaned?
- How water tight is YOUR electrical system?
Use the CVC tools designed for your problem!

Open end of hose has limited reach – job takes longer – tools designed for high velocity “scrubbing power”.

Elements of Effective Housekeeping

- Survey – areas with unacceptable accumulation (FM 7-76 useful to assess hazard)
- Look for opportunities to eliminate dust sources (overhead accumulations greatest concern – i.e., structural steel beams might have horizontal surface area 10% of floor)
- Designated responsibilities
- Adequate resources
- Safe cleaning methods
- Routinely document results
- Building clean design: 60° sloped surfaces, box in structural steel, etc.
- Routine management reviews of housekeeping schedule to ensure focus and continuous improvement

Dust Layer Where, How Much?

Lightly discolored – 1/64” layer

NFPA 654: Annex D

Assessing Dust Layer Hazard

- Dust layer allowable thickness varies with dust bulk density:
  - 1/32” layer basis for hazardous condition
  - Density 75#/ft³, MEC=350 gm/m³
  - 1/32” layer > dust cloud 10 feet high, dense enough for dust deflagration
- AT(inches)=((1/32)*75#/ft³)/(actual density#/ft³)
  - BD = 16; AT = 1/8”
  - BD = 18; AT = 1/4”
NFPA 654: Allowable Dust Accumulation, table A.6.6.2

- **Accumulation frequency:**
  - Infrequent (2-3 episodes/year)
  - Frequent (>3 episodes/year or within 24 hours)
  - Continuous (faster than 24 hours)

- **Housekeeping frequency:**
  - <1/32" – infrequent
  - <1/32" – infrequent – SAME SHIFT
  - <1/32" – infrequent – OFTEN ENOUGH TO KEEP LAYER
  - >1/8” – SHUT DOWN AND CLEAN UP IMMEDIATELY

- **Electrical classification:**
  - Infrequent – dust tight
  - >1/32” – frequent – Class II, Div. 2
  - >1/8” – infrequent – Class II, Div. 2
  - >1/8” – frequent – Class II, Div. 2

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NFPA 654 TIA Changes-2011

- **Layer Depth Criterion**
  - Not deflagration hazard if <1/64” or surface color discernable
  - 1/32” LDC can be adjusted by dust bulk density = 1/32 x (dens./75 #/ft³)
  - >1/8” – infrequent – Class II, Div. 2
  - >1/8” – frequent – Class II, Div. 1

- **Dust Deflagration Hazard**
  - Building <20,000 ft², >5% of area >LDC
  - Building >20,000 ft², 1000 ft² max > LDC

- **Process Equipment Explosion Hazard**
  - Means of suspending dust is present

- **Personnel exposed to deflagration hazard shall be protected with flame resistant clothing (NFPA 2113)**

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FM 7-76 (Prevention and Mitigation of Combustible Dust Explosions and Fire): Assessing Dust Layer Hazard

- **Hazard exists in 10 ft high building if:**
  - >5% of area has >1/6 ft dust layer
  - Dust bulk density assumed = 36 #/ft³
  - Equation for different conditions for suspendible dust above floor or floor dust that could be disturbed
    \[ T = \frac{H \cdot A_{\text{total}}}{(87.5 \times BD \times A_{\text{dust}})} \]
    - \(T\) = height of room, ft
    - \(H\) = height of floor, ft
    - \(A_{\text{total}}\) = total area, 20,000 ft² upper limit
    - \(A_{\text{dust}}\) = area with suspendible dust (bar joists, beams, piping, conduit, light fixtures can be 5-10% of floor area)

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Clean Design Concepts to Minimize Overhead Dust Accumulations

- **60° slopes on horizontal surfaces**
- **Enclose structural steel**
- **Solid deck plates versus open grating**

Spills from one level to the next through open grating become fugitive dust
Overhead Oscillating Fans – Tool to Minimize Dust Layers High in Room

Typical Layout of Overhead Fan Matrix (Multiple OOF to Cover Ceiling) Areas)

Comparison of Pro’s and Con’s

Advantages
- Easy to install; low maintenance
- Oscillating vertical cleaning radius
- Low power consumption - 400v 3 phase @ 0.75 kw/hr
- Very effective in overhead dust elimination
- Significant reduction/elimination of overhead cleaning/costs
- Significant reduction in overhead cleaning risk and liability
- Significant reduction of fire risk

Disadvantages
- Doesn’t reduce dust in the air - just stops it collecting on surfaces
- Correct number & location of fans required to achieve full benefits
- Some dead spots due to overhead obstructions
- Fans need to be left working when in production - cannot be switched off
- Increased volume of dust deposited on the floor & lower levels
- Initial cost and installation (turn key) ~ $5,600 per fan
- Running costs (low but still incurred)

Determining Cleanup Frequency
- Clean up area with care to avoid ignition risks – note areas where layer is thicker
- Purchase 9x9 baking pans, weigh them and mark the tare weight
- Suspend these pans in the areas where the dust was thicker
- Routinely monitor pan dust layer to get data on how fast your dust settles
- Clean up before the layer exceeds the allowable layer
Hiring a Cleaning Contractor

Questions you should ask
- Employee training given and up to date?
- Certifications from Chilworth or NFPA?
- Experience with Combustible Dust cleanup?
- Membership in industry organizations?
- What precautions do you take to
  - Prevent static electricity buildup?
  - Prevent heat stress?
  - Prevent falls?
  - Prevent interference or damage to plant equipment?
- What type of report at completion?

Questions the contractor should be asking
- What are the combustible dust properties, including Minimum Ignition Energy? Does the MSDS describe Combustible Dust hazards?
- What are your plant's safety procedures and process and electrical equipment for combustible dusts?
- Describe the process and the building around it where we will be working.
- What are waste disposal requirements?

Contractor Vacuum Truck

Humidity control

Truck static ground

Higher than normal water flow for illustration

Courtesy PSC Corporation
Safe Work Practices

Fall protection for climbing on structure and pipe racks

Electrical continuity checks

Courtesy PSC Corporation

Safe Practices on Lift

- Qualified drivers?
- Floor cleared of movable obstacles?
- Explosion proof portable vacuum cleaners?
- Vacuum cleaners adequately grounded?

Courtesy IMC

Contractor Cleanup Summary

- Contractor has combustible dust experience and training?
- Contractor perform a job safety analysis to ensure that risks are identified and risk mitigation procedures planned?
- Customer has good data about the combustible dust risks and has risk management procedures and equipment in place?

Final Thoughts

- Housekeeping for risk management
  - Avoid static ignition (low MIE, greater risk)
  - Plan to avoid other ignition sources
  - Minimize dust cloud formation
  - Use tools rated for dust explosion hazard
- Make sure your contractor is knowledgeable – an explosion could hurt your people and your business
- Effective process and dust collection design can greatly minimize housekeeping effort!
**Ignition Source Control**

- Hot work permits go beyond welding and cutting
- Static grounding systems verified to work and inspected routinely?
- Hot spot checks with InfraRed camera – ie, hot equipment insulation breakdown
- Document initial findings and routine integrity checks
- Magnetic separators used to remove tramp metal

**Hot Work Procedures Cover?**

In addition to Welding, Brazing, Torch Cuts
- Grinding?
- Mechanical Sparks?
- Static Electricity?
- Mechanical Friction?
- Grounding & bonding portable equipment?

**Hot Work Procedures Cover?**

Static Grounding?
- Ducts grounded?

*Courtesy Milrail Co.*

**Dust drum bonded to dust collector? – Courtesy Stuart R. Browne Manufacturing Co.*

**Hot Spot Monitoring – Look for High Temperature Surfaces**

- Hot process equipment: heaters, dryers, extruders, steam pipes, electrical equipment.
- Direct ignition of explosion dust cloud
- Ignition of dust layer that then ignites dust cloud (higher temps possible)

*Infra-Red Imaging Cameras Reveal “Hot Spots”*
Explosion Protection Equipment to Include in Maintenance Procedures

- Protection Systems
  - Process controls and interlocks
  - Static Grounding
  - Hazardous Classification Electrical
  - Classified fork trucks
  - Explosion Venting
  - Explosion Prevention
  - Explosion Isolation
- Dust collection systems
- Vacuum cleaning equipment

Sustaining Explosion Protection Results - Maintenance (NFPA 654) - Retroactive

- Personnel training
  - Hazard recognition
  - Dust collection system
  - Explosion protection
  - Initial & annual refresher training
- Testing (verify system performance as per design)
  - New system
  - Annually by owner
  - After system modification

Sustaining Explosion Protection Results - Maintenance (NFPA 654) - Management of Change (NFPA 654)

- Management of Change Procedures
  - Technical Basis for proposed change
  - Safety and health implications
  - Permanent or temporary change
  - Modifications to operating and maintenance procedures
  - Employee training requirements
  - Authorization requirements
  - Retroactive requirement
- Checklist for Combustible Dust Issues?
PPE: Flame Resistant Fabrics
(Minimize burns from flash fires)

- Everyday wearing apparel will ignite and burn
- Polyester will burn, melt and drip
- Flame resistant protective apparel is designed to self extinguish almost immediately.

Chances of Survival from Burn Injury
(Can’t protect against explosion)

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FRC Example: TECGEN®
Note: Undergarments of the wrong material can melt, causing burns

Flame Resistant Clothing?

- NFPA 2113 Standard on Selection, Care, Use, and Maintenance of Flame Resistant Garments for Protection of Personnel Against Flash Fire
- Workplace hazard assessment to determine if flammable materials are present in quantities that will generate a flash fire and endanger a person
- No regulatory hazard assessment yet
- Train operators on care and cleaning
Flame Resistant Clothing (NFPA 2113 Hazard Assessment)

- Hazard type, duration, magnitude?
- Adverse effects of unprotected expos.?
- Alternatives to FRC possible?
- Garment performance required?
- Garment decontamination required?
- Ergonomic constraints wearing FRC?
- Comparison of risks and costs?

Flame Resistant Clothing (NFPA 2113 – FRC required factors)

- Proximity to flash fire hazard zone?
- Flammable materials present during process operations?
- Flammables release more likely with task being performed?
- Operating conditions – dust potential?
- Engineering controls to reduce dusts?
- Accident history?
- Means and duration of egress from zone?

NFPA 2113 Recommended FRC Activities (Annex A)

- Where Comb. Duffs with these characteristics present: <75 micron, MIE<100 mJ, moisture < 10%
- Example environments
  - Charging eqpt. with dusty materials
  - Dust present on eqpt. or structural members
  - Changing filter bags in dust collectors
  - Dusty process – bag filling

Emergency Response

- Dust fires and explosions have different problems to address
  - Evacuation routes & assembly areas
  - Fire fighting techniques
    - Mist or fog first versus hard spray
    - Class D Extinguishers for metal dusts
  - Document the issues and train personnel
Incidents: History of Fires, Explosions?

Is there a dust explosions triangle like the “Safety Triangle”?

- Explosions (overpressure)
- Deflagrations (large flash fires)
- Dust fires (small fires)
- Near Misses (minor puffs, pops, flames)

Fatalities
Lost Work Day
Recordable
Near misses

History of Fires, Explosions?
Attitude towards past incidents?

- Hide or ignore
  - Fear of legal or regulatory action
  - Employees fear management action
  - Familiarity bug – “just a part of doing business in my industry – no big problem”
- Investigate to eliminate root cause
  - Incidents are warning of unsafe conditions
  - Use the data to reduce risk of employee injury and business interruption
  - Trends in my industry or similar processes

Employee Hazard Communications

- Combustible dust hazards are:
  - Understood by operators
  - Addressed in plant safe work practices
  - Managed by equipment maintenance
  - Managed by procedural compliance
  - Managed by appropriate personal protective equipment
  - Managed by correct Management of Change
- OSHA Guidance Document on Combustible Dust Hazard Communications

Possible Safe Work Practices

- Clean up procedures
- Bonding and grounding procedures
- Preventing static ignition (if low MIE)
- Wearing Flame Resistant Clothing
- Equipment operation to prevent dusting
- Emergency procedures
- Change Management procedures
- Other?
Summary

- Procedures need to be integrated with protective equipment
  - Coordinate protective functions
  - Prevent operator error from ignorance
- These procedures mentioned in either OSHA CD NEP or NFPA
- OSHA Regulations will emphasis procedures more than equipment – get ready with procedures that make sense now