

## 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

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## Key Elements: Implementing a Combustible Dust Program

### - Build Organizational Ownership?

Procedures	Equipment
<ul style="list-style-type: none"> <li>▪ Hazard assessment</li> <li>▪ Dust testing</li> <li>▪ Flame resistant clothing</li> <li>▪ Operator training</li> <li>▪ Housekeeping</li> <li>▪ Ignition source control</li> <li>▪ Equipment maintenance</li> <li>▪ Firefighting, emergency</li> <li>▪ Management of Change</li> <li>▪ Compliance audits</li> </ul>	<ul style="list-style-type: none"> <li>▪ Designs that meet regulatory requirements</li> <li>▪ Class II electrical equipment?</li> <li>▪ Static grounding, bonding</li> <li>▪ Hot surfaces, friction?</li> <li>▪ Dust collection systems</li> <li>▪ Vacuum cleaning</li> <li>▪ Explosion prevention, protection, isolation</li> <li>▪ Damage limiting construction</li> </ul>

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## 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

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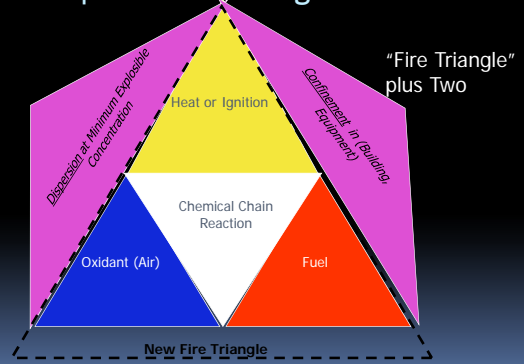
Can a combustible dust explosion occur here?  
Major Catastrophes, Common Materials

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

Comb. Dust Overview

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Dust Explosion Pentagon



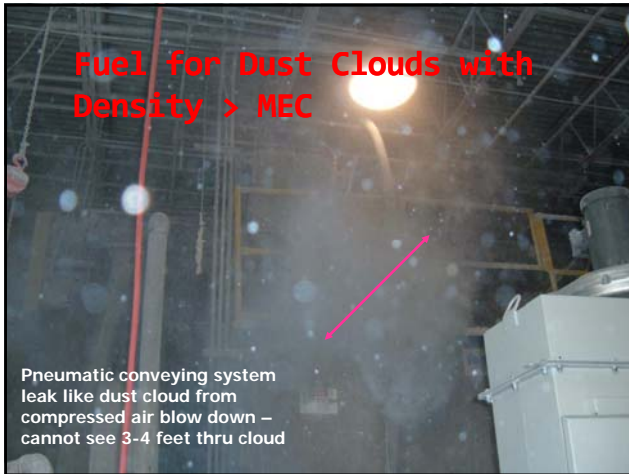
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Imperial Sugar – Dust accumulations were fuel for building wide deflagrations



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## Housekeeping

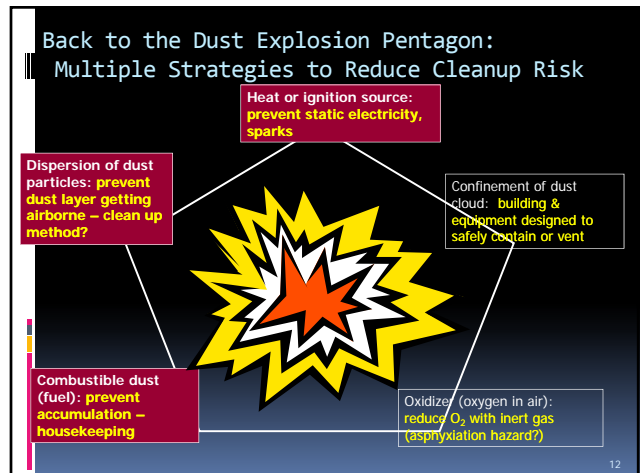
- The hazards associated with cleaning
- Safe cleanup methods
  - Manual
  - Vacuum cleaning
  - Housekeeping procedures
- Contractor cleanup
- Summary

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## 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

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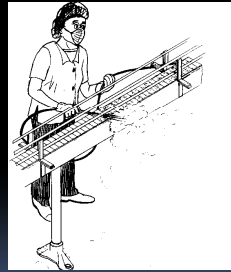


## Cleanup Methods

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

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## 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

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## Safe sweeping



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

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## Water wash down – what pressure?



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## 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?

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## Portable Vacuum Cleaner – Air Powered



Static dissipating features

- Drum grounding cable
- Conductive vacuum and air hoses
- Conductive wheels

Courtesy Vac-U-Max

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## Portable Vacuum Cleaner - Electric



HEPA filter

Courtesy Gardner Denver

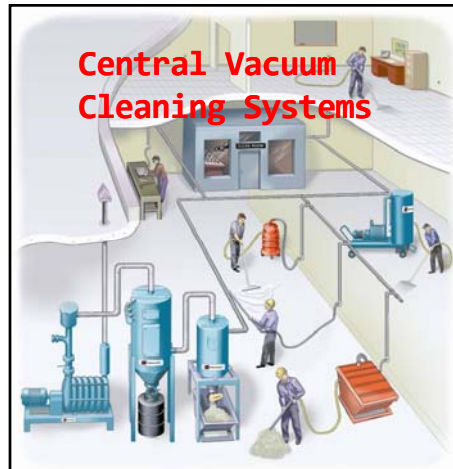


Courtesy Vac-U-Max

Electrical Classification II, Div 1

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## Central Vacuum Cleaning Systems



System components

- High vacuum producer (6-12" Hg = 82-164" w.c.)
- Filter/receiver
- Pre-separator (optional)
- Tubing branches to use zones
- Hoses and tools

Courtesy Gardner Denver

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**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”

Floors  
Pipes  
Crevices  
Equipment

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## 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

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## Dust Layer Where, How Much?

Lightly discolored ~ 1/64" layer

1/4"

3/32" 1/16" 1/32"

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## 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 #/ft<sup>3</sup>, MEC=350 gm/m<sup>3</sup>
    - 1/32" cover floor => dust cloud 10 feet high, dense enough for dust deflagration
  - AT(inches)=((1/32)\*75#/ft<sup>3</sup>)/(actual density#/ft<sup>3</sup>)
    - BD = 36: AT = 1/8"
    - BD = 18: AT = 1/4"
- Proportion of building with layer
  - Floor area > 5% up to 20,000 ft<sup>2</sup>, 1000 ft<sup>2</sup> maximum?
  - Overhead dusty areas 5-10% floor?
    - Bar joists and beams
    - Walls
    - Piping and conduit

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## NFPA 654: Allowable Dust Accumulation, table A.6.6.2

- Accumulation frequency:
  - Infrequent (2-3 episodes/year)
  - Frequent (>3 episodes/yr or within 24 hours)
  - Continuous (faster than 24 hours)
- Housekeeping frequency:
  - <math>1/32''</math> →   - <math>1/32''</math> →   - >
- Electrical classification:
  - Infrequent - at least dust tight
  - - >   - >

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## NFPA 654 TIA Changes-2011

- Layer Depth Criterion
  - Not deflagration hazard if <math>1/64''</math> or surface color discernable
  -
- Dust Deflagration Hazard
  - Bldg <math>< 20,000 \text{ ft}^2</math>, > 5% of area > LDC
  - Bldg >
- Process Equipment Explosion Hazard
  - Sufficient comb. dust to rupture equipment if suspended and ignited
  - Means of suspending dust is present
- Personnel exposed to deflagration hazard shall be protected with flame resistant clothing (NFPA 2113)

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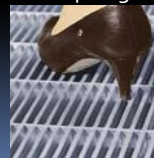
## FM 7-76 (Prevention and Mitigation of Combustible Dust Explosions and Fire): Assessing Dust Layer Hazard

- Hazard exists in 10 ft high building if:
  - > 5% of area has  $\geq 1/16''$  dust layer
  - Dust bulk density assumed =  $36 \text{ #/ft}^3$
- Equation for different conditions for suspendible dust above floor or floor dust that could be disturbed
  - $$T_{ex} = H \times A_{tot} / (87.5 \times BD \times A_{Dust})$$
    - H = height of room, ft
    - $A_{tot}$  = total area, 20,000 ft<sup>2</sup> upper limit
    - $A_{Dust}$  = 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

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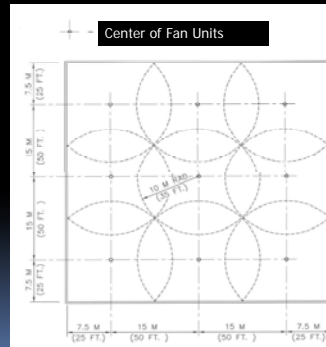
## Overhead Oscillating Fans – Tool to Minimize Dust Layers High in Room



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

Best application: light weight dusts like textiles or paper dust



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## 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, run 24/7
- Increased volume of dust deposited on the floor & lower levels
- Initial cost and installation (turn key)- ~ \$5 - 6 K per fan
- Running costs (low but still incurred)

Introduction

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## 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

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## 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?

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## Hiring a Cleaning Contractor

### 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?

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## Contractor Vacuum Truck



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## Humidity control



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## Safe Work Practices



Electrical continuity checks  
Courtesy PSC Corporation

Fall protection for climbing on structure and pipe racks

## Safe Practices on Lift



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

Courtesy IMC

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## 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?

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## 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!

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## 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

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## Hot Work Procedures Cover?

In addition to Welding, Brazing, Torch Cuts

- Grinding?
- Mechanical Sparks?
- Static Electricity?
- Mechanical Friction?
- Grounding & bonding portable equipment?



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## Hot Work Procedures Cover Static Grounding?



Ducts grounded?



Equipment grounded?  
Courtesy Milrail Co.



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

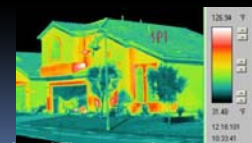
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## Hot Spot Monitoring – Look for High Temperature Surfaces

- 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"



©Sierra Pacific Infrared Thermography

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## 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

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## 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

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

- Inspection or monitoring
  - Written plan and checklists (very specific requirements NFPA 68 for Expl.Vents, NFPA 69)
  - Typically monthly checks
  - Report unusual changes
  - Retain records for 2 years
- Maintenance
  - Written plan
  - Routinely remove dust accumulations
  - Maintain collectors & fans as per manufacturer

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## Sustaining Explosion Protection Results - 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?

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## 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.

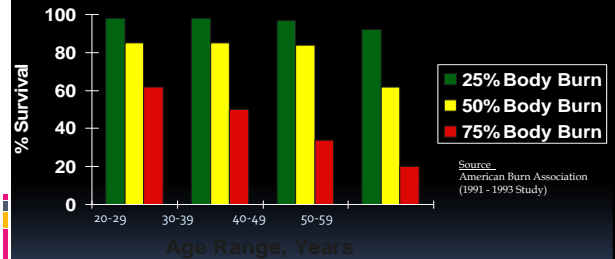


**TECGEN**

Advancing the Science of Safety

www.tecgenfr.com

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



Goal: minimize burn injury level

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## FRC Example: TECGEN®

Note: Undergarments of the wrong material can melt, causing burns

TECGEN XTREME®

TECGEN® balaclavas

TECGEN® baselayer



TECGEN® gloves



TECGEN® welding sleeves

## 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

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## 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?

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## 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?

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## NFPA 2113 Recommended FRC Activities (Annex A)

- Where Comb.Dusts 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

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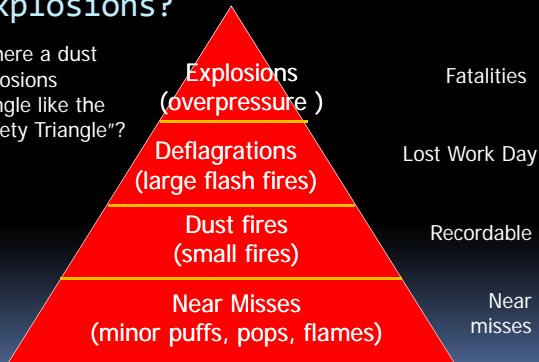
## Emergency Response

- 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

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## Incidents: History of Fires, Explosions?

Is there a dust explosions triangle like the "Safety Triangle"?



## 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

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## 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

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## 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?

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## 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

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