Advantages of a NFPA Combustible Dust Program

- Provide a safe work environment to protect workers.
- OSHA, Insurance Companies, and local building officials are enforcing what used to be recommendations and now are “Enforceable Standards”.
- Focus of OSHA has changed with the “Combustible Dust National Emphasis Program (NEP).” Enforcement has begun utilizing the General Duty Clause.
- Minimize production interruptions and protect capital equipment.
NFPA Combustible Dust and the Importance of Capture

• The most cited OSHA violations involving NFPA combustible dust compliance is housekeeping primarily from lack of or inefficient capture.
• 1/32” of combustible dust accumulation on building surfaces may be enough dust to fuel a secondary explosion.
• Over 90% of combustible dust explosion fatalities are the result of secondary explosion caused material buildup due to housekeeping or capture.

Plastic Molding Manufacturer
North Carolina

2003
• Polyethylene Powder
• 6 workers killed
• Hundreds of injuries
• Plant destroyed
• Facility was the major employer in area
Acoustic Board Manufacturer  
Kentucky

2003  
• Phenolic Resin Dust  
• 7 workers killed  
• 37 Injuries

Aluminum Casting Facility  
Indiana

2003  
• Aluminum Dust  
• 1 worker killed  
• Several Injuries
Industrial Facility

2008
• Sugar Dust
• 14 workers killed
• 38 Injuries
• Milling and Packaging

NFPA Combustible Dust Compliance and the Industrial Ventilation System

Dust Fires and Explosions

• Like all fires, a dust fire occurs when fuel (the combustible dust) is exposed to heat (an ignition source) in the presence of oxygen (air). Removing any one of these elements of the classic fire triangle (Figure 1) eliminates the possibility of a fire.

Classic fire triangle

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Dust Fires and Explosions

- A dust explosion requires the simultaneous presence of two additional elements—dust suspension and confinement (Figure 2). Suspended dust burns more rapidly and confinement allows for pressure buildup. Removal of either the suspension or the confinement elements prevents an explosion, although a fire may still occur.

Explosion Types

- A primary dust explosion occurs when a dust suspension within a container, room, or piece of equipment is ignited and explodes.
- A secondary explosion occurs when dust accumulated on floors or other surfaces is lifted into the air and ignited by the primary explosion.
  - Depending on the amount of dust in the area, a small deflagration or primary explosion may cause very powerful secondary dust explosions.
  - A secondary dust explosion may follow a primary non-dust explosion (e.g., natural gas, pressure, vessel, etc.).
Secondary Explosion

1) Dust settles on flat surfaces
2) Some "event" disturbs the settled dust into a cloud
3) Dust cloud is ignited

The "Typical" Explosion Event
The “Typical” Explosion Event

Initial
Internal
Deflagration

Shock Wave

Process
Equipment

The “Typical” Explosion Event

Initial
Internal
Deflagration

Elastic Rebound
Shock Waves
The “Typical” Explosion Event

Initial Internal Deflagration

Dust clouds caused by Elastic Rebound

Process Equipment

Time, msec.

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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

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The “Typical” Explosion Event

Secondary Deflagration
Vents from Structure

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Time, msec.

0 25 50 75 100 125 150 175 200 225 250 300 325

The “Typical” Explosion Event

Secondary Deflagration
Causes Collapse and Residual Fires

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Time, msec.

0 25 50 75 100 125 150 175 200 225 250 300 325
I. Hood Design
I. Hood Design

• Hoods are where system design begins
• We must understand the process to determine most effective hood design
• Common hood configurations include canopy, side draft, or connection to a process
• Hood design dictates how much air we have to transport to provide worker protection

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• Adding enclosures reduces volume of air needed to control a contaminant.
• Covers on conveyor belts and similar material handling equipment reduces needed air volume and improves collection.
**Velocity Definitions**

- **V₁ = Capture Velocity**
- This is what is required to turn the contaminant stream and draw it into the system. Typical range of capture velocities is 100 – 500 ft/min
- Capture velocity required and distance to work determine volume.

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**Velocity Definitions**

- **V₂ = Face Velocity**
- This is simply the velocity of the air where it enters the system. Typically 150-250 for a canopy, 2000 ft/min for a slot. Does not contribute to capture!

**NFPA Combustible Dust Compliance and the Industrial Ventilation System**
Velocity Definitions

- $V_3 = \text{Conveying Velocity}$
- This is the speed at which you transport the contaminant to the collection device. It is critical to system performance. If it’s too low, settling and plugging of ductwork occur. If it’s too high, excess wear occurs, and the system energy requirements will be high.

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Typical Conveying Velocities

- MUA, HVAC: 1500-2500 ft/min
- Mist, Fumes: 2500-3500 ft/min
- Industrial dust: 3500-4500 ft/min
- Metal dust, Cement: 4500-5500 ft/min

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NFPA Combustible Dust and Conveying Velocities

- NFPA combustible dust regulations require conveying velocities be maintained in all sections of the ductwork to eliminate fuel in case of an explosion.
Ductwork Design - Airflow

- Effective airflow design saves energy, reduces wear, and lowers operating cost.
- Examples of good construction:
  - Long radius elbows
  - Small angle branch entries
  - Gradual tapers and hood entries

Ductwork Design - Construction

- Construction is critical

You pay for good ductwork once; you pay operating costs again and again over the entire life of the system.
NFPA Combustible Dust and Ductwork Design

- NFPA regulations require a total system design review be performed when additional equipment is added or removed to ensure conveying velocities are maintained.
- Ductwork between filtration equipment (baghouse) and the process or room return must have explosion isolation devices.

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III. Collection Devices

- Baghouse
  - Cloth Bag Filter
  - Cartridge Filter
- Wet Scrubbers
  - Impingement
  - Packed Tower
- Electrostatic Precipitators

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Baghouse Application

- Most collector styles will work on most applications, if properly applied
- Collector capacity varies with dust type and loading
- Collector is selected after system is designed and volume is selected

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Baghouse Application

- Two Main Parameters
  - Air-to-Cloth ratio

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Air-to-Cloth Ratio - Definition

- Cubic Feet of Air Per Minute (CFM) ÷ Square Feet of Cloth Media

\[
\frac{\text{Ft}^3/\text{min}}{\text{Ft}^2} = \text{Ft/min}
\]

Air-to-Cloth Ratio = Filtering Velocity

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Appropriate Air-to-Cloth Ratios

- Industrial Dust, Foundry Sand, Moderate Loading 5.5/1
- Sand Systems, Finishing Systems, Heavier Loadings 5.0/1
- Furnace Fume, Melt Systems, Ultra Fine Particulate 4.0/1

NFPA Combustible Dust Compliance and the Industrial Ventilation System
Baghouse Application

• Two Main Parameters
  – Air-to-Cloth ratio
  – “Can” Velocity

Can Velocity

• Can Velocity is the “upward” velocity in the collector housing.
Can Velocity Calculation

• Net can area is gross housing cross section, less circular area of filters.

Gross Housing Area = 200 ft²
400 bags, 6” dia., = 78.6 ft²
Net Can Area = 121.4 ft²

\[ \frac{Q}{A} = V_{\text{can}} \]
Approximate Can Velocities

- Heavy Dust, Moderate Concentration: 350 ft/min max
- Lighter Dust, or Heavier Concentration: 300 ft/min max
- Very Light Fine Dust, Difficult Applications: 250 ft/min max

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Baghouse Pulsing Systems

- Time – Based on fixed interval
- Demand – Based on Pressure Drop
- IntelliPulse (Pressure Holding) - Computer controlled to minimize air usage
Baghouse Pulsing

- Minimizing pulsing is the goal
  
  Saves compressed air
  Reduces bag wear
  Protects filter cake
  Reduces emissions

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Combustible Dust and the Baghouse

The baghouse are the perfect host for a combustible dust explosion. All five components of the explosion pentagon are present:

- Fine particulate makes up the dust cake on the bag.
- Filter pulse systems disperse the fine dust in a dense cloud above the Minimum Explosive Concentration (MEC)
- Air is conveying medium
- Sparks and fires from process machines are common occurrence.
- The filter enclosure provides a means of containment

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What About the Dust?

• You get a lot of dust. That 50,000 CFM system from earlier is delivering 428 lbs. of dust per hour, 3,424 lbs. per 8 hr shift!
• Dust removal is critical to collector operation
• Screw conveyor and rotary valve run all the time
• No storage in the hopper!

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Future Baghouse Requirements

• Historical emission level was .01 gr/CF
• MACT standard for existing facilities is .005 gr/CF
• MACT standard for new facilities is .001 gr/CF
• Improvements come from application, filter media, and pulse management

NFPA Combustible Dust Compliance and the Industrial Ventilation System
• Good installation is no longer enough
• Performance must be proven at startup
• Performance must be monitored
• MACT requirements are in effect for most industries
• OSHA is enforcing NFPA regulations for combustible dust

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IV. Exhaust Fan

• Air Flow
• Static Pressure
• Accessories

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IV. Exhaust Fan

NFPA Combustible Dust Compliance and the Industrial Ventilation System
IV. Exhaust Fan

- Energy Conservation
  - Need high static for system to work long term
  - Good duct design lowers static pressure requirements
  - Efficient Hood design lowers volume requirements
  - Conservative dust collector application lowers pressure drop
  - Retrofitting an existing system with explosion isolation may add additional static pressure requirements.
V. Makeup Air

- Integral component to facility air quality
- Your building is always in balance, even without makeup air
- Much can be done with unheated makeup air correctly distributed

NFPA Combustible Dust Compliance and the Industrial Ventilation System

NFPA Combustible Dust Regulations and Makeup Air

- NFPA Regulations may not allow the filtered air to be returned to the space. If allowed the air must be filtered to 99.9% efficient at 10 μm and the energy from a combustible dust explosion be removed

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Industrial Ventilation

• Any Questions?