OSC|10
Ohio Safety Congress & Expo

What You Need to Know About Combustible Dust

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Explosive Dusts: Who, What, Where When, & Why

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Overview

- ***What is an explosion?***
- ***What is a combustible dust?***
- ***When does a dust explosion hazard exist?***
- ***How do dust explosions behave?***
- ***How can dust explosions be controlled or prevented?***

The Explosion Hazard

- ***What Is An Explosion?***
  - Rapid release of energy that produces damage
  - Chemical explosion
    - Reaction based
      - combustion reaction
      - decomposition
  - Physical explosion
    - Rapid failure of vessel under pressure

Combustion Explosions

- ***This is a fire, a really, really fast fire.***
- ***A fast fire requires premixed fuel.***
  - Already mixed with air in correct proportions
- ***To develop pressure, you need confinement.***
  - Fire increases gas temperature
  - Hot gas expands
  - If volume is fixed, pressure will rise

How Bad Will It Be?

- ***Explosion severity depends on***
  - Fuel reactivity
  - Amount of turbulence
    - Dust explosions = highly turbulent by definition
  - Amount of fuel
- ***How bad it is also depends on***
  - Structure
  - Secondary events like fire
  - Generally always bad

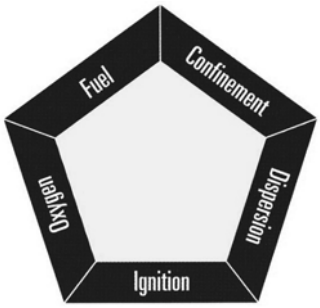
Combustion Explosions

- ***Deflagrations***
  - Flame front moves slower than speed of sound
  - Uniform pressure in enclosure
    - Maximum pressure 8 to 9 times ambient
  - Time to react and mitigate damage
- ***Detonations***
  - Flame front moves at/above speed of sound
  - No time to react

When Does An Explosion Hazard Exist?

- ***Need*** *confinement*
  - Building / equipment
- ***Need*** *fuel*
  - Flammable vapor/gas, combustible dust
- ***Need*** *dispersed premixed fuel*
  - Combustible dust
    - Suspended in air or ready to be suspended
- ***Need ignition energy***
- ***Need oxygen***

Combustion Explosions



What is a Combustible Dust?

- ***Organic material***
- ***Unoxidized metal***
- ***Other oxidizable materials (e.g. zinc stearate)***

What is a Combustible Dust?

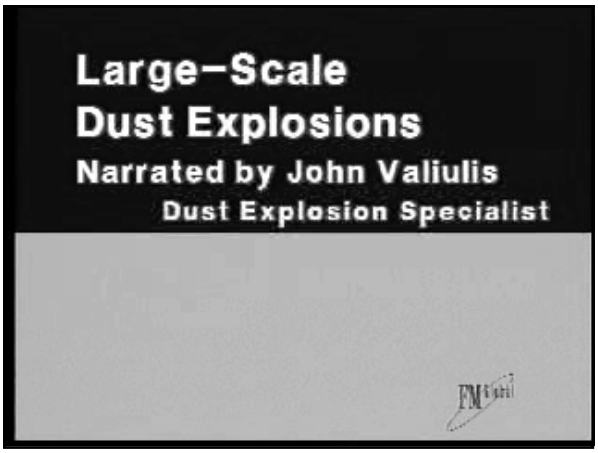
- ***500 microns (1/50th inch) or smaller***
  - different materials have different size threshold
  - usually range of particle sizes
  - fines segregation = increased hazard
- ***Might not burn in pile or solid form***
- ***Simple version – Did it start as a rock?***

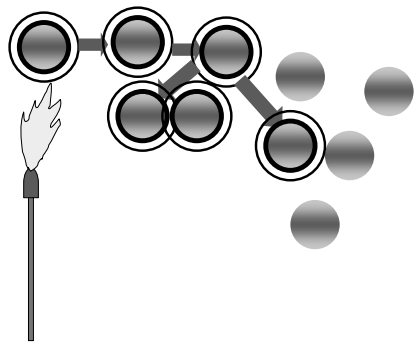
Where Does Dust Come From?

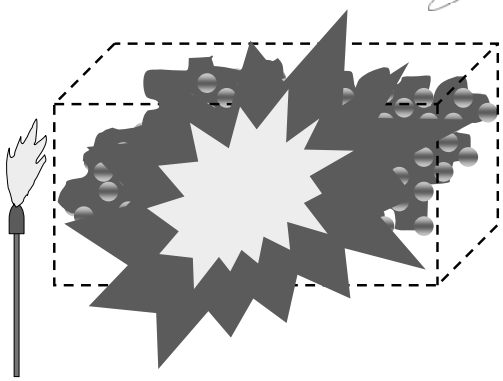
- ***Intentionally produced***
- ***Unintentionally produced***

Dust Explosion Hazard

- ***Why do dusts explode instead of burn?***
  - High surface to volume ratio
    - Instant vaporization when heated
  - Air around every particle
- ***Explosion severity is driven by***
  - Explosivity characteristics
  - Particle size
  - Moisture content
  - Ease of ignition







Explosibility Characteristics

K_{st} is a measure of the dust explosibility.

- ***The dust explosibility constant defined as the maximum rate of pressure rise of a dust explosion in a 1 m^3 vessel. The units are bar m/s.***
- ***Test method used to obtain this constant is standardized world wide.***
- ***K_{st} is used in all modern dust explosion vent sizing to characterize the reactivity of a particular dust.***

Explosivity Characteristics

K_{st}	*Explosibility*
$K_{st} < 200$	***Moderate / ST-1***
$200 \leq K_{st} < 300$	***Strong / ST-2***
$300 \leq K_{st}$	***Very strong / ST-3***

Dust Explosion Hazard

- ***When does it exist?***
  - Potential to produce dispersed premixed fuel
  - Always present in dust handling equipment
  - May be present in buildings
    - Collected on building structure
      - Can become suspended

Dust Explosion Hazard

FM Global criteria for potential dust explosion hazard

- ***Combustible dust***
- ***In dust collection equipment***
  - Always
- ***In buildings***
  - Dust suspended in air
  - Dust accumulated on building structure
  - Dust handling equipment

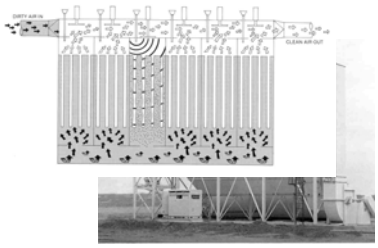
What Equipment Might Have an Explosion Hazard

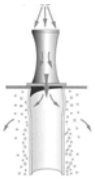
- ***Look for elements of explosion pentagon***
- ***Assume ignition a possibility***
  - typical 10 - 100 mJ (match = 100 J)
- ***Suspended concentration above MEC?***
  - MEC visibility *assumed* < 10 ft (3 m)
  - MEC concentration need not occupy entire volume e.g. filling powder silo from rotary valve
- ***Consider normal, abnormal, and upset conditions***

Examples of Equipment With Explosion Hazard

- ***Pneumatic transport of powdered product***
- ***Air/material separators (a.k.a. dust collectors)***
  - low (nonexplosible) concentration input
  - pulsing or shaking creates high concentration areas
    - illustrative drawing

Baghouse Explosion Hazard





When Does a Room Explosion Hazard Exist?

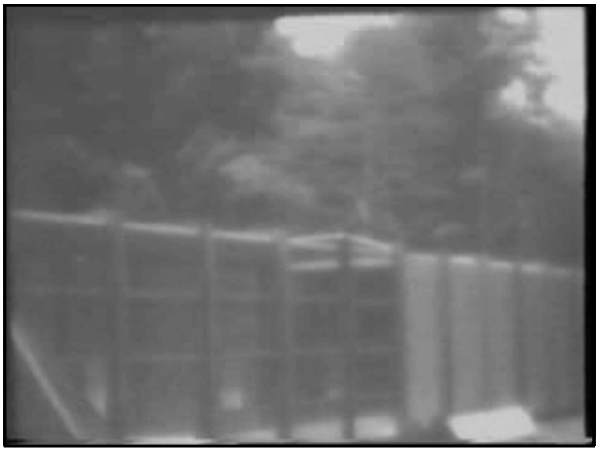
- ***When there is sufficient dust to put 5% of building volume into explosible range***
- ***1/16" or LESS = thickness of a coin***
- ***WHEN DUST IS IN A BUILDING!!!***

When is Dust "Suspendible"

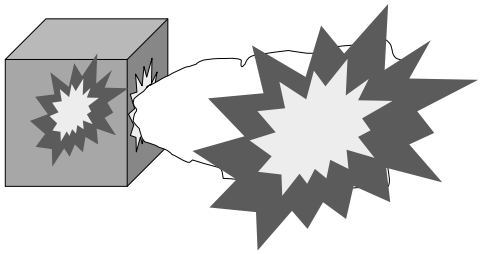
- ***Above floor level***
- ***At floor level with other explosion hazard capable of creating disturbance***
  - equipment explosion hazard in same area
  - room or equipment explosion hazard in adjacent area

Behavior of a Dust Explosion

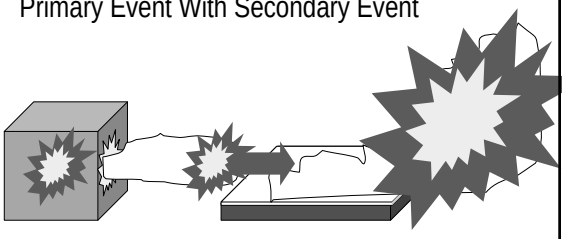
- **Assume explosion propagates readily between connected volumes**
  - unburned dust is pushed ahead of expanding cloud of burning dust
  - fuel rich explosion: explosion can continue as the fireball finds new air
  - pressure wave moves well ahead of flame front
  - pressure piling effect in interconnected vessels



Dust Explosion Scenario - Primary Event



Primary Event With Secondary Event



Mitigating Dust Explosions

- ***Damage limiting construction***
  - Equipment
  - Buildings
- ***Containment***
  - Equipment
- ***Explosion isolation***
  - Equipment

Damage Limiting Construction

- ***Venting***
- ***Pressure resistance***
- ***Open structures***
- ***Design varies***
  - FM Global – proprietary software model
  - NFPA 68 – empirical correlation of test data

Explosion Quench Pipe

Containment

- ***Explosion resistant: 6 barg (87 psig) design***
  - Can be higher depending on the dust.

Need for Explosion Isolation

- ***For two vessels protected by explosion containment***
- ***Between two vessels with an explosion hazard (and adequate individual protection)***
- ***Between equipment and buildings***

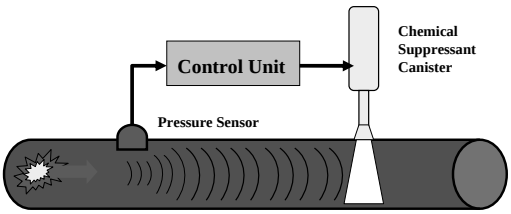
Explosion Isolation Options

- ***Chemical explosion blocking system***
- ***Rotary air locks***
- ***Rapid-action valves (gate or butterfly type)***
- ***Rapid-action valve (float-type), Ventex ESI®***
- ***Flame front diverter (a.k.a. explosion diverter)***
- ***High speed abort gate***

Chemical Explosion Blocking

- ***Explosion is detected in volume of origin, normally by pressure sensor***
- ***Explosion suppressant injected into connecting pipe at precise time to prevent flame front from breaking through***

Explosion Blocking With Chemical Agent



Rotary Airlocks

- ***Explosion quenched within the gap between the vanes and the housing (similar principle to flash arrestor)***
- ***Not all rotary valves qualify for explosion isolation!***

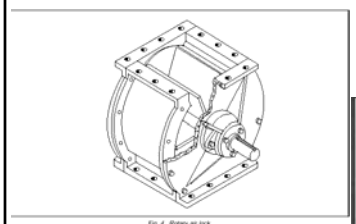
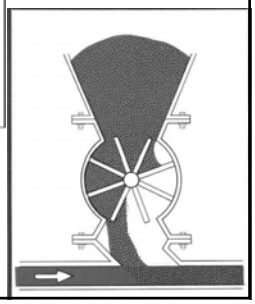


Fig. 4. Rotary air lock

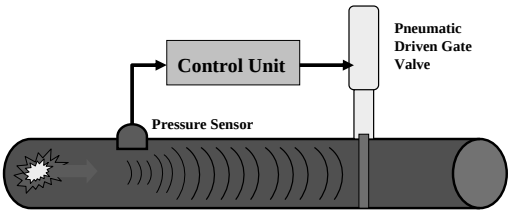


Rapid-action Valve (Gate or Butterfly type)

- ***Closes in milliseconds using high pressure gas as driving force***
- ***Distance between explosion detection device and valve long enough to allow valve to close before flame front arrival***

Courtesy of Fike Metal Products

Explosion Blocking With Rapid-action Valve

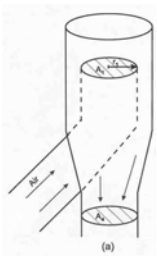


Flame Front Diverter (Explosion Diverter)

- ***Works in both directions (except where fan downstream)***
- ***Can have small outdoor protrusion to provide isolation on an indoor system***
- ***Cannot be used with gases or vapors***

Flame Front Diverter (Explosion Diverter)

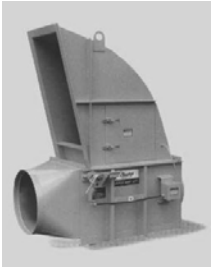
- ***Pressure wave moves well ahead of flame front***
- ***Pressure wave opens explosion vent***
- ***Flame front cannot make the 180º turn after explosion vent is opened (unless it is sucked into the downstream side)***



High Speed Abort Gate

- ***Signal releases an electromagnet, which drops a swing gate into air path***
- ***Works in one direction***
- ***Moving air plus dead weight close the gate***
  - rush of air ahead of an explosion flame front would help close the gate faster

Abort Gate



Abort Gate

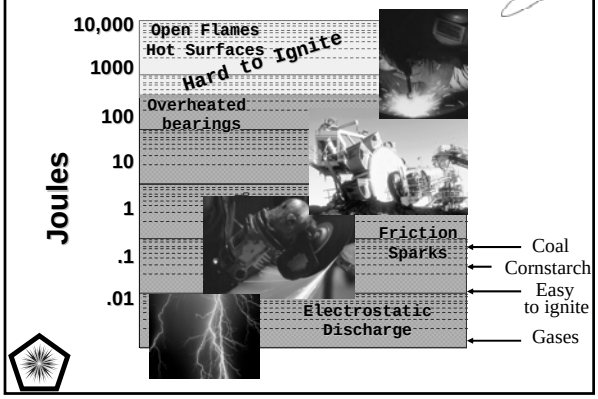
Explosion Prevention: General

- ***Comprehensive dust fire and explosion awareness program***
  - Educate staff on basic hazards
  - Present specific hazards and precautions relevant to employee's department
  - annual familiarization for PEO and/or fire department
  - periodic refresher training

Explosion Prevention: General

- ***Basic dust ignition source control***
  - annual infrared scan (electrical equipment)
  - hot work permits
    - specifically address dust hazards
  - prohibit smoking and open flames
  - hazardous location electrical equipment (see OS 5-1 and/or NFPA 499)

Ignition Sources



Explosion Prevention: General

- ***Maintain production and protection equipment***
  - ID & eliminate fugitive dust sources continually
  - spark detection & extinguishing systems
  - metal detection & metal extraction
  - assign accountability
  - keep records

Equipment Explosion Prevention

- ***Phlegmatization (inerting with non-combustible dust)***
  - must not have segregation of inert dust
  - safe mix determined by test
  - 50-75% inert usually required
- ***Prevent dust from being liberated***
  - oil mist dust suppression
  - pre-cleaning coarse material to remove fines

Housekeeping

- ***Assigned accountability***
- ***Management commitment for time and resources***
- ***Fixed schedule with periodic review for adequacy***
- ***Particularly important for accumulations above floor level***
- ***Vacuum, sweeping, power wash acceptable***

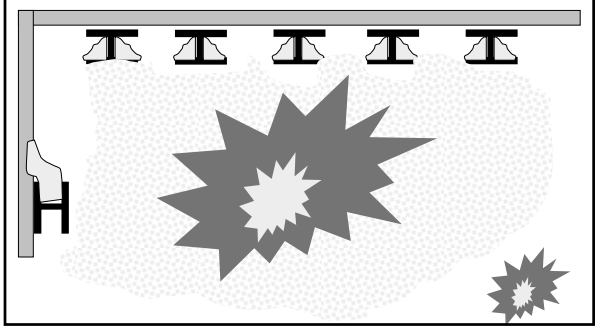
Collect and Confine

- ***Properly design dust collection equipment***
- ***Properly maintain dust collection equipment***

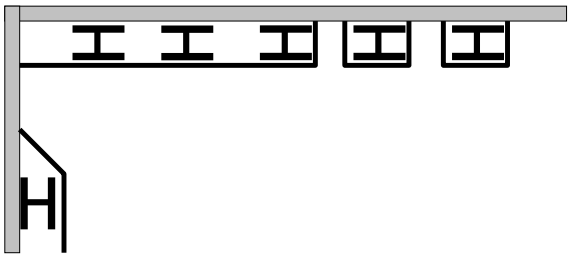
Eliminate Surfaces / Control Spread

- ***Can arrange building elements to minimize accumulations***
  - box in beams, joists
  - sloped cover on ledges, equipment tops (60º slope)
- ***Prevent dust from migrating to adjacent areas***
  - door & window seals
  - room pressurization

Construction



Modified Construction



Dust In Buildings

- ***Eliminate dust by fixing dust collection system***
- ***Housekeeping is only a "Partial" solution***