WELL AT HOME SAFE AT WORK OSC 12 Ohio Safety Congress & Expo

Understanding Combustible Dust Hazards and Associated Mitigation Techniques

Presented by
Bob Korn

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February 7, 2008
Imperial Sugar Refinery, Port Wentworth, GA
14 Fatalities, 40 Injured
Sugar Dust, Initial explosion in an enclosed conveyor belt, propagated to packaging warehouse, where secondary explosion occurred.
Estimated Rebuild Cost: $250 Million, Completion, Jan 2010

Who is Fike?

- Celebrating our 67th Year in 2012
- Over 1000 employees worldwide
- 13 subsidiaries worldwide
- Family Owned-Privately Held
- Global Provider of Industrial and Commercial Safety Protection Products and Services

World Headquarters
Blue Springs, MO

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Understanding Combustible Dust Hazards and Associated Mitigation Techniques

- Who is Fike
- Fundamentals of Dust Explosions
- Dust Testing
- Explosion Protection Mitigation Solutions
  - Explosion Venting
  - Flameless Explosion Venting
  - Explosion Isolation
  - Explosion Suppression

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Fike Product Lines

Pressure Relief

Oil & Gas

Engineered Products

Fire Suppression

Explosion Protection

Why Use Explosion Protection?

Explosion Characteristics

Flame and Pressure Waves
(2 Components)

"Open Air Deflagration"

What is an Explosion?

An explosion is generally defined as a destructive chemical reaction that produces noise, heat, and rapid expansion of gases.

It happens in milliseconds

Industry Definitions

- Explosion
  - "Rupture of an enclosure due to the internal pressure from a deflagration."
- Deflagration
  - "Propagation of a combustion zone at a velocity that is LESS than the speed of sound."
- Detonation
  - "Propagation of a combustion zone at a velocity that is GREATER than the speed of sound."

"Deflagration"

Same Fuel, Real Time

Anatomy of an Explosion

Typically 3 of the 4 ingredients are present in most industrial processes.

Variable = Ignition Source

Human Error…?!!?!?

Anatomy of an Explosion

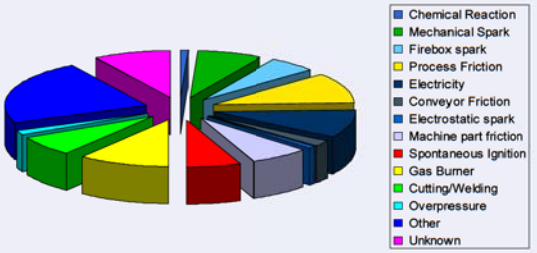
Requirements:

- Enclosure
- Suspended Fuel – Dust or gas or combination
- Oxidant
- Ignition

Potential Ignition Sources

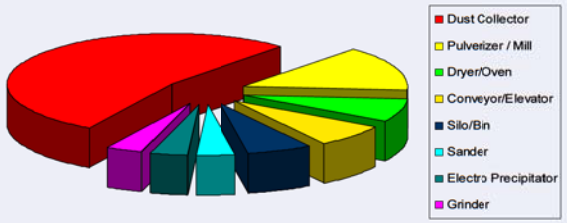
- Sparks from electrostatic discharges
- Overheated mechanical components
- Impact Sparks
- Hot embers, droplets
- Welding torch
- Flames
- Human Error

Explosions By Ignition Source



Source: Factory Mutual

Explosions by Equipment Type



Source: Factory Mutual

Deflagration Index

A measure of how severe and fast-moving an explosion can be

- K_G • Gases
- K_{ST} • Dusts

K_{ST} Values

Material	Particle Size Microns	P_{Max} barg	K_{ST} bar-m/sec	Hazard Class
Coal (Bituminous)	24	9.2	129	1
Sugar	30	8.5	138	1
Polyethylene	<10	8	156	1
Magnesium	28	17.5	508	3
Cornstarch	7	10.3	202	2

What kind of stuff explodes?

Gases & Vapors
- propane
- acetylene
- hydrogen
- alcohol
- solvents
- petrochemical fumes

Dusts
- chocolate
- cornstarch
- plastics
- wood
- sugar
- grain
- metal dusts

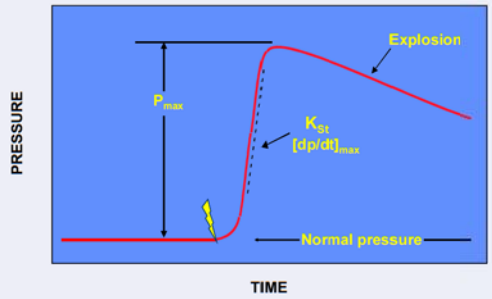
K_{ST} Values

Hazard Class	K_{ST} (bar-m/sec)	P_{Max} (bar)
ST-1	< 200	10
ST-2	201 – 300	10
ST-3	>300	12

Definitions: Explosion Pressures

- P_{max} – Maximum Pressure, the maximum pressure developed in a contained explosion
- P_{red} – Reduced Pressure, maximum pressure developed in a vented enclosure during an explosion
- P_{stat} – Static Activation Pressure, activation or burst pressure of an explosion vent(also referred to as set pressure)

Explosion Pressure Curve



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How do you determine if you have a combustible dust?

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Step 1: Collecting samples for testing

Process Media : Identify the worst credible hazard for the process. The explosive properties of a process media may vary in different parts of a process.

Fugitive Dust: Accumulations of dust on the floor and other flat surfaces can supply fuel for secondary explosions.

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What is a Combustible Dust?

NFPA Definition: A combustible particulate solid that represents a deflagration hazard when suspended in air or some other oxidizing medium over a range of concentrations regardless of particle size or shape.

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Combustible Dust Testing

20L³ Vessel – ASTM E1226 Testing

1m³ Vessel – ASTM E1226 Recommended Testing

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Step 2 : Is my sample a combustible dust?

Screening Test: Determines if dust is explosive.

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Step 3: Determination of P_{max} and K_{st}

20L Dust Explosibility - ASTM E1226.

- Wide range of dust concentrations tested to find optimum concentration.

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NFPA Explosion Protection Standards:

When, Why and Where Standards:

- NFPA 654 — *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*
- NFPA 484 — *Standard for Combustible Metals*
- NFPA 664 — *Standard for the Prevention of Fire and Dust Explosions in Wood Processing and Woodworking Facilities*
- NFPA 61 — *Standard for the Prevention of Fire and Dust Explosions in Agricultural and Food Processing Facilities*

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Step 4: Determination Likelihood of Explosion

- MEC Test- Minimum Explosible Dust Concentration (MEC) per ASTM E1515
- MIE Test - Minimum Ignition Energy of a Dust Cloud in Air (MIE) per ASTM E2019
- MIT Test - Minimum Hot Surface Ignition Temperature (MIT) per ASTM E2021

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Explosion Protection Methods

How do you protect your facility?

1. Perform a Hazard Assessment
2. Protect the Equipment
3. Isolate the Hazard to Prevent the Propagation of the Explosion

NFPA Explosion Protection Standards

The "How to" Standards:

- NFPA 68 Standard on Explosion Protection by Deflagration Venting (2007)
- NFPA 69 Standard on Explosion Prevention Systems (2008)

National Fire Protection Association
NFPA
The authority on fire, electrical, and building safety

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Explosion Protection Methods

Standard Methods

- Explosion Venting
- Flameless Explosion Venting
- Explosion Isolation
- Explosion Suppression
- Combination of any above

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Explosion Venting

Bulged Composite Vent

Multi-Domed Single Element Vent

Composite Vent

Bucket Elevator Vent

Special Application Vents

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Venting Design Factors

- Deflagration characteristics of the combustible material
- Identification of equipment to be protected and its design specifications including strength
- Location of the equipment
- Pathway of released fireball and pressure
- Exposure to the environment

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Protect the Equipment
Explosion Venting Concept: *Control the Pressure*

- A predetermined vent area releases pressure at a given level P_{stat} resulting in a reduced pressure P_{red}.
- Explosion flame, pressure and unburned fuel are vented to a safe area. The most widely used method.

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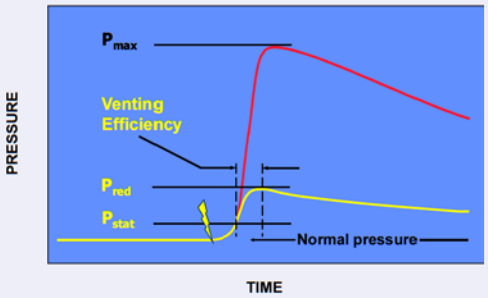
Vented Explosion



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Explosion Vents - Dust Collector

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Examples Explosion Venting

Dust Collector

Cooling Tower

Explosion Venting

ADVANTAGES

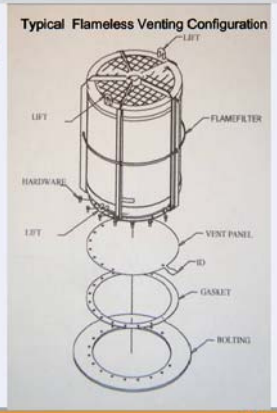
- Relatively inexpensive
- Easy to install or replace
- Low or no maintenance
- Passive system

CONSIDERATIONS

- Releasing pressure does not put out the flame. Flame, pressure and unburned products will exit through the vent and may cause further damage or injury.
- Toxic products may be dispersed into the atmosphere.
- More Vent area than can practically be installed may be needed.

Flameless Venting

Typical Flameless Venting Configuration



Examples Explosion Venting

SILO VENTING

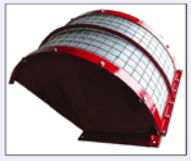
PIPELINE VENTING

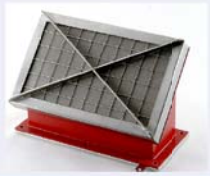
Flameless Venting

Releases the pressure and extinguishes flame

When do you use Flameless Venting?

- For indoor installations – eliminates need for equipment relocation or duct work
- For outdoor installations in areas normally occupied by personal





Explosion Venting

Flameless Venting

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Flameless Venting

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Explosion Isolation

Vented Vessel -Flame Propagation

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Flameless Venting

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Explosion Isolation

Vented Vessel -Flame Propagation

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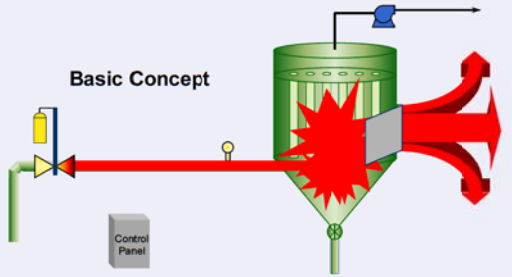
Explosion Isolation

Prevent the Flame Propagation



NFPA 69 Chapter 11 and 12

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NFPA 654

Explosion Isolation

7.1.4 Isolation of Equipment.

7.1.4.1 Where an explosion hazard exists, isolation devices **shall** be provided to prevent deflagration propagation **between pieces of equipment** connected by ductwork.

7.1.4.2 Isolation devices shall include, but shall not be limited to, the following:

(1) Chokes
(2) Rotary valves
(3) Automatic fast-acting valve systems in accordance with NFPA 69
(4) Flame front diverters in accordance with NFPA 69
(5) Chemical isolation systems in accordance with NFPA 69

7.1.5 Deflagration Isolation.

7.1.5.1 Where an explosion hazard exists, isolation devices **shall** be provided to prevent deflagration propagation from air-material separators upstream **to the work areas**.

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Explosion Isolation

(4) Automatic Fast Acting Valve Systems

10 Bar Resistant
6" – 24"

2 Bar Resistant
6" – 12"

10 Bar Resistant
2" – 24"

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Explosion Isolation

Chemical Isolation Barrier

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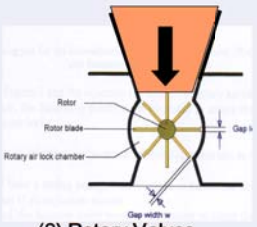
Explosion Isolation



(2) Rotary Valves

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Explosion Isolation

Most Common Method

Ducts 2" – 22"

Ducts 24" +

(5) Chemical Isolation Systems

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Explosion Isolation

EXPLOSION VENTING DOES NOT PREVENT FLAME PROPAGATION IN DUCT

Vented Dust Collector -Flame Propagation

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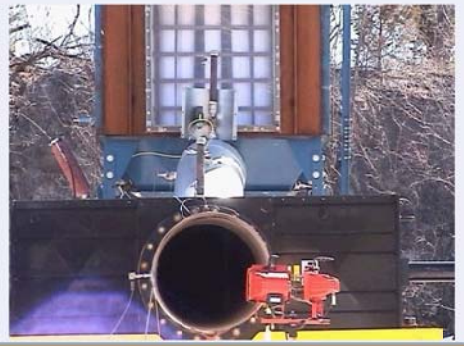
Explosion Isolation, 24" Real Time

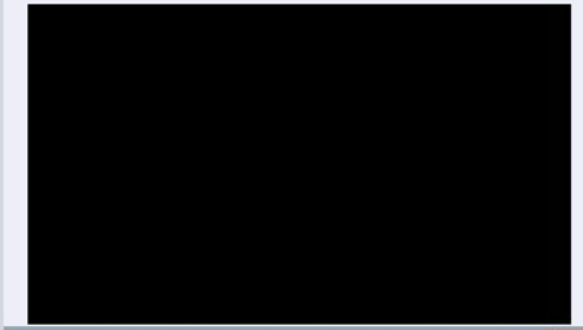


Explosion Suppression Systems

When is suppression recommended?

- WHEN OTHER PROTECTION SOLUTIONS ARE TOO COSTLY
  - Vent Discharge Ducts
  - Enclosure Relocation
- WHEN THE OBSTACLES ARE TOO DIFFICULT
  - Congested Facilities
  - Personnel Exposure
  - Limited Real-estate
    - On equipment
    - In facility
- WHEN OVER PRESSURE PROTECTION ISN'T ENOUGH
  - High Kst
  - Fire Management
  - Toxic / Environmental Risk
  - High Value Equipment / Fire Damage
  - Down Time / Loss Production
  - Rebuild Costs

Explosion Suppression Concept



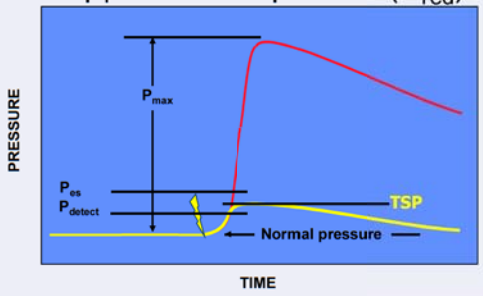
Explosion Isolation

- Product Selection Criteria
  - Bi-Directional
  - Flame Blocking
  - Flame and Pressure Blocking
  - Containment Process?
  - Duct Size
  - Placement Distance
  - Economics

Explosion Suppression
System Layout

Explosion Suppression

Suppressed Explosion (P_{red})



Explosion Suppression

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Suppressed Propane Deflagration

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Explosion Suppression

Suppression System Designs Considerations

- Deflagration characteristics of the combustible material
- Identification of equipment to be protected and its design specifications including strength
- Detection techniques, Pressure - Optical
- Suppressant type, quantity and suppressing characteristics
- Access to installed suppressors and ease of maintenance
- Deflagration propagation between process vessels
- Startup, normal operation and upset conditions

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Suppressed Propane Deflagration

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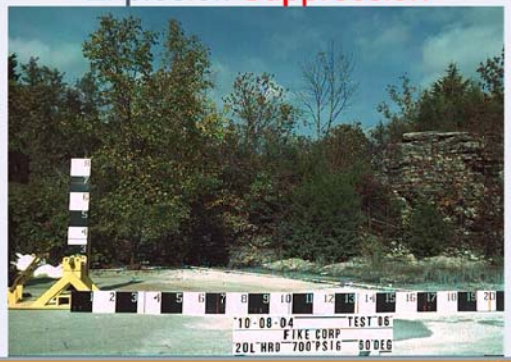
Explosion Suppression



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Explosion Suppression

Dust Collection

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Explosion Suppression

Dust Collection

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Thank You!

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Explosion Suppression

Product Drying

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334 Understanding Combustible Dust Hazards and Associated Mitigat Techniques

Robert Korn

Wednesday, March 28, 1:15 to 2:15 p.m.

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