
Dust Explosions: Basics and Prevention

SACHE Faculty Training Seminar

Rich Matuszewicz

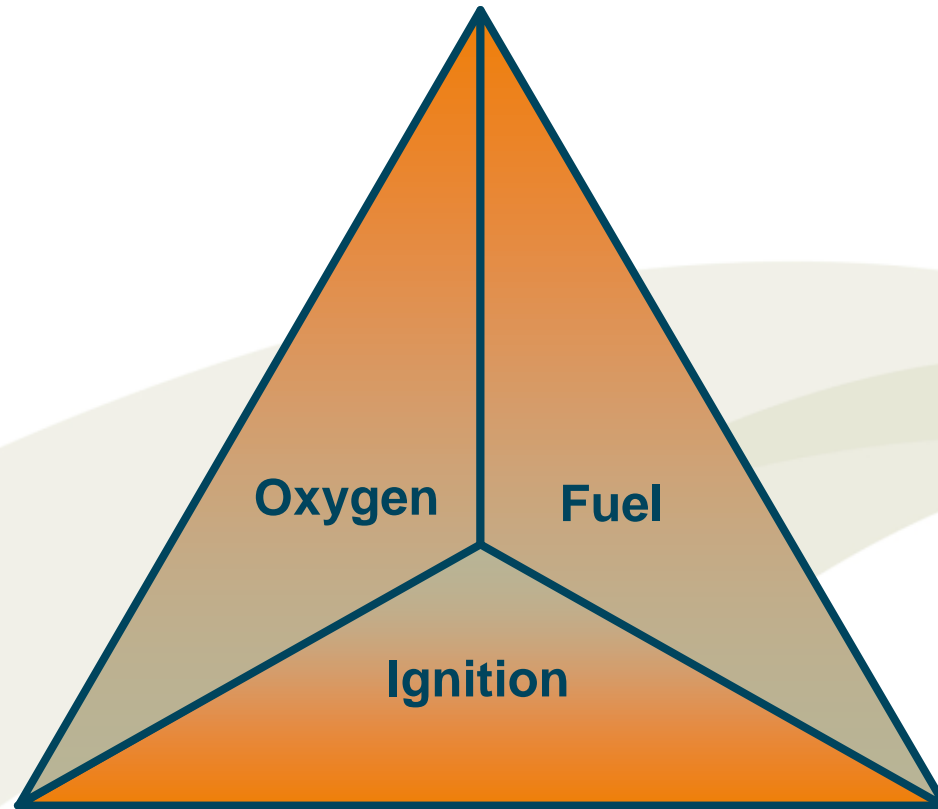
Arkema Inc.

September 15, 2008

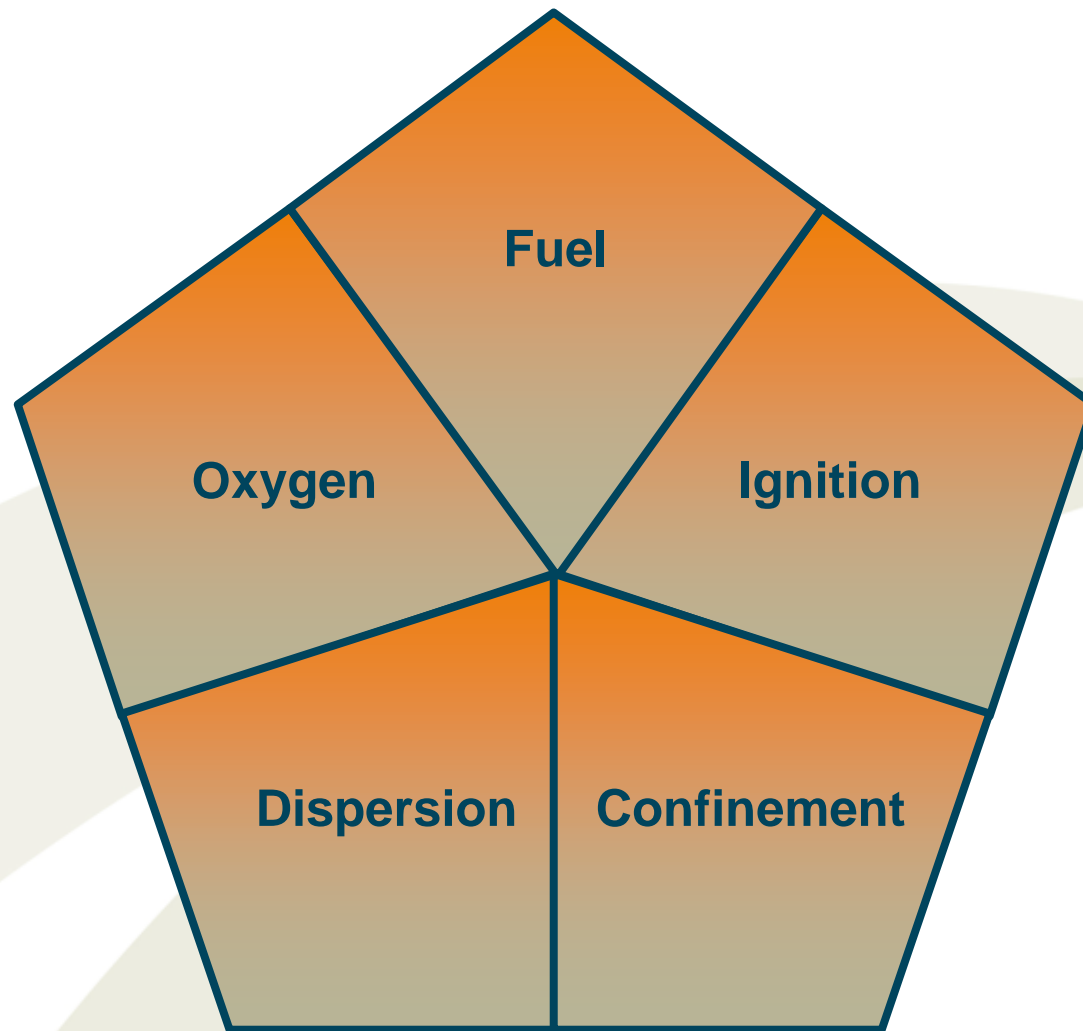
Presentation Outline

- ✓ Personal Introduction
- ✓ Dust Explosion Pentagon
- ✓ Fuel
- ✓ Oxygen
- ✓ Ignition
- ✓ Dispersion
- ✓ Confinement
- ✓ Mitigation
- ✓ Inerting
- ✓ Ignition Sources
- ✓ Explosion Venting
- ✓ Suppression
- ✓ Safeguards in Combination
- ✓ Closing
- ✓ Suggested References
- ✓ Questions

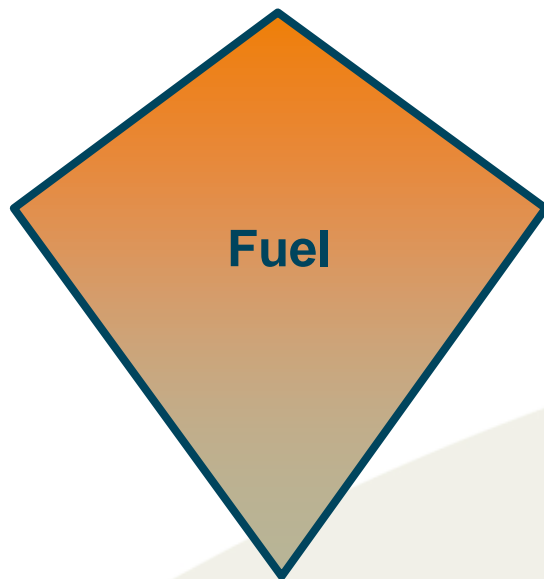
Flammability Triangle



Dust Explosion Pentagon



Dust Explosion Requirements - Fuel



- ✓ **Any Organic Dust Having a Particle Size Below 400 Microns (0.016 Inches) Should Be Evaluated.**

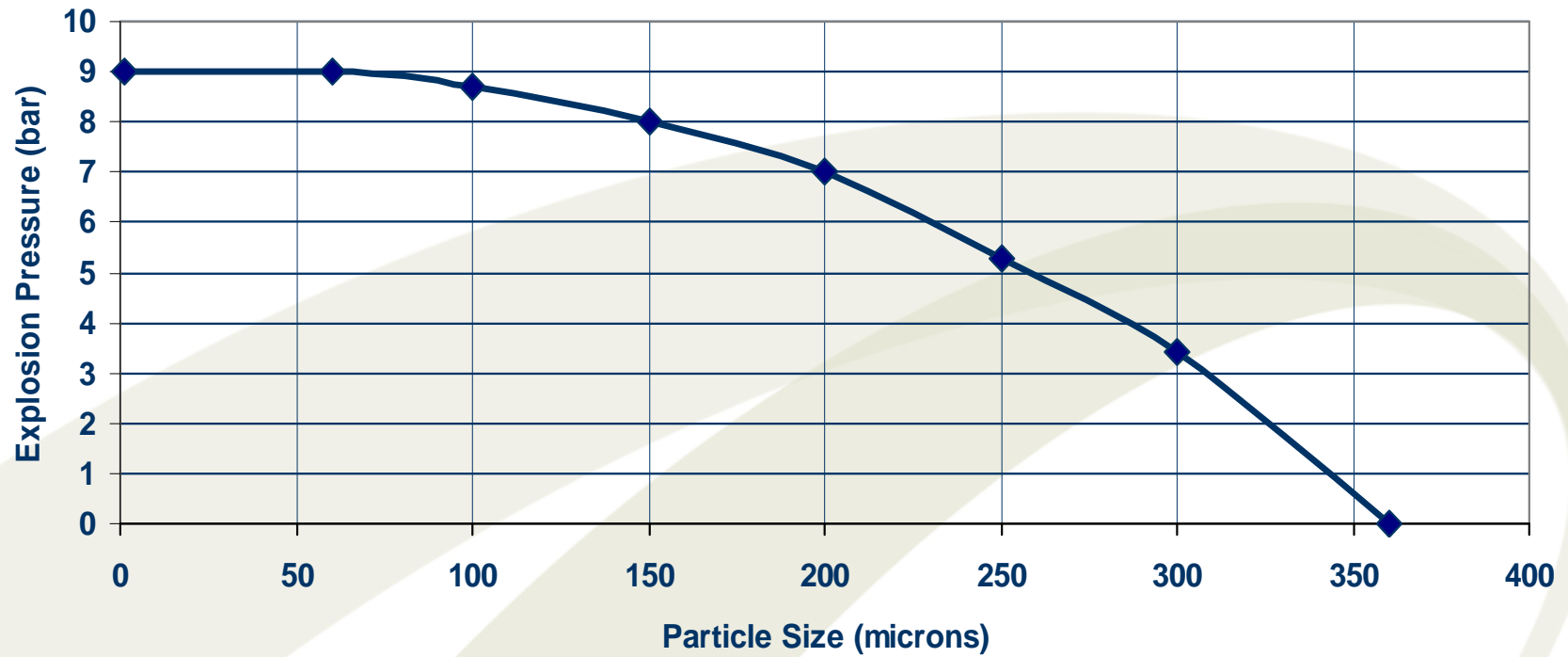
- ✓ **Examples Include:**
 - **Cornstarch**
 - **Flour**
 - **Polymer Fines**

- ✓ **Metallic Dusts are also Hazardous.**

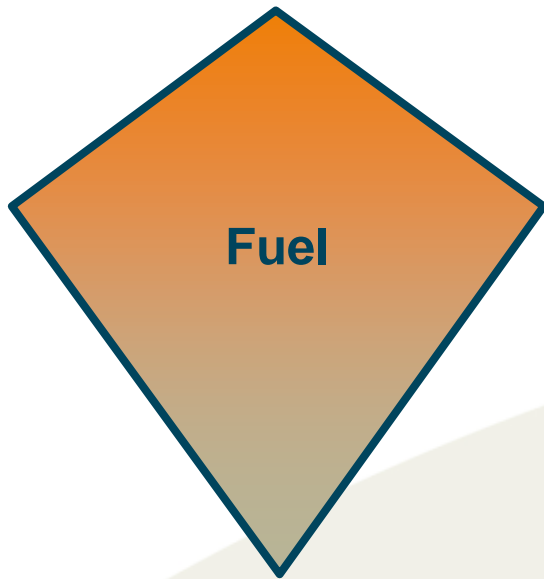
- ✓ **Some Dusts With a High Halogen Content (e.g., Halon[®]) Have Fire Retardant Properties.**

Dust Explosion Requirements – Fuel (cont'd.)

Polyethylene Dust Data



Dust Explosion Requirements – Fuel (cont'd.)



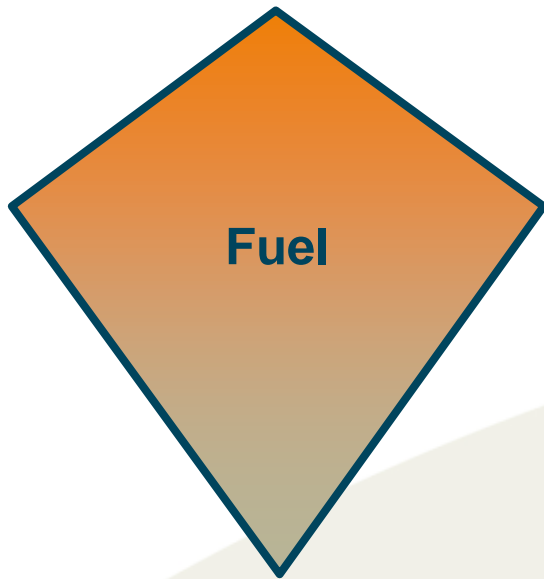
✓ **The Severity of a Potential Explosion Is Predicted Based on Standardized Laboratory Tests.**

✓ **“Explosion Severity” – K_{St} (bar·m/sec)**

✓ **Examples:**

<u>Dust</u>	<u>K_{St}</u>	<u>Rating</u>
➤ Coal Dust	129	Moderate
➤ Flour	202	Severe
➤ Polymer Fines	383	Very Severe
➤ Magnesium Powder	508	Very Severe

Dust Explosion Requirements – Fuel (cont'd.)

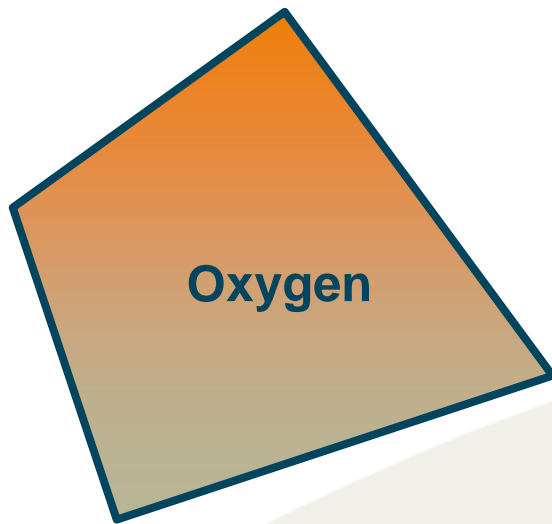


- ✓ **The Explosivity of a Dust Depends on:**
 - **Moisture Content**
 - **Particle Shape**
 - **Morphology**
 - **Et Cetera . . .**

- ✓ **It Is Very Important to Adhere to the Standard Method Procedures to Determine K_{St} .**

- ✓ **It Is Also Important to Obtain a Representative Sample for Analysis.**

Dust Explosion Requirements - Oxygen

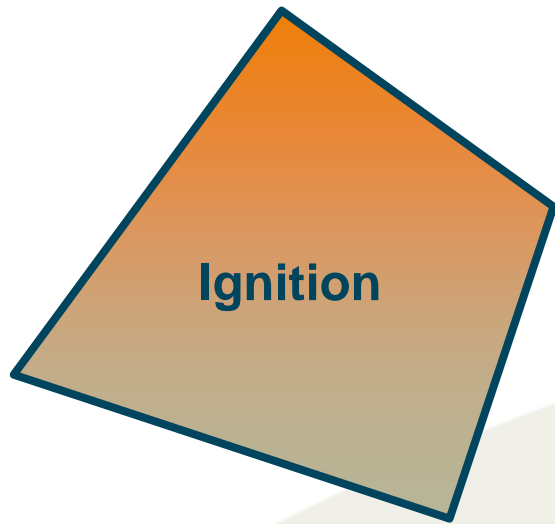


- ✓ **MOST Dust Explosions Require Oxygen from an Outside Source**
- ✓ **Most Common Source – Air**
- ✓ **Oxygen Could Be Included in Fuel Molecule.**
- ✓ **MOC – Minimum Oxygen Concentration**

Examples:

<u>Dust</u>	<u>MOC</u> <u>O₂ in N₂ (vol%)</u>
➤ Coal Dust	12 - 14
➤ Flour	11
➤ Polymer Fines	10 - 11
➤ Magnesium Powder	3

Dust Explosion Requirements - Ignition

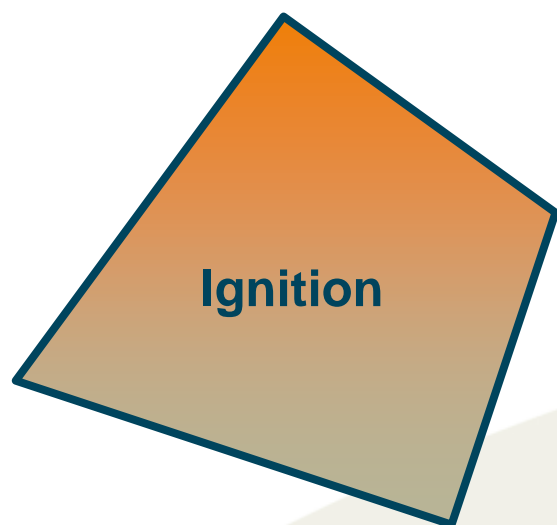


- ✓ **Minimum Amount of Energy Required to Initiate an Explosion - MIE**

Examples:

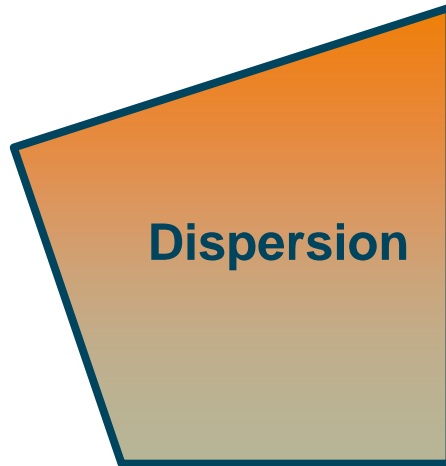
<u>Dust</u>	<u>MIE (mJ)</u>
➤ Cornstarch	300
➤ Wheat Flour	540
➤ Copolymer Fines	11
➤ Aluminum Shavings	> 1,800

Dust Explosion Requirements – Ignition Sources



- ✓ **Thermal:**
 - **Flames (Cigarette, Welding)**
 - **Glowing Embers (Decomposition, i.e. “Smoldering Nest”)**
 - **Hot Surface (Overheated Motor, Heater Malfunction)**
- ✓ **Mechanical**
 - **Spark (Metal to Metal Contact)**
 - **Excessive Friction**
- ✓ **Electrical**
 - **Contact Spark**
 - **Static Discharge**

Dust Explosion Requirements - Dispersion

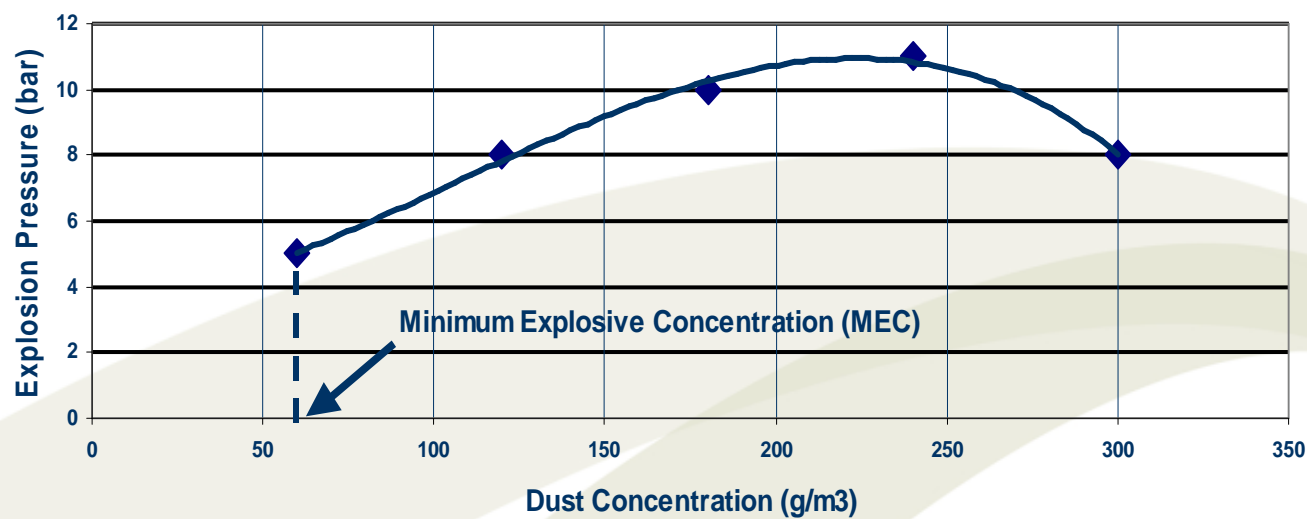


- ✓ **No Dispersion \Rightarrow No Explosion**
 - **Surface Burning on Layer of Dust**
- ✓ **Degree of Dispersion = f(particle size, air flow, dust flow)**
- ✓ **Watch for Secondary Explosions in Areas with Poor Housekeeping**

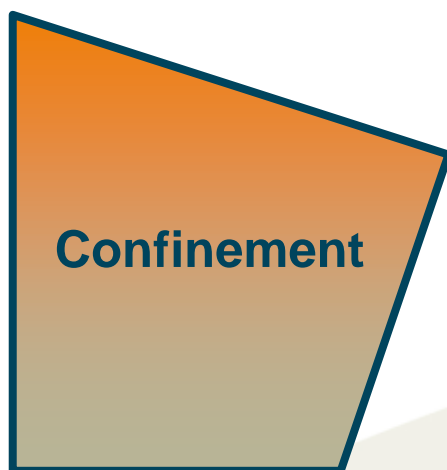
Potential Problem Areas:

- **Baghouses**
- **Silos/Hoppers (While Filling)**
- **Charge Chutes**
- **Mixers/Blenders**
- **Dryers**

Dust Explosion Requirements – Dispersion Limits



Dust Explosion Requirements - Confinement



- ✓ **Explosion or Flash???**
- ✓ **No Confinement ⇒
No High Overpressure -
Flash Only**
- ✓ **Fireball/Flash Fire is Still
Dangerous**

Confined Systems:

- **Baghouses**
- **Silos/Hoppers**
- **Charge Chutes**
- **Mixers/Blenders**
- **Dryers**

Non-Confined Systems:

- **Bulk Powder
Unloading**
- **Bag Charging**
- **Open Mixers**

Dust Explosion – Mitigation Options

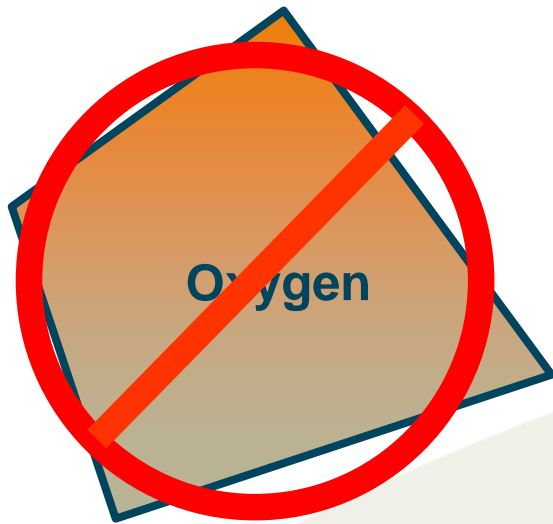
✓ Prevention:

- Inertion
- Eliminate Ignition Sources

✓ Protection:

- Explosion Venting
- Suppression
- Containment
- Isolation

Dust Explosion – Prevention: Inerting



- ✓ **Operate Below Minimum Oxygen Concentration - MOC**
 - Use Nitrogen, Carbon Dioxide, Combustion Gases
- ✓ **Effective, But Can Be Expensive**
- ✓ **Need for Quality Oxygen Sensors**
 - Dust Proof
 - Well Maintained

Dust Explosion – Prevention: Ignition



✓ Eliminate Ignition Sources:

- Follow Electrical Classification Requirements
- Ground Equipment to Safely Discharge Static Charges
- Eliminate “Hot Spots”
- No Open Flame Policy
- Use Magnets to Trap Stray Metal Pieces
- Etc.

Good Ideas!!! Prudent Practices!!!

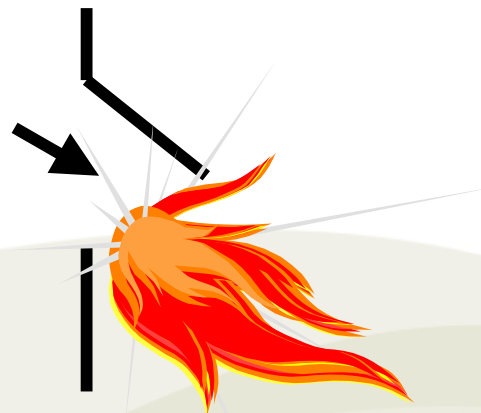
BUT . . .

Can You Really Guarantee NO Ignition Sources???

Dust Explosion – Protection (Added to Prevention)



✓ Explosion Venting:



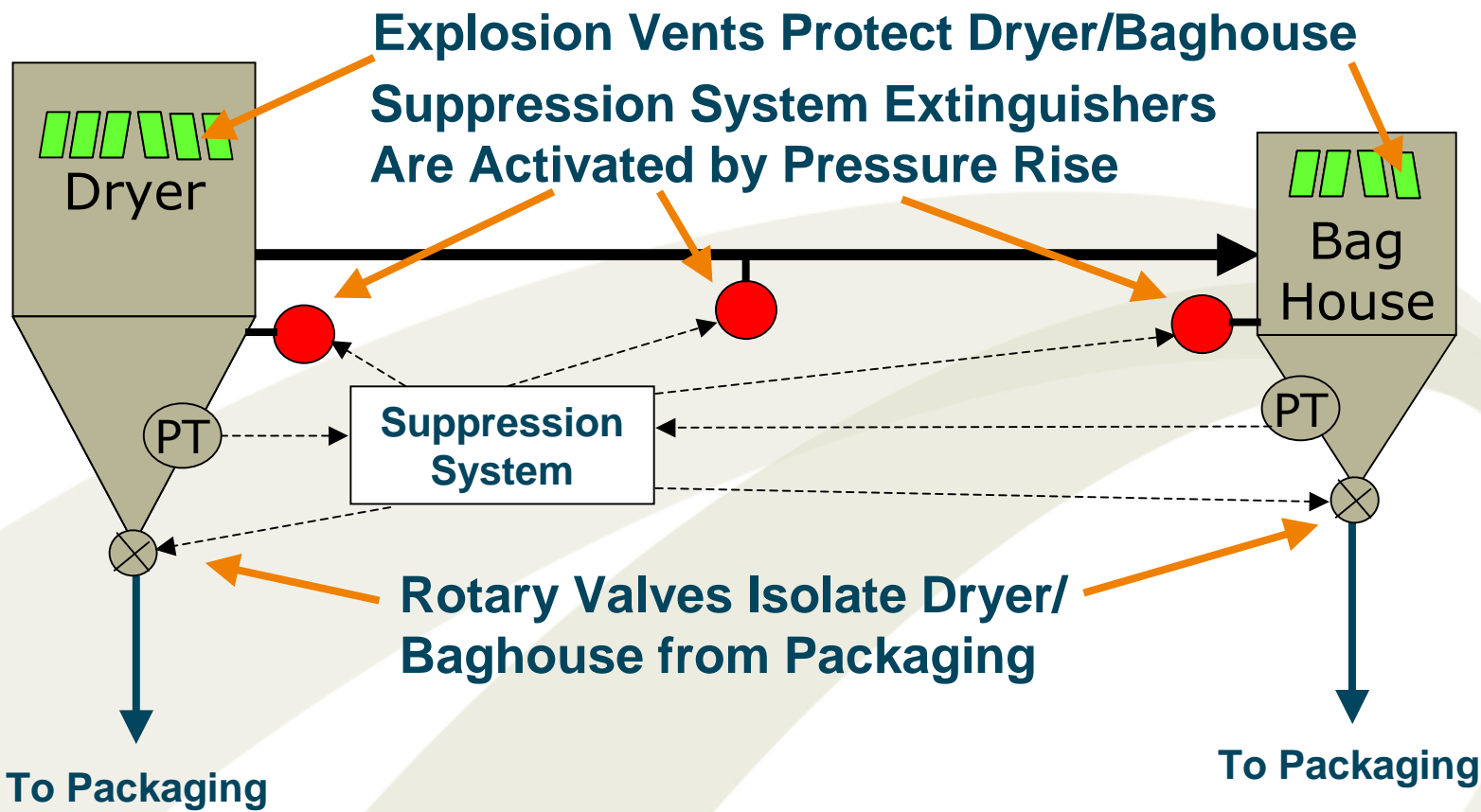
- Vent Opens Automatically at Onset of Pressure Wave
- Will Still Have Fireball/Flash
- Vent Discharges to a Safe Location
- Requires Careful Design

Dust Explosion – Protection: Suppression

- ✓ **High Tech Explosion Suppression Systems can be Designed and Integrated as Part of the Equipment Configuration**
 - **Extinguishers Discharge Inside of Confined Vessel**
 - **Halogenated Hydrocarbons**
 - **Ammonium Hydrophosphate (Monobasic)**
 - **Others**
- ✓ **Fast Activation at Onset of Minute Increases in Pressure**
- ✓ **Suppression Occurs Before Design Pressure of the Vessel is Exceeded**

Dust Explosion – Protection Suite Example

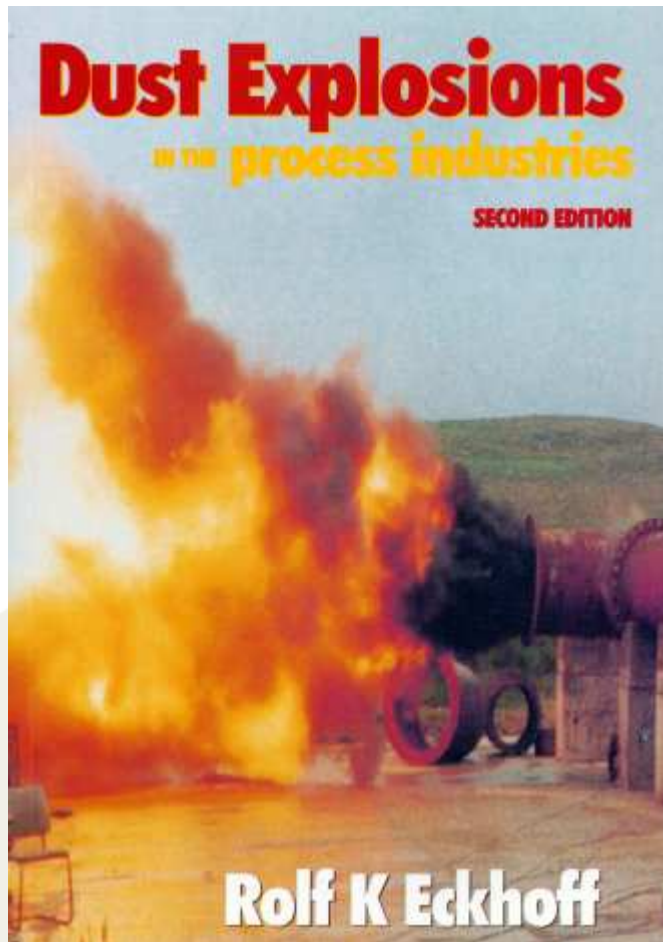
Water Deluge Puts Out Residual Fire



Closing

- ✓ **Dust Explosions Represent a Considerable Hazard**
- ✓ **Once the Mechanisms are Understood, More Easily Mitigated**
- ✓ **Mitigation Consists of Prevention and Protection Safeguards**
- ✓ **Knowledge is the Key**

References

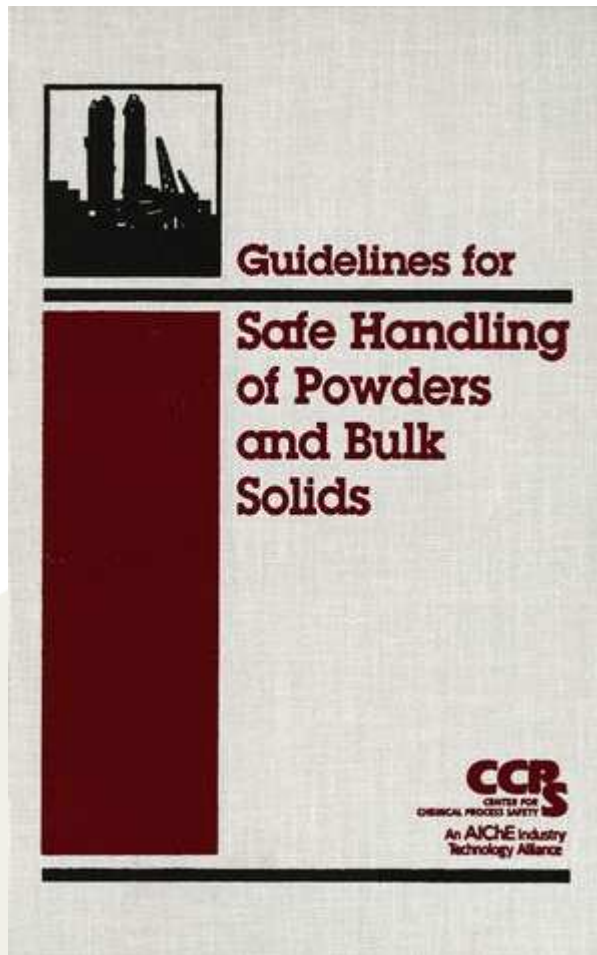


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References (cont'd)



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Questions???

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