Dust Explosion Data: How to Identify and Communicate the Hazard

Tom Janicik, PE, CSP
Sr. EHS Project Manager

COVIDIEN

Agenda

- Overview of US Chemical Safety and Hazard Investigation Board (CSB) Combustible Dust Hazard Study
- Combustible Dust Hazard Basics
- Dust Explosion Testing Basics
- Communicating the Hazard
- References/Resources
- Summary
- Q&A

Investigation Report - CSB Combustible Dust Hazard Study

COVIDIEN

CSB Combustible Dust Hazard Study

- Overview
- Dust Explosion Basics
- Major Incidents
- Common Major Incident Factors
- Major Deficiencies Identified
- CSB Report MSDS Related Recommendations

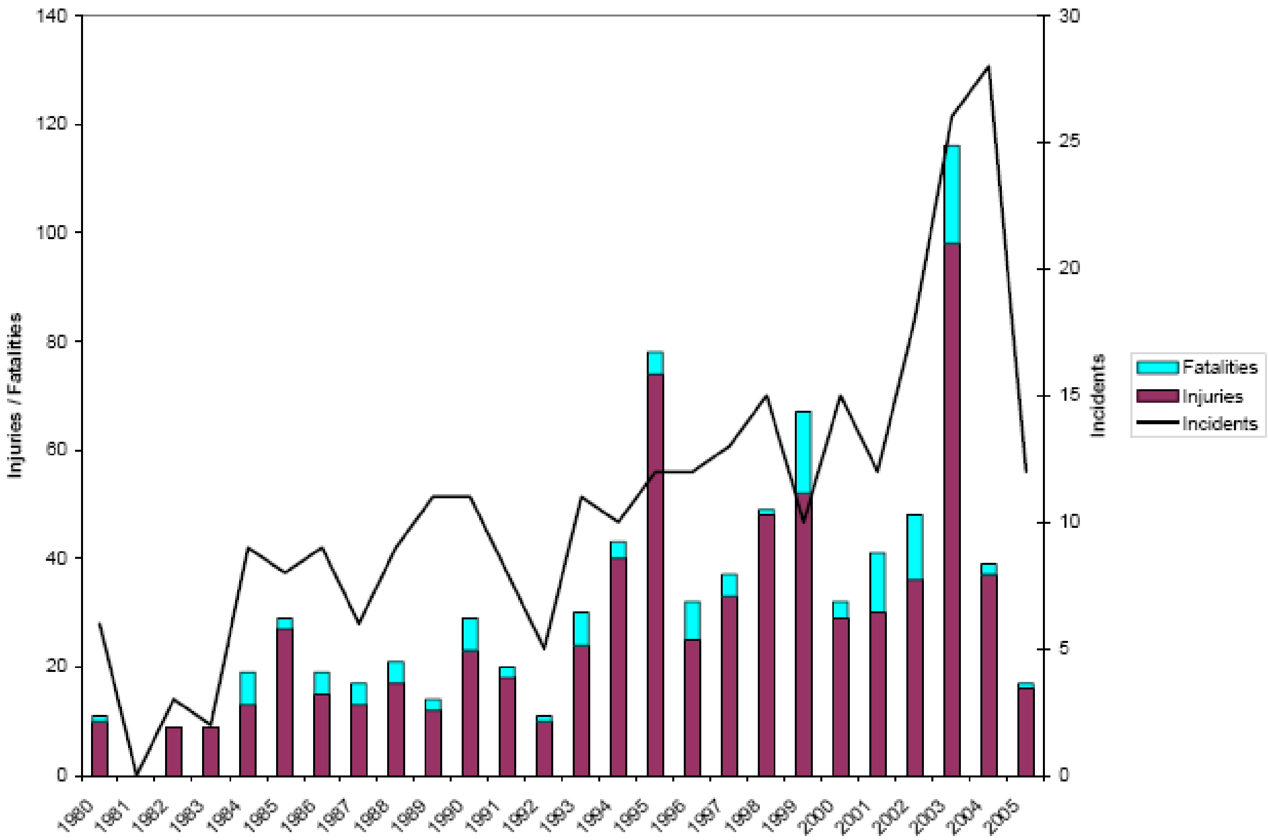
COVIDIEN

CSB Study Overview

- 281 combustible dust incidents (over 25 year period ending in 2005)
- 119 fatalities, 718 injuries, millions of dollars in lost facilities and productivity
- Included 7 catastrophic dust explosions in the past decade
- Materials involved commonly thought to be benign (e.g. plastics, rubber, foodstuffs and wood dust)

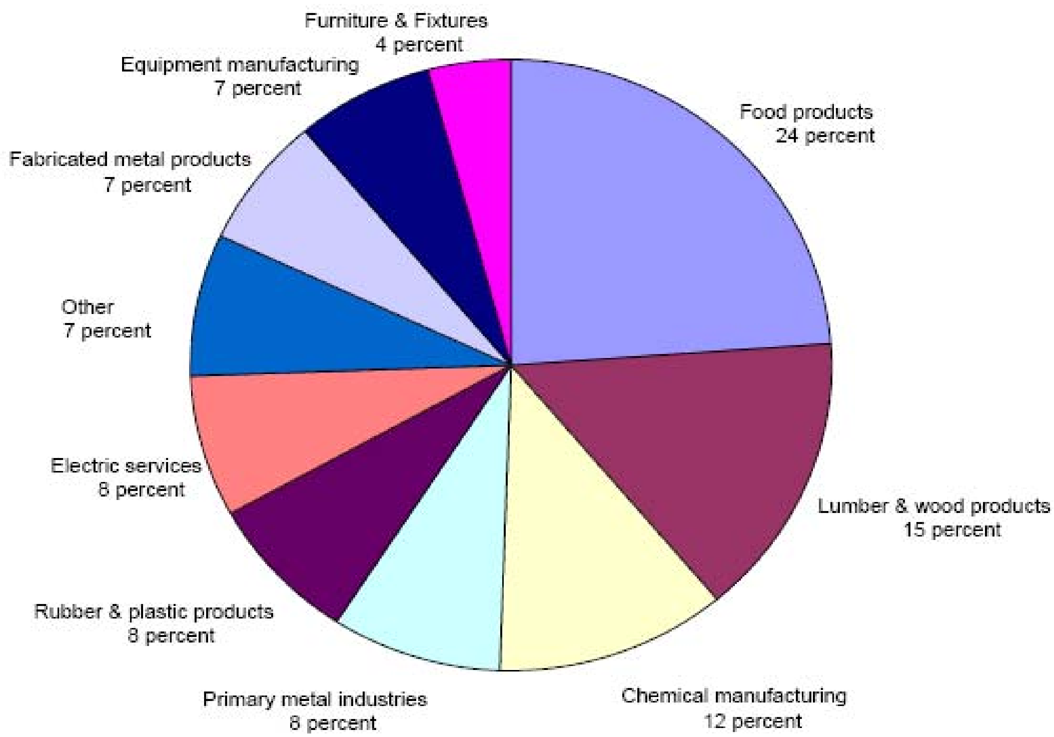
COVIDIEN

Dust Incidents, Injuries and Fatalities 1980 - 2005



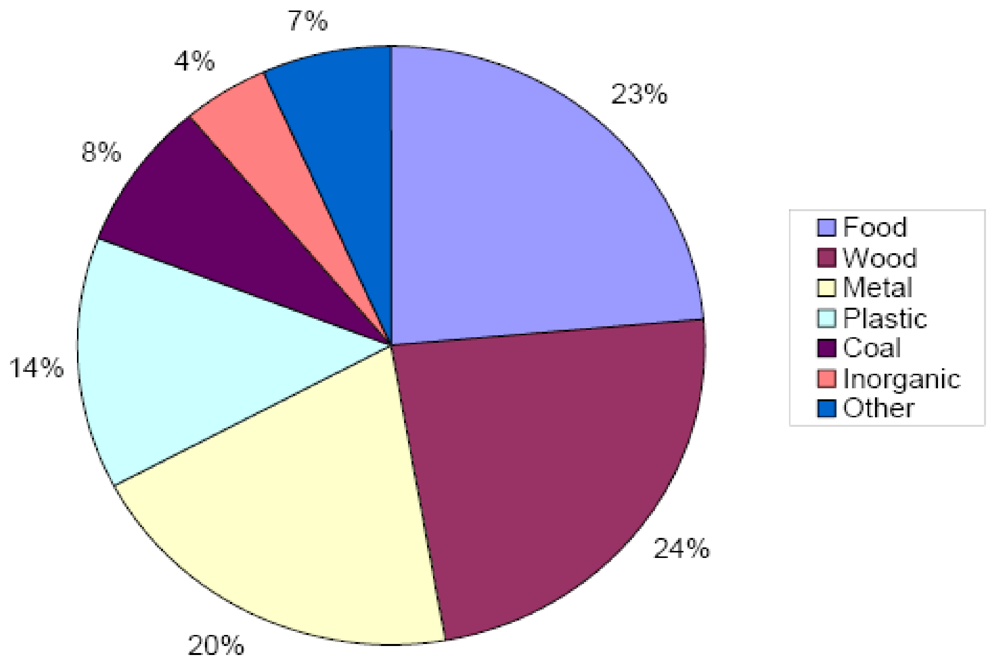
COVIDIEN

Distribution of Combustible Dust Incidents by Industry



COVIDIEN

Distribution of Combustible Incidents By Material



Combustible Dusts

- Most solid organic materials, as well as many metals and some nonmetallic inorganic materials, will burn or explode if finely divided and dispersed in sufficient concentrations.
- NFPA warns that more than 1/32” of dust over 5% of a room’s surface area presents a significant explosion hazard.

COVIDIEN

Dust Characteristics

- NFPA definition of dust:
  - Particles smaller than 420 microns
- Other factors affecting explosivity
  - Finer particle sizes more explosive
  - Particle shape
  - Aspect ratio
  - Surface area/volume ratio
  - Humidity, moisture content
  - Agglomeration
  - In-process particle changes

COVIDIEN

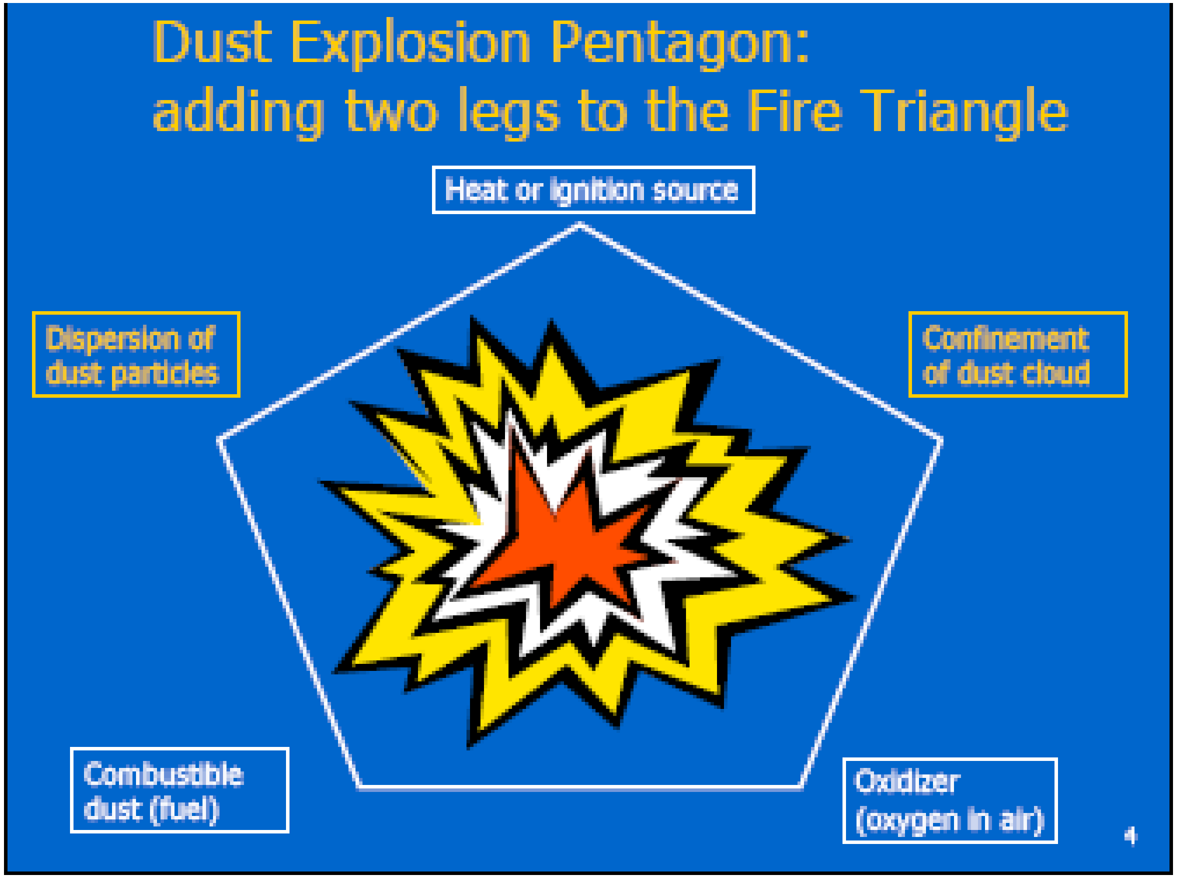
Particle Size of Common Materials

Common Material	Size (microns)
Talcum powder, fine silt, red bloods cells, cocoa	5 to 10
Pollen, milled flour, course silt	44 to 74
Table salt	105 to 149
Coarse sand	297 to 1000

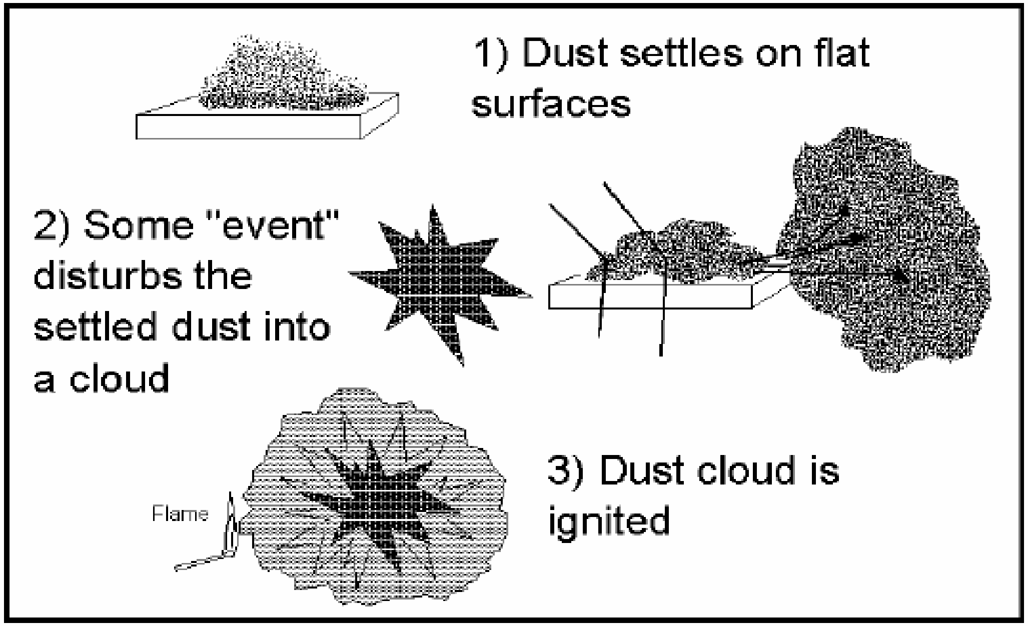
Note: The phenolic resin powders (CTA Acoustics) had a particle size of 10 to 50 microns.

COVIDIEN

Dust Fire and Explosion Pentagon



Secondary Dust Explosion



1/29/03 - West Pharmaceutical Services, Inc. – Kinston, NC

6 fatalities and destroyed the facility

Area Between Mixers #1 & 2

COVIDIEN

Southwest Wall of Compounding Area Deflected Outward

Remains of ACS Warehouse viewed from Compounding Area

COVIDIEN

2/20/03 – CTA Acoustics – Corbin, KY

7 fatalities, 37 injured, destroyed the manufacturing facility

COVIDIEN

10/29/03 – Hayes Lemmerz International – Huntington, IN

1 fatality, several injured

COVIDIEN

Common Major Incident Factors

- Identify dust explosion hazards and recommend protective measures. Workers and managers should be <u>aware</u> of dust explosion hazards.
- Conform to applicable NFPA standards designed to prevent or reduce the effects of the explosions.
- Do not allow excessive accumulations of combustible dust to occur and maintain effective housekeeping practices.
- Procedures and training to eliminate or control combustible dust hazards.

COVIDIEN

Common Major Incident Factors

- Identify and control potential ignition sources.
- Analyze and address root causes of fire incidents and warning events.
- Design and maintain dust collectors and associated ducting to minimize the potential for explosions.
- Thoroughly review process changes for potential hazards.

COVIDIEN

Most Common Equipment Involved

- Dust collectors account for more than 40 percent of all dust explosions.
- Grinders, silos, hoppers and mixers are also involved in numerous incidents.

COVIDIEN

Failure to follow NFPA 484 Guidance on locating and maintaining a Dust Collector

COVIDIEN

MSDS Observations from CSB Report Incidents

- Aqueous polyethylene slurry – listed no combustible hazards
- Phenolic resin – did not provide adequate warning of the explosion hazard (referenced NFPA 654, however the information was inconsistent with the guidance in the standard)
- Survey of seven other phenolic resin MSDSs showed that only two include clear dust explosion warnings

COVIDIEN

MSDS Observations from CSB Report Incidents

- Quantitative combustible dust fire and explosion properties are not specifically and clearly required by the existing OSHA Hazard Communication standard or ANSI Z400.1.
- Qualitative statements are commonly less than adequate (i.e. 41% of the 140 combustible powder MSDSs the CSB surveyed did not warn users about dust explosion hazards, and only 5% referenced appropriate NFPA dust standards to prevent dust explosions).

Note: Appendix B of this CSB report contains a complete discussion of the MSDS analysis.

COVIDIEN

CSB MSDS Related Recommendations - OSHA

2. Revise the Hazard Communication Standard (HCS) (1910.1200) to:
   - Clarify that the HCS covers combustible dusts, including those materials that may reasonably be anticipated to generate combustible dusts through downstream processing or handling.
   - Require Material Safety Data Sheets (MSDSs) to include the hazards and physical properties of combustible dusts, as well as clear information on safe handling practices and references to relevant consensus standards.

3. Communicate to the United Nations Economic Commission for Europe (UNECE) the need to amend the Globally Harmonized System (GHS) to address combustible dust hazards by:
   - defining combustible dusts,
   - specifying the hazards that must be addressed in chemical information sheets, and
   - addressing the physical properties that must be included on a chemical information sheet pertinent to combustible dusts.

COVIDIEN

CSB MSDS Related Recommendations – ANSI Z400.1 Committee

- Modify ANSI Z400.1 *American National Standard for Hazardous Industrial Chemicals--Material Safety Data Sheets* to recommend that MSDSs include information on:
  - combustible dust hazards, safe handling practices, and references to relevant fire codes in MSDS;
  - hazard information about the by-products of materials that may generate combustible dusts due to processing or handling;
  - identification of combustible dust hazards and selection of physical properties to include in MSDS.

COVIDIEN

Measured Properties of Combustible Dusts

- Kst – Dust deflagration index. Measures the relative explosion severity compared to other dusts.
- Pmax – Maximum explosion overpressure generated in the test chamber. Used to design enclosure and predict the severity of the consequence.
- (dp/dt) – Maximum rate of pressure rise. Predicts the violence of an explosion. Used to calculate the Kst.
- MIE – Minimum ignition energy. Predicts the ease and likelihood of ignition of a dispersed cloud by electrostatic ignition sources.

COVIDIEN

Measured Properties of Combustible Dusts

- MEC – Minimum explosible concentration. Measures the minimum amount of dust, dispersed in air, required to propagate an explosion. Analogous to the lower flammability (LFL) for gas/air mixtures.
- LOC – Limiting oxygen concentration. Determines the least amount of oxygen required for the explosion propagation through the dust cloud

COVIDIEN

Dust Explosion Classification

Dust Explosion Classification	Deflagration Index, Kst Range (bar.m/sec)	Hazard Descriptor
ST-0	0	No Explosion
ST-1	1-200	Weak to Moderate Explosion
ST-2	201-300	Strong Explosion
ST-3	> 300	Very Strong Explosion

COVIDIEN

Dust Explosion – Ignition Sensitivity (Chilworth)

Minimum Ignition Energy (MIE) mJ	Guidance
>100	Conductive items should be bonded and grounded (< 10 Ohms to ground). Avoid “Propagating Brush Discharges” by restricting use of insulating liners and coatings.
25-100	Take the above precautions and consider grounding personnel (Resistance to ground < 10^8 Ohm.
4-25	Take the above precautions and control electrostatic ignition discharge hazards from the surface of bulk granular materials of high resistivity. Consider possibility of ignition from dust clouds if volume is higher than $50m^3$.
1-4	High sensitivity to ignition. Take the above precautions and restrict use of insulating materials.
< 1	Extremely sensitive to ignition. Precautions should be as for flammable vapors and gases. Consider possibility of ignition from dust clouds.

COVIDIEN

Potential Example MSDS Language

Emergency Overview:
May form Explosible Dust Concentrations in air!
May form Explosible Dust-Air mixtures!

Fire Fighting Measures:
Dusts at sufficient concentrations may form explosible mixtures with air.
Results indicate a Strong Explosion severity.
Due to the low Minimum Ignition Energy (MIE) results, this material is extremely sensitive to ignition from electrostatic sources.
Dust accumulations should be avoided to prevent potential for secondary dust explosions.

Dust Class : St-2 (Strong Explosion Characteristics)
Kst Value (bar.m/s) : 250
Maximum Explosion Pressure-Pmax (bar) : 8.9
Maximum Rate of Pressure Rise-dP/dt (bar/sec) : 850
Minimum Ignition Energy-MIE (mJ) : 5
Minimum Ignition Temp.-Dust Cloud (°C) : 570
Minimum Ignition Temp.-Dust Layer (°C) : > 400

COVIDIEN

Potential Example MSDS Language

Fire Fighting Measures (continued):
Limiting Oxygen Concentration (% by volume) : 11
Minimum Explosible Concentration (g/m³) : 60
Volume Resistivity Ambient R.H. (ohm.m) : > 10^{14}
Volume Resistivity Low R.H. (ohm.m) : > 10^{14}
Charge Decay Time Ambient R.H. (hours) : 3.2
Charge Decay Time Low R.H. (hours) : 6.5

Handling and Storage:

Avoid dust cloud formation and control ignition sources. If this material is to be reduced to or collected as a powder, ensure a suitable design basis of safety is established per NFPA Standard 654: *Prevention of Fire and Dust Explosions from the Manufacturing, Processing and Handling of Combustible Particulate Solids,* or comparable industry standard. Failure to establish a suitable design basis of safety may lead to a flash fire or explosion.

COVIDIEN

References

1) U.S. Chemical Safety and Hazard Investigation Board (CSB) Investigation Report - Combustible Dust Study Report No. 2006-H-1 November 2006
2) Chilworth Technology, Inc. Safety Watch 2000 – No.1 Static Electricity in Powders, Vahid Ebadat, Ph.D.
3) “Handling dusts & powders safely – a strategic guide to characterisation & understanding”, Chilworth Technology Ltd ©2006
4) AIChE Center for Chemical Process Safety (CCPS) book titled “Guidelines for Safe Handling of Powders and Bulk Solids” published 2005 and “Deadly Dusts” video.

COVIDIEN

Related NFPA Codes

- NFPA 654 Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids (2006)
- NFPA 484 Standard for Combustible Metals, Metal Powders, and Metal Dusts (2006)
- NFPA 68 Guide for Venting Deflagrations (2008)
- NFPA 69 Standard on Explosion Prevention Systems (2002)
- NFPA 70 National Electrical Code
- NFPA 77 Recommended Practice on Static Electricity (2006)
- NFPA 91 Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids (2004)
- NFPA 499 Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas (2004)

COVIDIEN

Summary

- Overview of CSB Combustible Dust Hazard Study
- Combustible Dust Hazard Basics
- Dust Explosion Testing Basics
- Communicating the Hazard
- References/Resources
- Q&A

COVIDIEN