

# **GENERAL DYNAMICS**

Bath Iron Works

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## **Combustible Dust**

**New Emphasis on an Old Hazard**

# Agenda

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- History of Combustible Dust Regulations
- Current OSHA emphasis
- Inferno
- Technical Information
- BIW Findings
- Conclusions
- Recommendations/Suggestions

# History of Dust Regulations

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- In the late 1970's a series of grain dust explosions occurred, killing 45 and injuring 34
  - OSHA issued a "Grain Elevator Industry Standard Alert"
- In 1987 OSHA issued a "Grain Handling Facilities Regulation" (1910.272)
  - This significantly reduced the injuries caused by grain explosions
- From 1987 to 2005, dust explosions continued to occur outside of grain handling industries (pharmaceuticals, foundries, acoustical insulation, aluminum wheel manufacturing, and others)

# West Pharmaceuticals Services



**Nylon fiber  
explosion  
and fire**

**2003**

**6 fatalities**

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# Hayes Lemmerz International



**Aluminum  
dust  
explosion  
and fire**

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**2003**  
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**1 fatality**

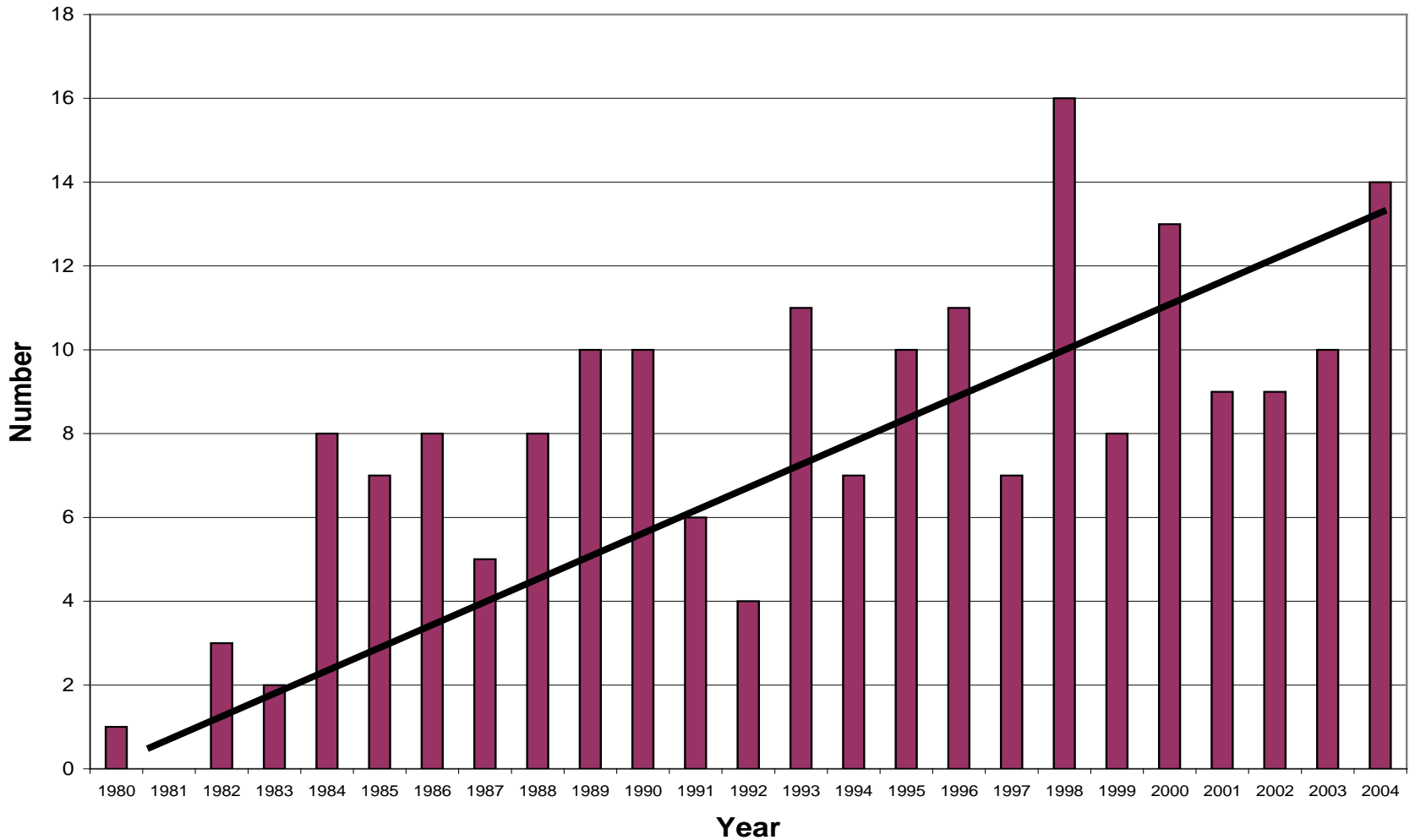
**6 injuries**

# History Of Dust Regulations

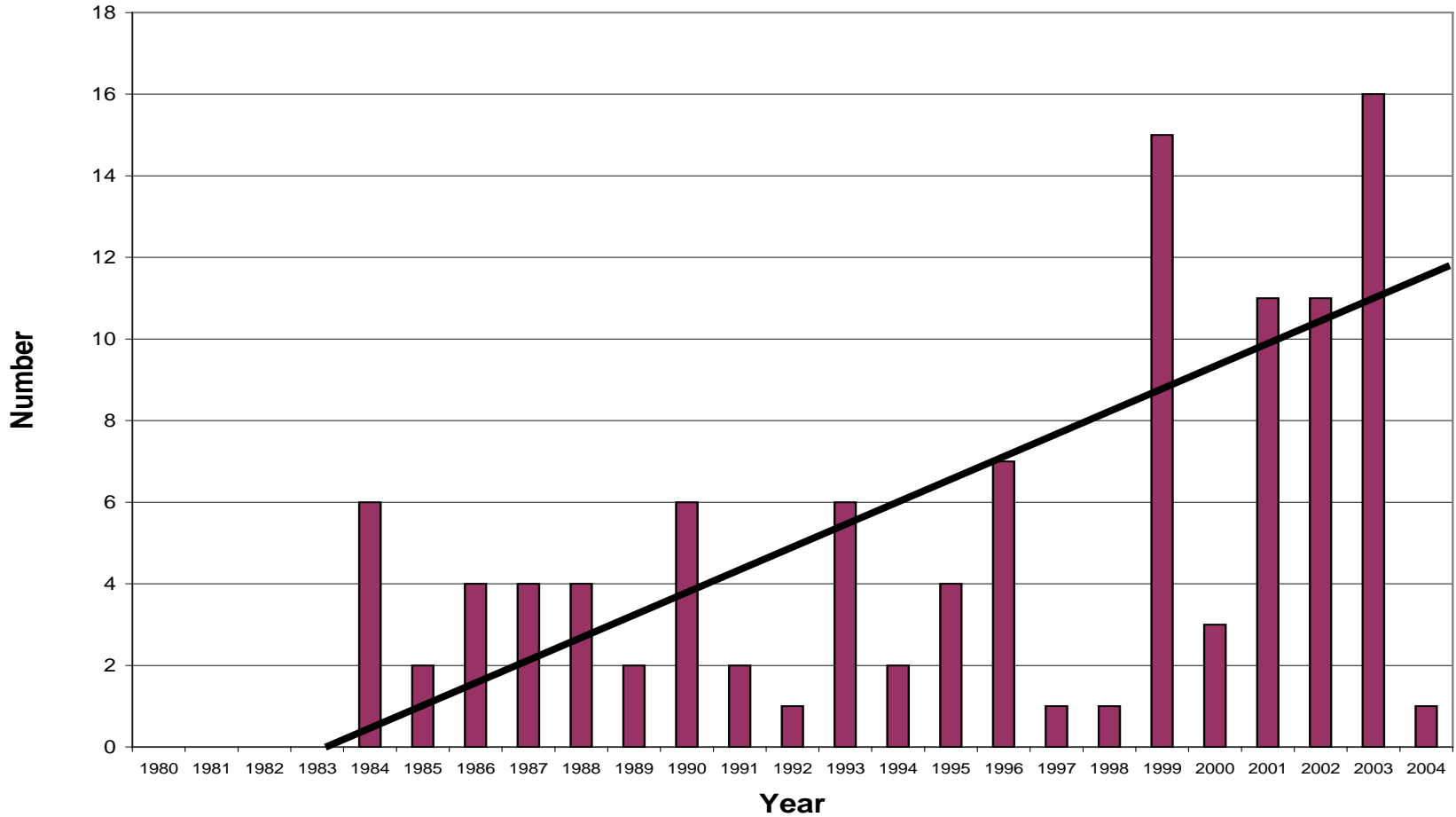
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- The Chemical Safety Board (CSB) identified 281 combustible dust incidents from 1980-2005
  - 119 fatalities
  - 718 wounded
  - 44 states
  - variety of industries
- OSHA issued a Safety and Health Informational Bulletin (SHIB) on July 31, 2005 entitled “Combustible Dust in Industry: Preventing and Mitigating the Effects of Fire and Explosion” – Informative Effort
- From 2006 through 2008, 16 fatalities and 84 injuries occurred

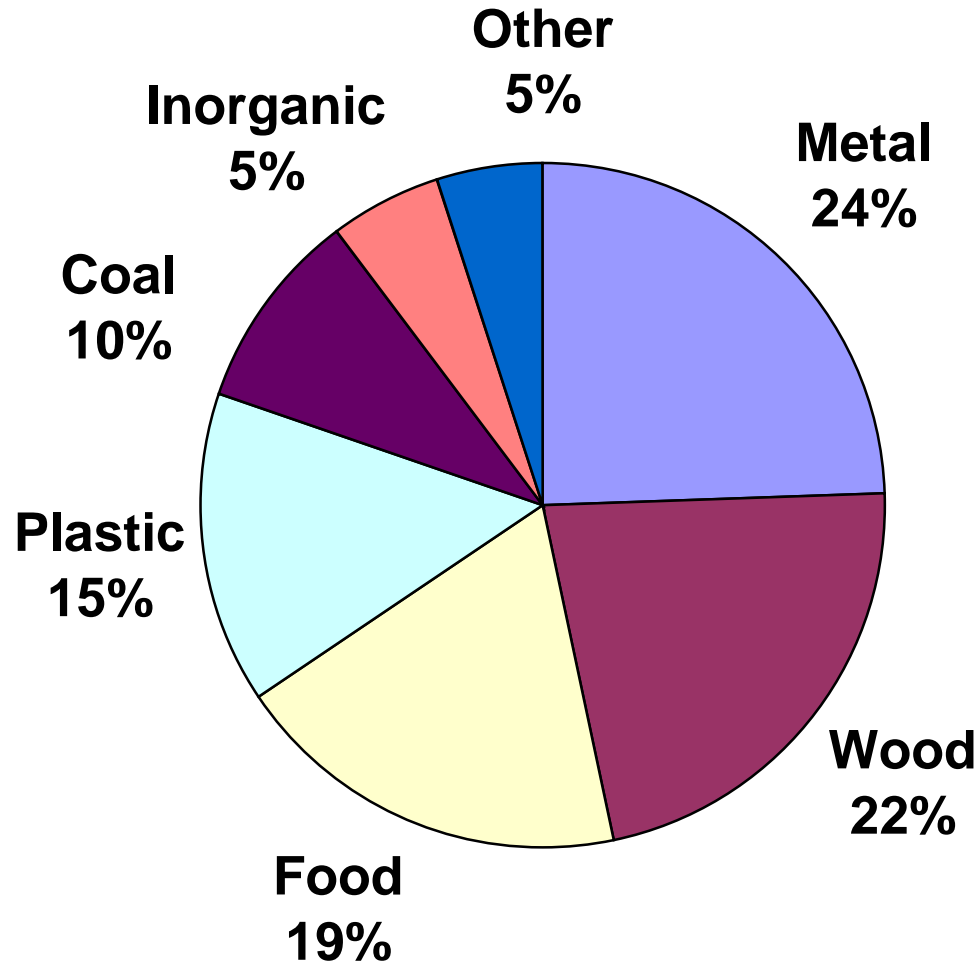
# Combustible Dust Incidents



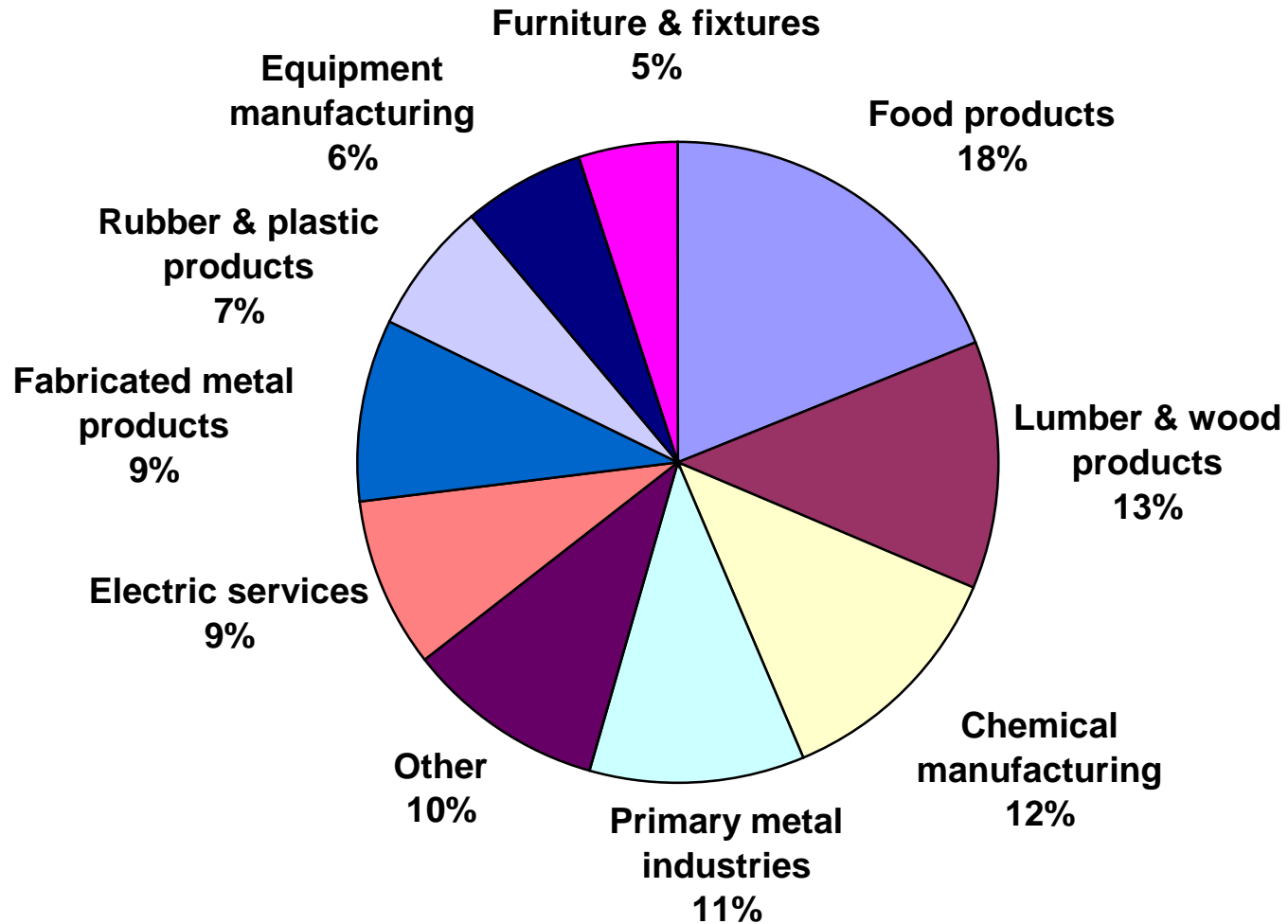
# Fatalities Per Year



# Materials Involved



# Industry Type



# Question

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- Why is the trend on dust explosions and associated fatalities increasing? Is it . . .
  - lack of regulations?
  - more companies reporting incidents?
  - the introduction of new materials with unknown hazards?
  - industry apathy – lack of knowledge?
  - **aging facilities and a very slow accumulation of dust? or**
  - all of the above?

# The Catalyst for Change



**Imperial  
Sugar  
Refinery**

**Savannah, Ga**

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**2008**  
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**14 fatalities**

**37 injured**

# More Recently

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- Imperial Sugar Refinery Incident 2008
- CSB recommends that OSHA issue a General Industry Regulation for combustible dust
  - ↗ Congress supported the recommendation
- Interim measures include:
  - ↗ OSHA re-issued their National Emphasis Program (NEP) on combustible dust (CPL-03-00-008)
    - included outreach, training, and enhanced enforcement
  - ↗ on March 11, 2008, Edwin Foulke, Assistant Secretary DOL, OSHA, issued a letter to Nicholas Chabraja, Chairman of the Board General Dynamics and other businesses

# National Emphasis Program (NEP)

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- NEP educates the public on combustible dust hazards
- OSHA trained Compliance Officers to recognize combustible dust hazards (CPL-03-00-006 & 008)
- Between November 1, 2007 and February 24, 2009, OSHA inspected 813 sites with a focus on dust hazards (with another 148 inspections in states with OSHA-approved State plans)
  - 3,662 violations

# Commonly Cited Issues

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- Dust collectors were located inside a building without proper explosion protection systems
- Horizontal surfaces were not minimized to prevent the build up of dust – design phase
- Air from dust collectors was recycled through ductwork back into the work area
- Duct work from the dust collection system to other areas of the plant was not constructed of metal

# Combustible Dusts

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- Areas within general industry that may have combustible dust include:
  - ↗ Carpenter/wood working shops
  - ↗ Composite fabrication shops
  - ↗ Abrasive blast operations
  - ↗ Powder coating operations
  - ↗ Paper shredders
  - ↗ Grinding dust – metal or paint
  - ↗ Paint overspray – ventilation duct work
  - ↗ Aluminum or titanium chips or dust
  - ↗ Powdered metals in machine shops

# OSHA Takes Action

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- OSHA does not currently have a combustible dust standard, so they cite the General Duty Clause based on consensus standards such as:
  - NFPA 484: Combustible Metals
  - NFPA 654: Manufacturing, Processing and Handling of Combustible Particulate Solids
  - NFPA 664: Wood Processing and Wood Working Facilities
- A regulation is being developed
  - ANPR was issued October 21, 2009
  - Comments were due by January 19, 2010

# OSHA Takes Action (cont.)

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- General Duty Clause overview:
  - ↗ Employer failed to keep workplace free of serious hazards to which employees were exposed
    - any feasible and effective means for abatement
    - hazard must be reasonably foreseeable
  - ↗ Hazard was recognized
    - industry or consensus standard
    - employer recognition
    - obvious
  - ↗ Hazard caused or was likely to cause death/serious harm
  - ↗ Feasible means available to abate hazard

# OSHA Takes Action (cont.)

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- OSHA Combustible Dust Expert Forum held May 13, 2011 in Washington, DC
  - ↗ Scope of Combustible Dust Standard
    - Does it only address the extremely explosible dusts or all combustible dusts?
    - Does it include facilities with any amount of combustible dust or only large producers?
    - Does it exclude certain industries?
  - ↗ Focus on Preventing Secondary Explosions
    - Should standard focus only on secondary events (fugitive dust) and omit requirements that address only primary explosions?

# OSHA Takes Action (cont.)

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## ↗ Applying Standard to Existing Facilities

- How should a rule address high potential costs of engineering controls?
- Are facilities already complying with NFPA Standards?
- Grandfather clause?

## ↗ Use of Multiple Layers of Protection

- Given costs and benefits, should multiple layers of protection (e.g., engineering controls plus housekeeping) be required?

***Comment: No consensus among the experts. OSHA will have a difficult time writing a regulation***

# Video

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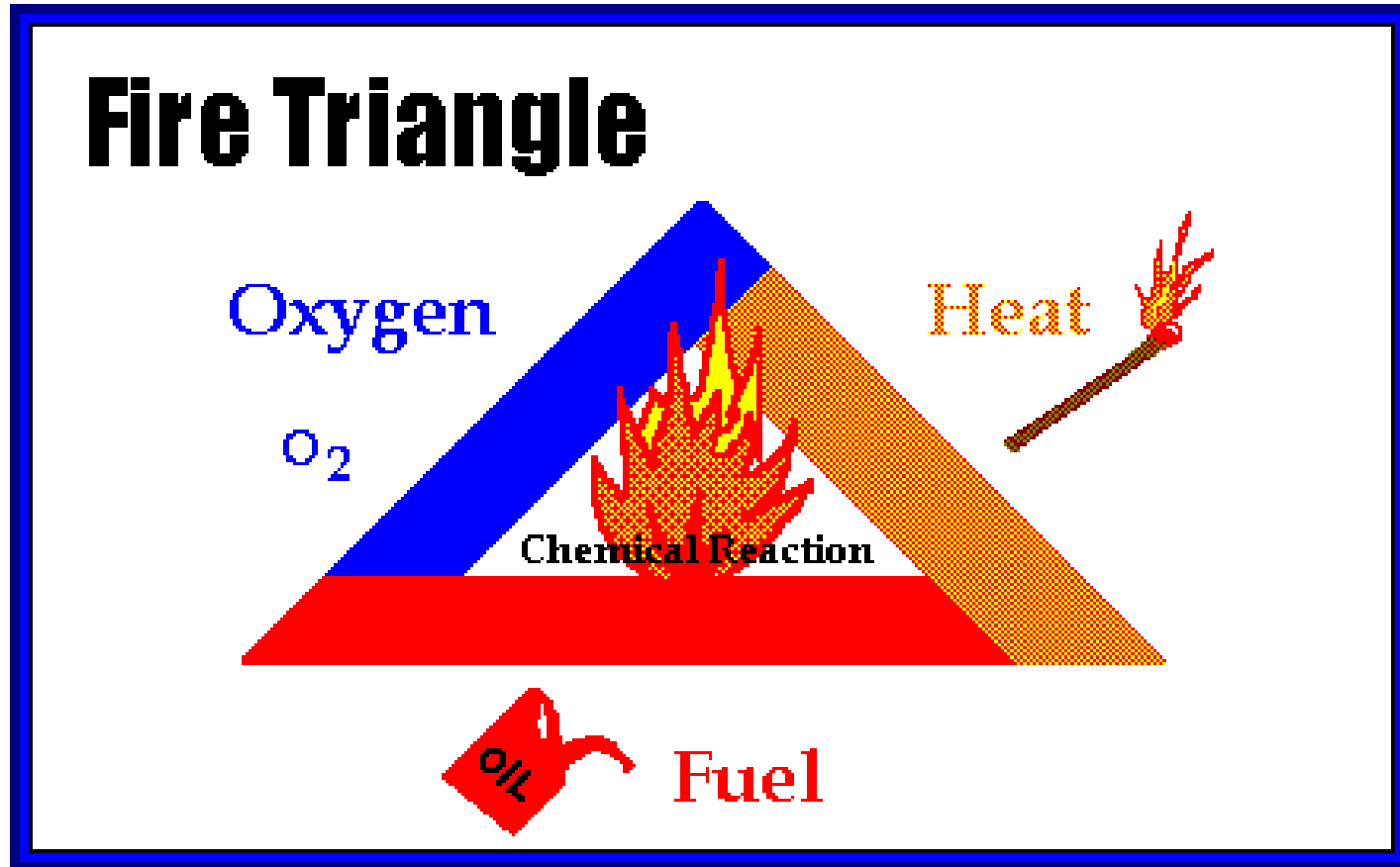
## Inferno: Dust Explosion at Imperial



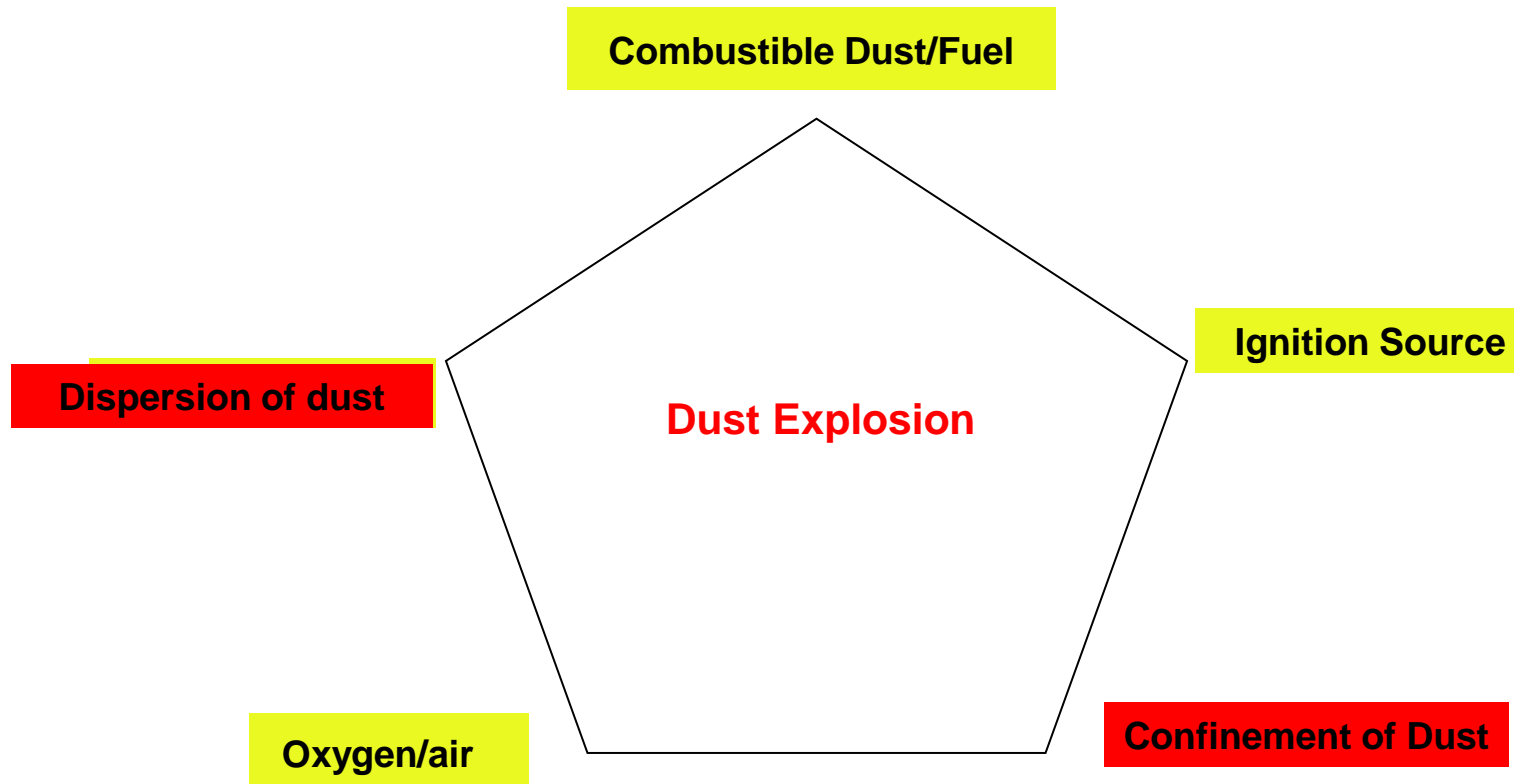
# **Technical Information**

# Typical Fire Triangle

Liquids and Gases



# Combustible Dust Pentagon



# Conditions for a Dust Explosion

- Dust must be explosible, which is dependent on:
  - ↗ make-up of dust
  - ↗ particle size (<40 mesh sieve or < 420 microns)
- Dust concentration must be above the MEC (Minimal Explosible Concentration) – requires **confinement**
- Dust must be **dispersed**
- An ignition source must be present
- Oxygen must be present



# Dust Concentrations

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- Examples of a potential explosible concentration: (unit of measure is grams per cubic meter)
  - You can't see a 25-watt light bulb through a cloud 6 feet away
  - You can't see your hand held out at arm's length

# Dust Concentrations (cont.)

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- Problem – No real time measurement device to determine dust concentrations – Use IH methods
- Even the dirtiest shipyard process (abrasive blasting) does not reach explosible concentrations
- Standard operating procedure is to use ventilation and housekeeping to reduce the concentration and the build-up of dust

# Airborne Dust

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- An initial disruption (possibly a primary explosion or earth quake) is needed to make dust airborne, which can result in the proper concentration for an explosion to occur
- Housekeeping is a key engineering control. **Elevated surfaces are a priority and are often overlooked, especially in shipyards.**
- *Should the standard focus on the initial explosion, the secondary explosion, or both?*

# Airborne Dust (cont.)

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- Combustible dust that is airborne is a potential **explosion hazard**
  - Usually related to process equipment, vent ducts or dust collectors
  - Not easily inspected and **no test equipment available to determine real time concentrations**
  - Most safety professionals do not have the ability to quantify the hazard

# Laboratory Testing

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- Several labs can determine if a dust is combustible - use OSHA NEP for guidance
- More difficult to determine if dusts are explosible and at what concentration
  - 20-liter test sphere called out in NEP and NFPA documents (being revised)
  - Dust is air-injected into a cylinder that contains strong igniters (dual 5KJ) until the dust explodes
  - Screening test -\$695 Go / No-Go test
  - Chilworth, Fauske, Fike

# Laboratory Testing (cont.)

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- Explosible dusts are classified in accordance with their Kst values (explosion severity)
  - ↗ ST 0 = non-explosible (silica)
  - ↗ ST 1 = (0 - 200 Kst) weak explosion (sugar)
  - ↗ ST 2 = (200 - 300 Kst) strong explosion (flour)
  - ↗ ST 3 = (>300 Kst) very strong explosion (Al)

# 20 Liter Test Chamber



# BIW Internal Assessment

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- Inspected all areas of shipyard with a focus on dusty processes **and adjacent areas**
- Sampled dust in suspect areas
- Had dust tested internally and externally
- Reviewed dust collection equipment for compliance to OSHA NEP and NFPA standards

# BIW Test Results

- Six samples of very fine steel dust from abrasive blasting operations were sent for a screening test
  - ↗ results indicated an explosible dust
  - ↗ additional testing performed to determine Kst value -  
 $K_{st} = 13$
- All blast facilities were cleaned from top to bottom
  - ↗ several weeks of work
  - ↗ **\$\$\$\$\$ OUCH**
- *BIW Lab continued to test the steel dust and could not make an explosion*



# Dust Collector Explosions

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- Dust collectors represent the most common piece of equipment associated with dust explosions (per Factory Mutual study conducted over a 10-year period prior to 1995)
- 58 dust collector explosions were reported by three (3) insurance companies
  - \$14.73 million in losses (1995 dollar value)
- The explosion hazard inherent in dust collection processes is widespread

# Dust Collector Explosions



Clearly there were no explosion vents installed on this dust collector

Picture taken from the internet

# Dust Collector Requirements

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- BIW verified that dust collectors that capture combustible dust:
  - were located outside of buildings
  - were equipped with explosion venting
  - had explosion vents directed in a safe area away from personnel
  - did not recirculate air back into the building

# Carpenter Shop Dust Collector (BIW)



External exhaust



Explosion Vents

*Prior to replacement, this wood dust collector was located and exhausted inside the building*

# Torit Dust Collector (BIW)



Abrasive blasting dust collectors

# Inside a Torit Dust Collector



*Banks of filter cartridges collect fine dust particles, then get shaken or pulsed to release the dust*

# BIW Test Results

- BIW Lab still couldn't get dust to explode – kept trying
- Consulted a dust expert who recommended we send samples to Fike Industries to retest in a larger cylinder (1M<sup>3</sup>)
  - ↗ Results were non-explosible for all 6 samples
  - ↗ **Approximate cost: \$5000 per sample**
- 20 L test results can be misleading
  - ↗ ST 1 dusts with K<sub>st</sub> less than 50 can produce a false-positive indication in a 20L test chamber
  - ↗ Test anomaly is called **“overdriving”**
  - ↗ Igniters cause the pressure increase, not the dust



# 1 M<sup>3</sup> Test Chamber



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# Conclusions

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- The public and workplaces are not fully aware of the hazards
- Dust accumulations occur over long periods of time
- Housekeeping is key to preventing secondary dust explosions
- Housekeeping should include a focus on elevated, often ignored areas
- Primary concerns are dust collectors

# Conclusions (cont.)

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- Lack of a real-time testing device to determine if an explosible concentration exists results in inconsistent application of controls
- Dust collector manufacturers are reluctant to warrant their equipment
- Assessment of a potential explosible dust hazard is best left to the experts
- Common sense may be the best prevention method - housekeeping

# Conclusions (cont.)

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- Businesses, fire departments, codes officers, and state regulators may not be educated on combustible dust hazards
  - Fire fighters' initial response is unique (contrary to normal firefighting technique)
- Combustible dust can accumulate over many years before it becomes a potential explosion problem
- This long latency period creates a situation where people don't recognize it as a hazard

# Recommendations/Suggestions

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- Identify your dusty processes
- Inspect the adjacent areas with attention to overhead spaces
- Determine if the dust is combustible
- Assess your dust collectors
  - ↗ Location – outside if possible
  - ↗ Ducting – do not recirculate air
  - ↗ Bonding/grounding – verify it
- Develop a housekeeping program
- Consult the experts
- Keep your eyes out for a proposed standard!

# Training Material

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- OSHA NEP
- CSB.gov/Video Room
  - ↗ Combustible Dust - An Insidious Hazard
    - A video depicting the steps leading up to and the results of a dust explosion
  - ↗ Inferno: Dust Explosion at Imperial Sugar
    - a video showing a dust explosion