



Combustible Dust Review

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1/29/03 - West Pharmaceutical – Kinston, NC
Polyethylene powder



6 fatalities, 38 injuries, and destroyed the facility

2/30/03 - CTA Acoustics – Corbin, KY



7 fatalities, 37 injuries

2/7/08 - Imperial Sugar – Port Wentworth, GA



14 fatalities and numerous injuries

Local incident, 2006

Operator was charging material to manway

Local Ventilation

Bags of Para-Formaldehyde

Hood



2 injured, property damage, fire department imposed downtime.
Production halted for four months.

Local Incident, continued

Damage to interior wall

Explosion Relief Panels
separated from Bldg. Structure.

And this was a
primary event,
not a “Big One”

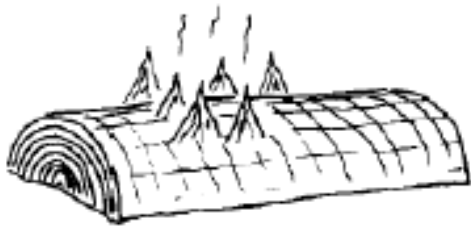


Employee prior experience

- Plant made wood pellets for stoves, using fine sawdust.
- Hammer mill had a flexible dust collection tube, ungrounded.
- Buildup of dust in the tube increased velocity, and static spark developed.
- Duct exploded about 10-12 feet above employee's head, triggering multiple subsequent explosions.
- He was thrown 15 feet across the room into a steel girder. Injuries included cracked hip, bruises, contusions, lacerations, relocated collar bone.
- Walls and floor were on fire, heavy smoke and no visibility. Exterior walls blown off; interior walls buckled.
- Employee found a side door. Exiting, a piece of exterior wall fell, cutting him on the neck near an artery.
- Passed out, woke to voices that he must be dead. Called out as loud as he could. ER doctor drove past the plant on the way to the hospital. Said he couldn't believe anyone could survive that amount of force.
- More difficult than recovery from injuries was having courage to go back in the building. "The smell never leaves you and brings back the emotion and sounds from the day. You can move on with your life but it will always be with you..."

What creates combustible dust?

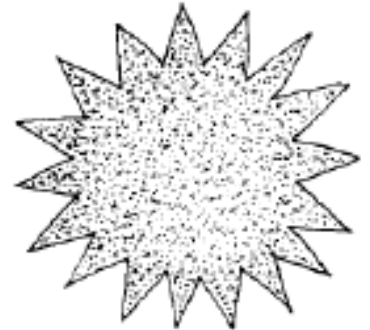
Many solid materials become highly flammable when reduced to fine powders



a. Slow combustion

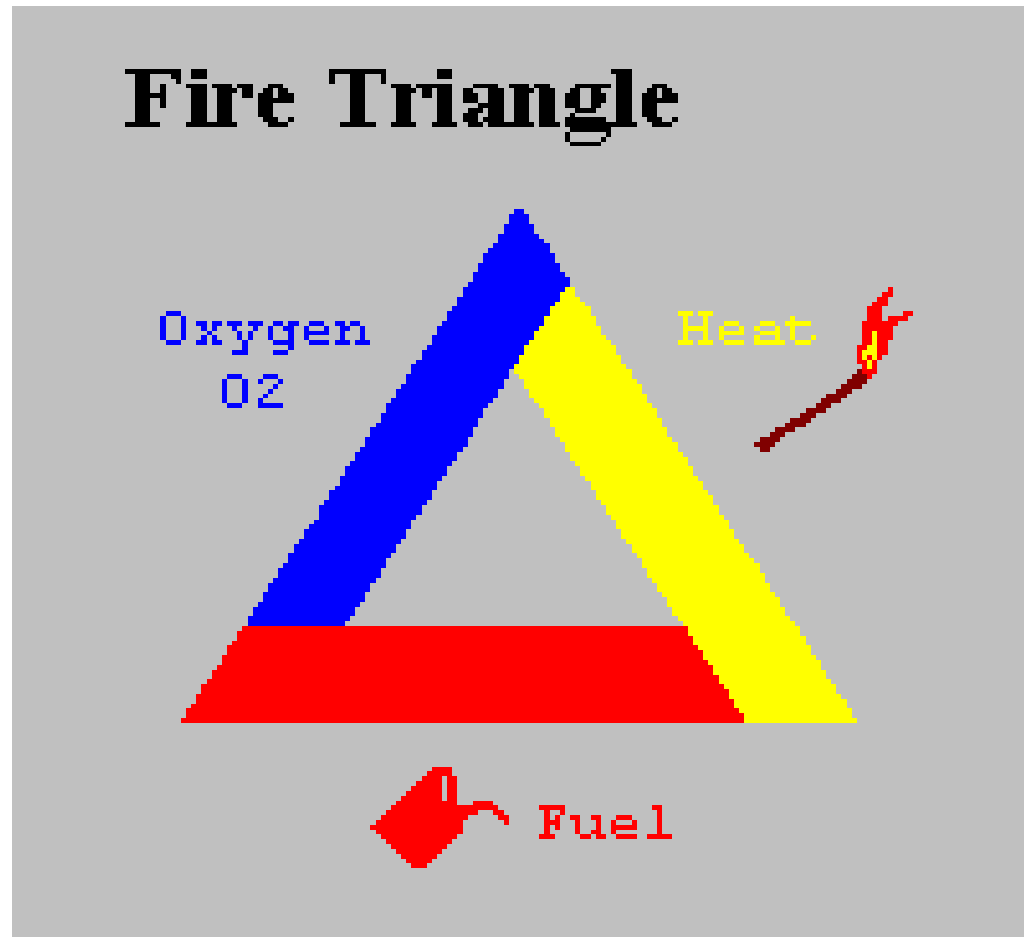


b. Fast combustion



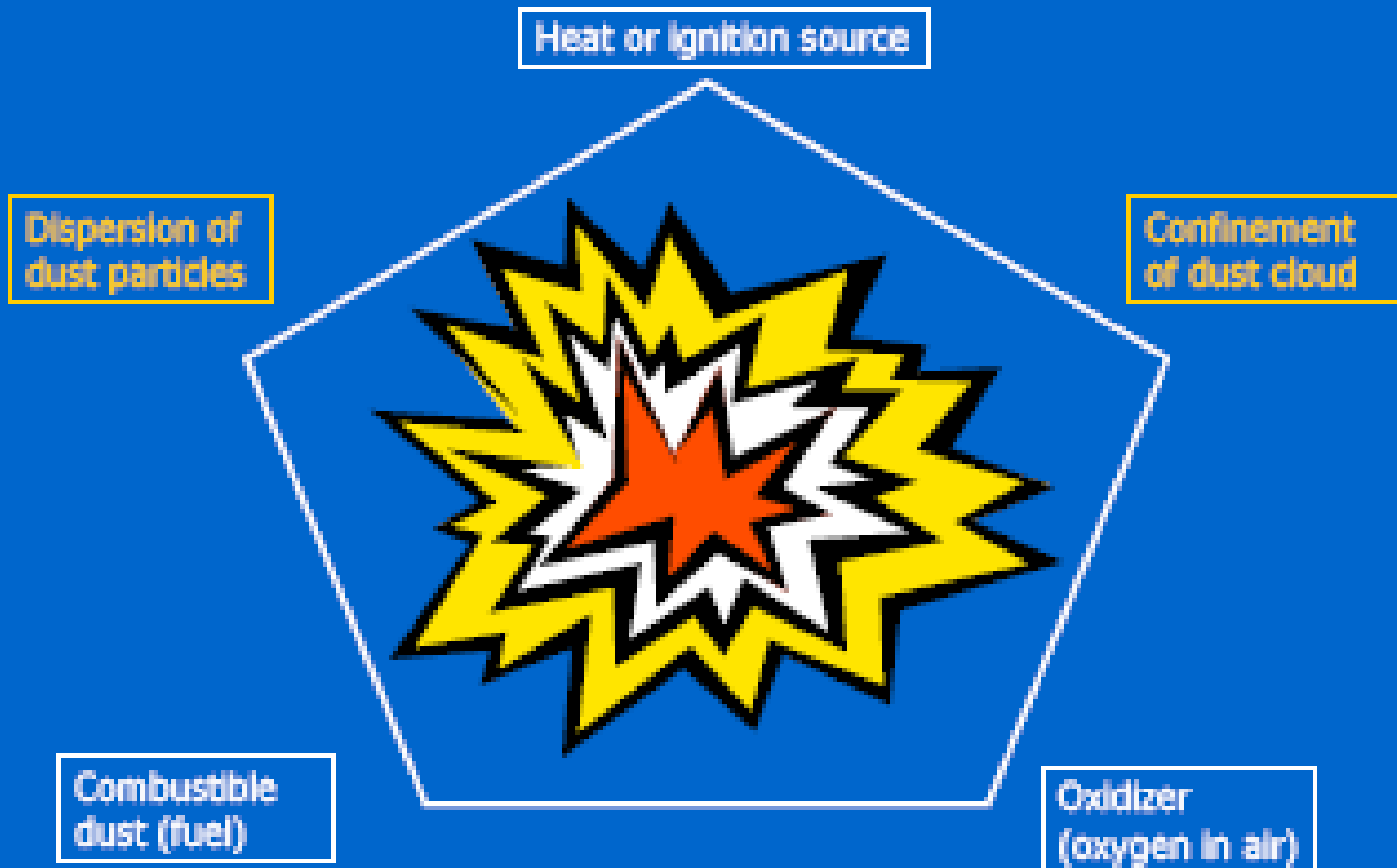
c. Dust explosion

Fire Triangle – a Review



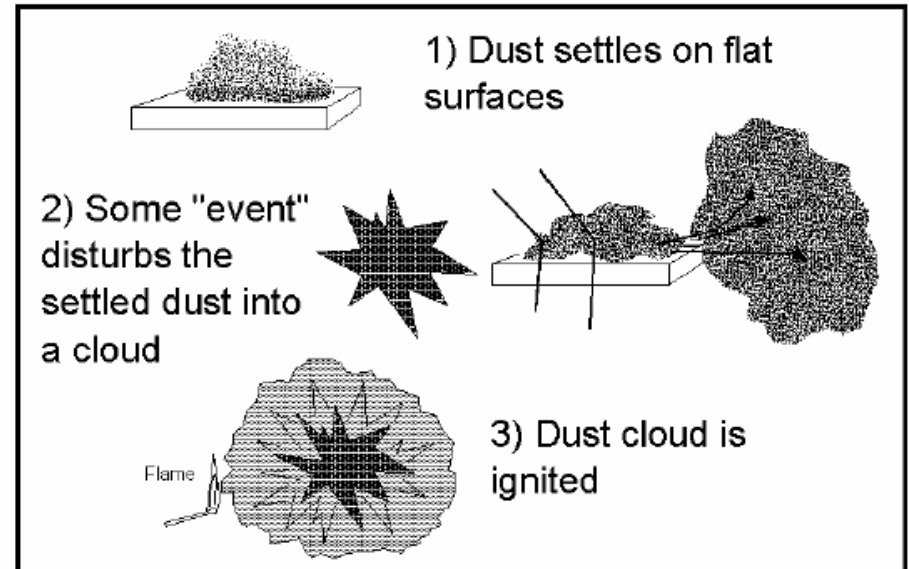
Combustible Dust

Dust Explosion Pentagon: adding two legs to the Fire Triangle



Combustible Dust

- Primary event initiates
 - Usually localized issue
 - May or may not have large impact on its own
- Secondary event
 - Catastrophic losses
 - Made possible through dust accumulations
 - Suspended ceilings
 - Floors, tables, ceiling beams, etc.



Combustible Dust

❑ Common terms used

- **Flammable, Explosive, Combustible** – for dusts, all the same
- **MIE – Minimum Ignition Energy** - Predicts the ease and likelihood of ignition of a dispersed dust cloud (mJ)
- **Kst** – Measures the relative explosion severity compared to other dusts (bar m/sec)
- **Pmax** – Maximum pressure of a dust explosion (bar)
- **MEC – Minimum Explosive Concentration** - Measures the minimum amount of dust, dispersed in air, required to spread an explosion. Analogous to LFL. **NOT RECOMMENDED AS A BASIS OF SAFETY**
- **LOC – Limiting Oxygen Concentration** - Determines the least amount of oxygen required for explosion propagation through the dust cloud.
- **Resistivity** – Indicates amount of time established charge would take to dissipate

Combustible Dust

Data Review

Compound	Location	MIE, mJ	Kst, bar-m/s (0-200 weak; 200-300 strong; >300 very strong)
Polyethylene powder	West Pharma	15	140 (weak)
Phenolic resin	CTA Acoustics	3	165 (weak)
Sugar	Imperial Sugar	30	80 (really weak)
Grain dust	Everywhere	30	89 (really weak)
p-Formaldehyde	Local incident	20	178 (weak)
Active Pharmaceutical Ingredient (API) 1		<3	402 (very strong)
Active Pharmaceutical Ingredient (API) 2		<1 - 10	195-259 (strong)
Active Pharmaceutical Ingredient (API) 3		5-10	246 (strong)

Equipment Involved in Dust Explosions

EQUIPMENT	US (1985 – 1995)		UK (1979 – 1988)		Germany (1965 – 1980)	
	No.	%	No.	%	No.	%
Dust Collectors	156	42%	55	18%	73	17%
Grinders	35	9%	51	17%	56	13%
Silos/ Bunkers	27	7%	19	6%	86	13%
Conveyors	32	9%	33	11%	43	10%
Dryers/ Ovens	22	6%	43	14%	34	8%
Mixer/ Blender	>12	>3%	7	2%	20	5%
Other/Unknown	84	23%	95	31%	114	27%
Total	372	100%	303	100%	426	100%

Combustible Dust

☐ *Hazard Management Options*

- “Break a Leg” of the pentagon
 - Fuel (accumulations of 1/32” over surface area of at least 5% of the floor area (up to 1000 ft²), including overhead beams, joists, ducts, tops of equipment, ceilings, etc.).
Housekeeping is paramount
 - Oxygen exclusion (inerting)
 - Ignition source (bonding/grounding, elimination of non-conductives, insulators, electrical classification, limited free flow product, equipment maintenance, foreign metal elimination, **personnel grounding**)

- In addition to breaking a leg:
 - Deflagration containment
 - Relief and Isolation
 - Suppression systems

How do you ground personnel?

- Wristlets tethered to grounded equipment.



- Static dissipative shoes

- Note: >80% cotton socks only
- Floor must be adequately conductive and grounded (resistance $<1 \times 10^6$ ohms), kept clean, and on a testing schedule.



- Shoe grounders



How do you know you're grounded?

- Test stations

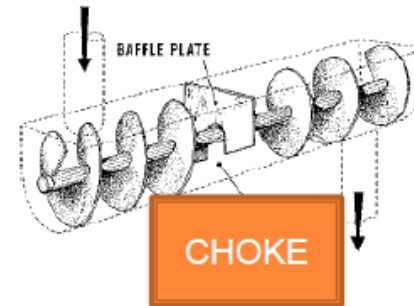
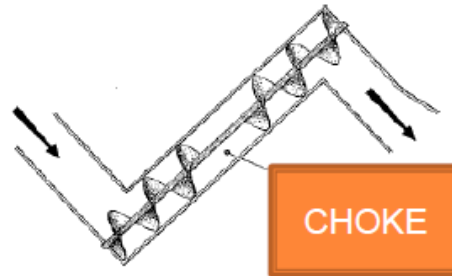


Other Prevention and Mitigation Methods

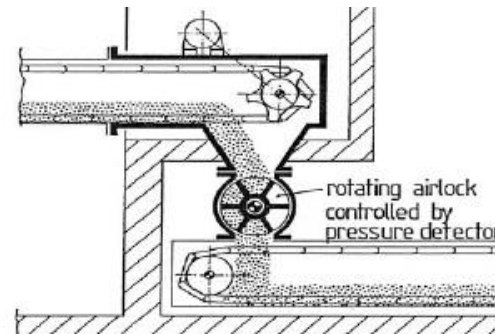
- **Electrical Equipment – Class II, Div 1 or 2**



- **Screw conveyors – prevent transmission of dust explosion**

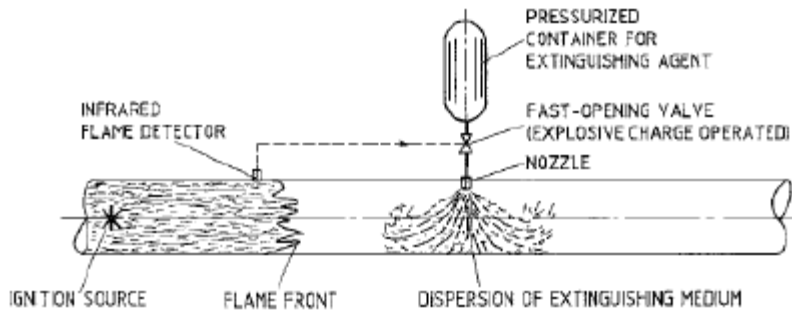


- **Rotary valves**



Prevention and Mitigation – Isolation/Suppression

Active devices in ducts

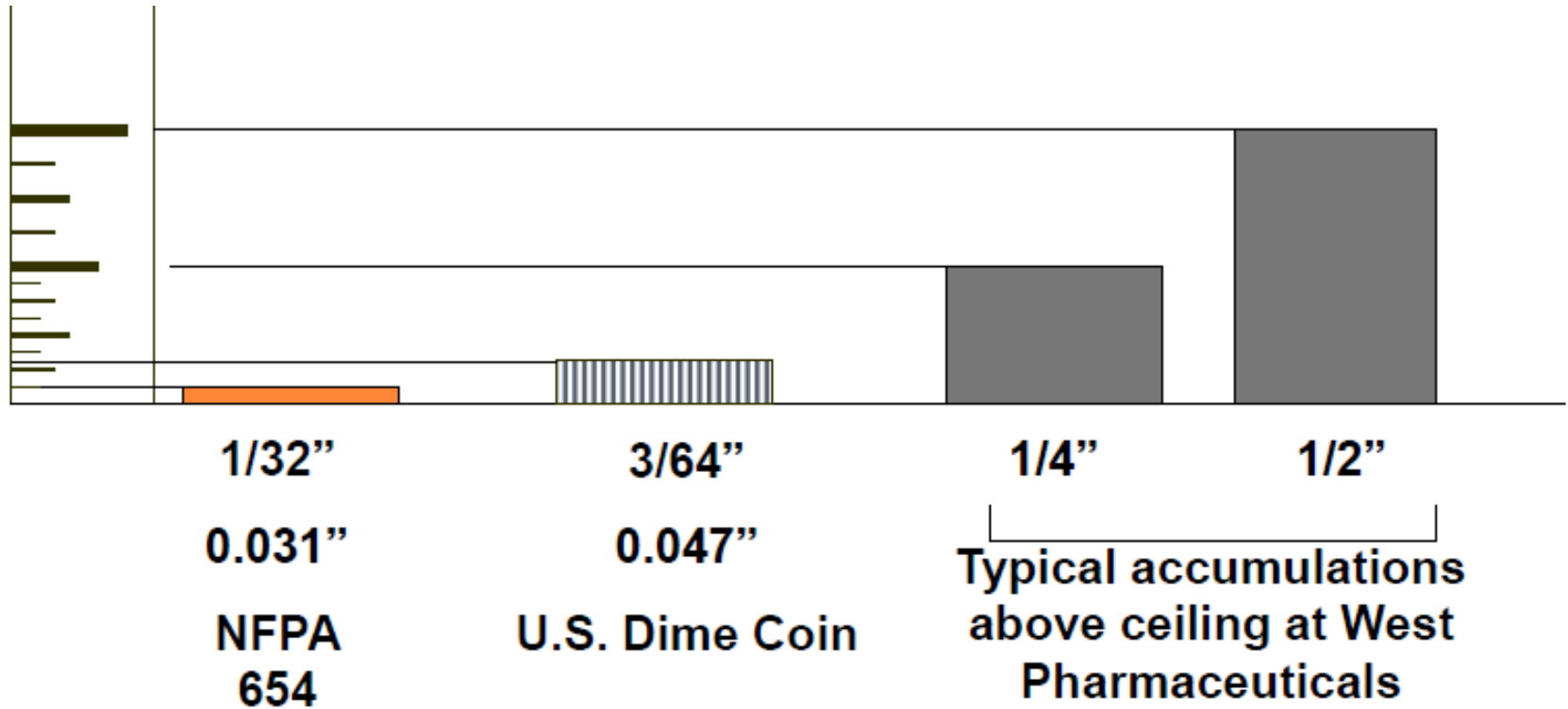


Extinguishing agent ahead of flame

Automatic valve closing ahead of flame



Prevention and Mitigation - Housekeeping



References

- NFPA 68 - Standard on Explosion Protection by Deflagration Venting, 2018
- NFPA 69 - Explosion Prevention Systems, 2014
- NFPA 77 - Static Electricity, 2014
- NFPA 652 - Standard on the Fundamentals of Combustible Dust, 2016
- NFPA 654 - Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids, 2017

Combustible Dust

☐ **CSB Imperial Sugar Combustible Dust Explosion Video** (4 mins) —

<https://www.youtube.com/watch?v=fl-jlNqpCQ8>

Three points to remember:

Housekeeping, Housekeeping, Housekeeping

On a lighter note (3 min):

<https://www.youtube.com/watch?v=yRw4ZRqmxOc>