Combustible Dust Hazards: Recognition, Assessment and Control

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Agenda

- Combustible Dust Fundamentals
- Industries and Materials
- Regulatory Framework
- Dust Hazard Analysis Process
- Controls
- Incidents/Case Studies
- Q&A

FUNDAMENTALS

Dusts that are explosible:

Any combustible material may become an explosion hazard when it is finely divided into dust

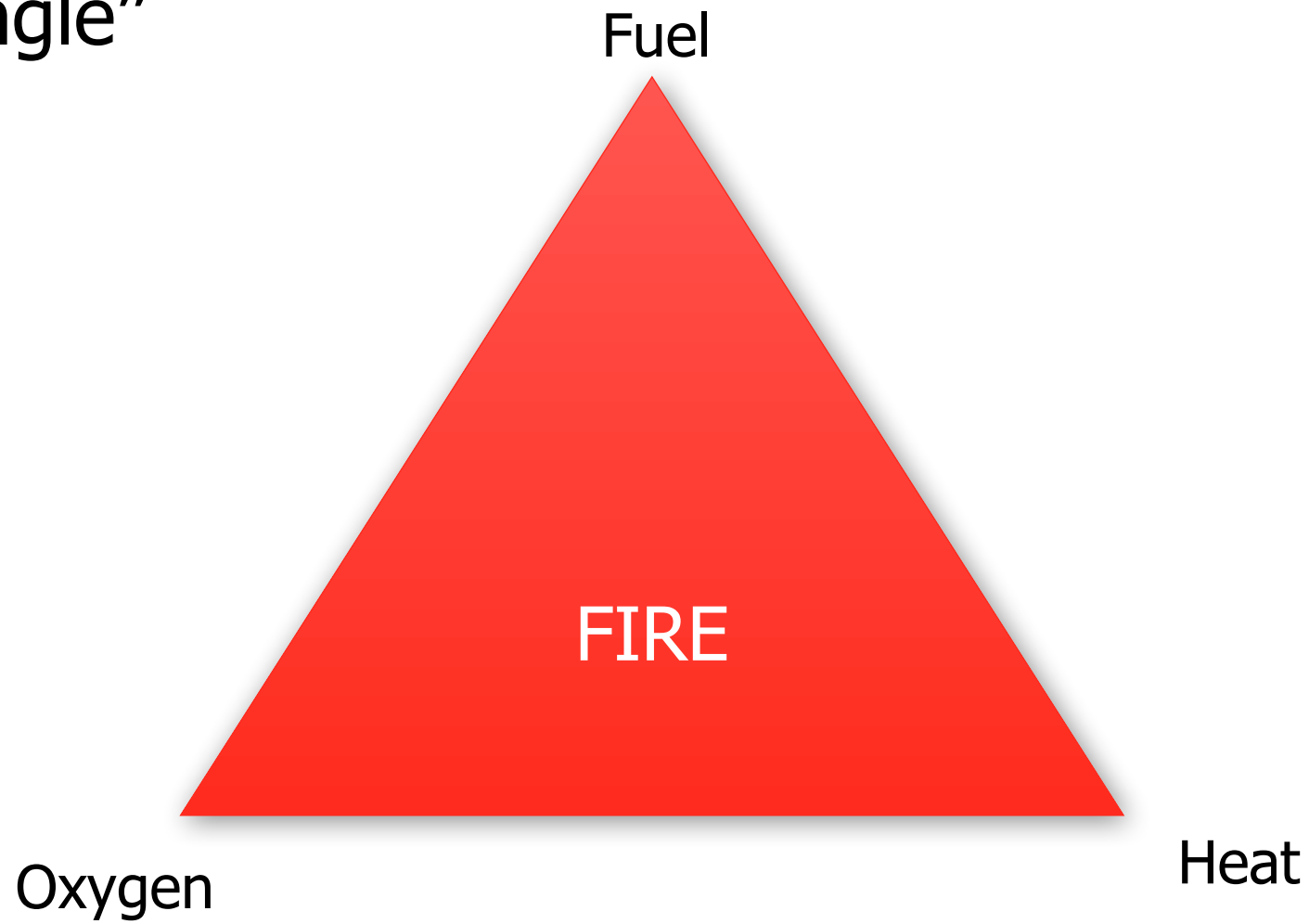
Dusts that are combustible/explosible:

- Wood
- Textile
- Flour, Corn Starch, Sugar
- Coal
- Plastic
- Pharmaceutical drugs
- Metals (Aluminum, Iron, Magnesium, Titanium)

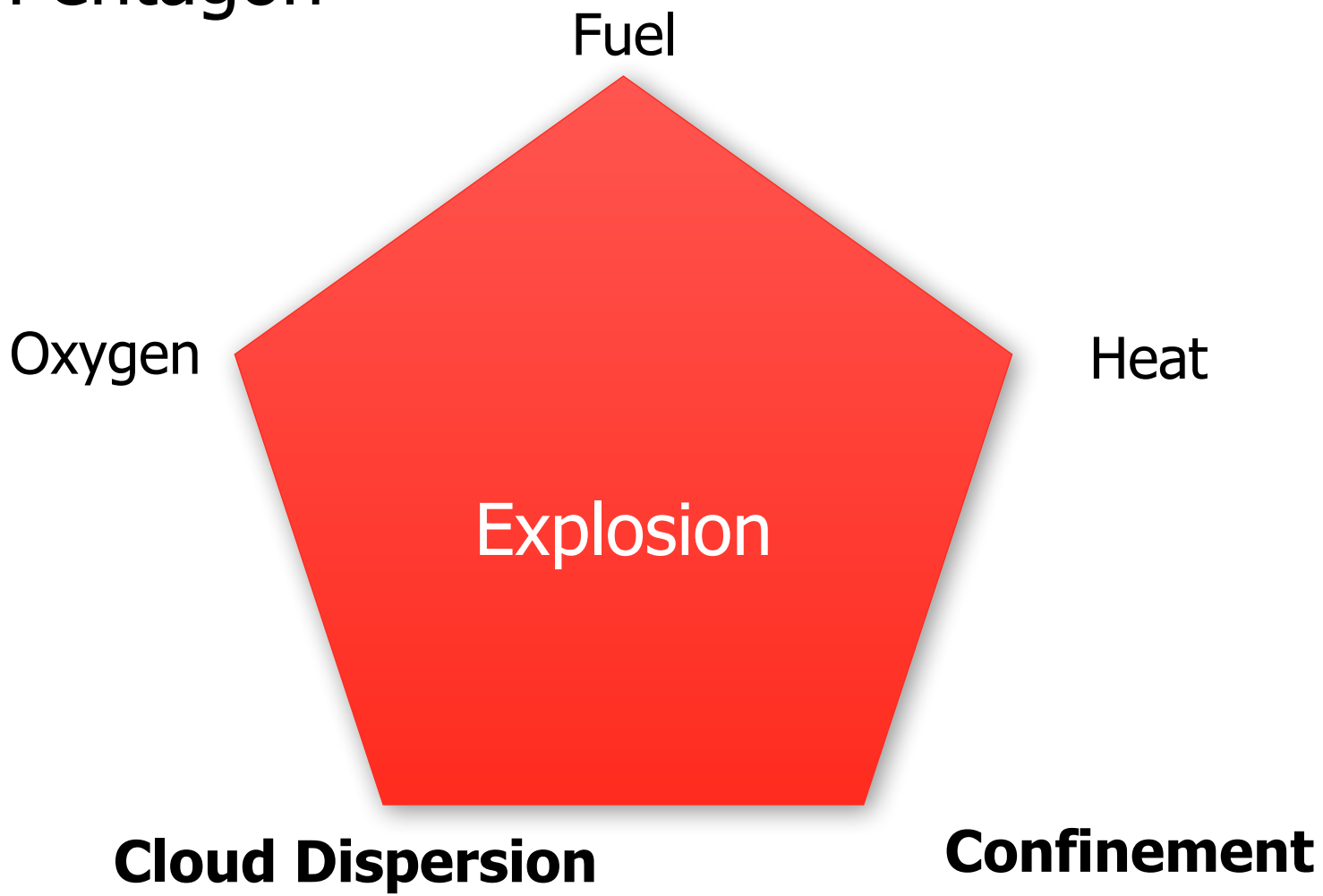
Industries That Generate Combustible/Explosible Dust

- Food and Agriculture
- Chemical Manufacturing
- Wood Working
- Metal Fabrication
- Pharmaceutical Production
- Plastics, Rubber and Composites Manufacturing
- 3D Printing
- Textiles
- Fossil Fuel Power Generation

“Fire Triangle”



"Explosion Pentagon"



Experimental setup

Finely-ground flour is dispersed

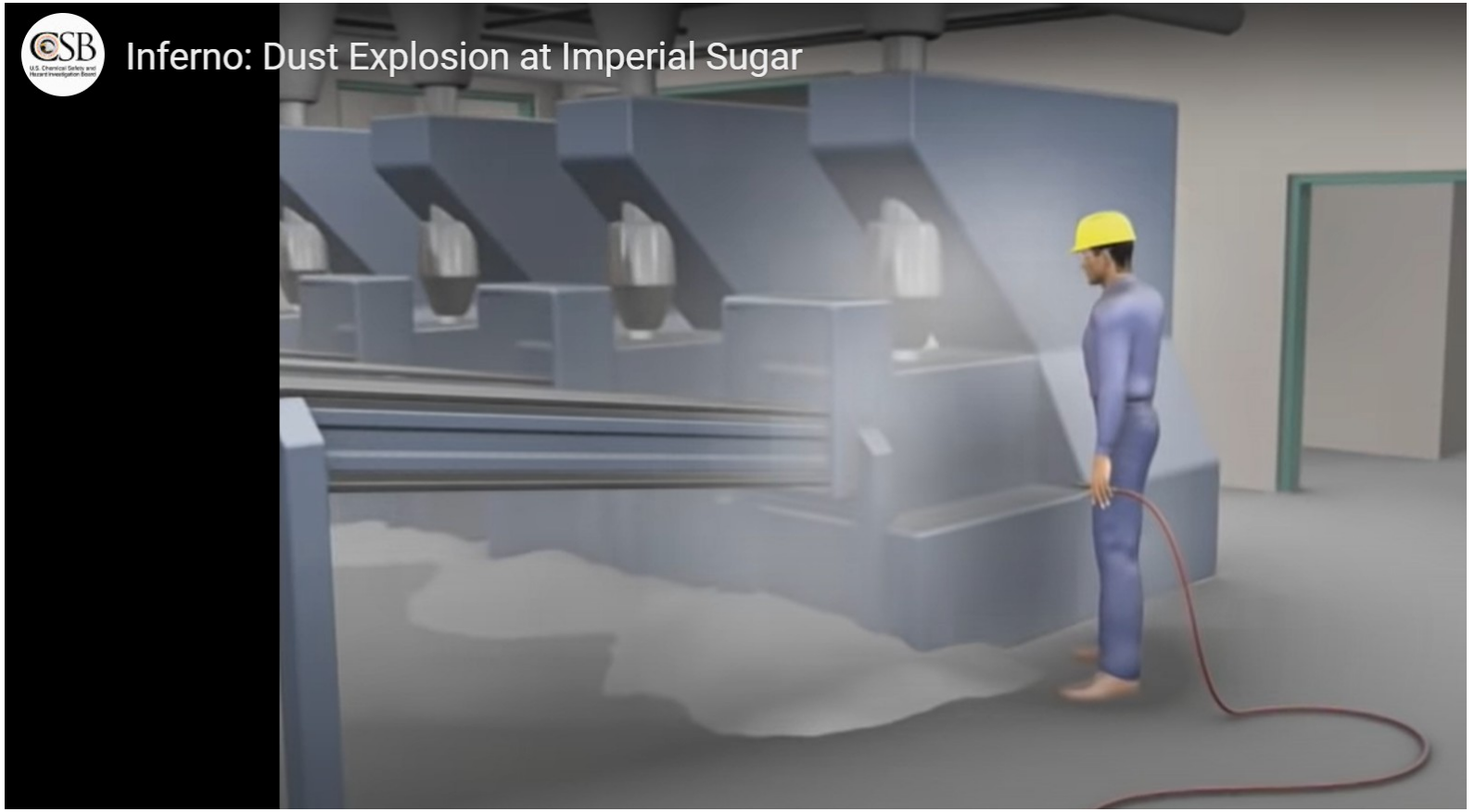
Cloud of flour is ignited

Fireball spreads rapidly

Intense radiant heat has nothing to ignite here

Fireball and superheated gases rise

Suspension of Dust to Create a Cloud - Compressed Air Usage



Impacts of Combustible Dust Accidents

"The force from such an explosion can cause employee deaths, injuries, and destruction of entire buildings."

"The U.S. Chemical Safety and Hazard Investigation Board (CSB) identified 281 combustible dust incidents between 1980 and 2005 that led to the deaths of 119 workers, injured 718, and extensively damaged numerous industrial facilities."

- Fed OSHA

Regulations

Combustible Dust Regulations and Standards

- **Cal/OSHA Title 8 CCR Section 5174**
- NFPA 652 Standard on Fundamentals of Combustible Dust
- NFPA 654 Standard for Prevention of Fire and Dust Explosions from Manufacturing, Processing and Handling of Combustible Particulate Solids
- NFPA 61 Standard for Prevention of Fire and Dust Explosions in Agricultural and Food Processing Facilities
- NFPA 484 Standard for Combustible Metals, Metal Powders, and Metal Dusts
- NFPA 664 Standard for Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities
- NFPA 68 Guide for Venting of Deflagrations
- NFPA 69 Standard on Explosion Prevention Systems
- NFPA 77 Recommended Practice on Static Electricity
- NFPA 499 Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas

Combustible Dust Regulations and Standards

Cal/OSHA Title 8 CCR Section 5174

- Any action which liberates combustible dust that exceeds a concentration of 25 percent of its lower explosive limit shall not be permitted unless all sources of ignition are eliminated
- No source of ignition shall be permitted until all dust-producing operations have been stopped, airborne dust allowed to settle, and accumulated dust removed
- All machines, conveyors, housings, and conductive surfaces shall be electrically bonded to ground
- Enclosed areas, except in closed or covered containers, shall be cleaned as often as necessary to prevent accumulation of dust on floors, ledges, beams, equipment, machines
- Machines and equipment located, constructed, enclosed or vented, so that the force of an explosion may be dissipated without endangering employees
- Smoking prohibited
- Dust collectors shall be located outdoors or in detached rooms of fire-resistant construction and provided with adequate explosion vents (except liquid-spray type collectors)

ASSESSMENT

Dust Hazard Analysis (DHA)

A systematic review to identify and evaluate the potential fire, flash fire, or explosion hazards associated with the presence of one or more combustible particulate solids in a process or facility - NFPA 652

- Required for existing and new facilities
- Deadlines: Sept 7, 2020 (Jan 1, 2022 for Food and Agriculture)
- Reviewed and updated every 5 years
- *The absence of previous incidents shall not be used as the basis for not performing a DHA*

Dust Hazard Analysis (DHA)

Considers materials and process systems

- Properties of the dust (Kst, Pmax, MEC, MIE, MIT)
- Typical and upset process conditions
- *Housekeeping*
- *Ignition sources*
- *Dust suspension mechanisms*
- *Oxidizing atmosphere*

Dust Accumulations

Even if floors and accessible surfaces are frequently cleaned to remove dust accumulations, hard to reach surfaces could have dust begin to pile up.

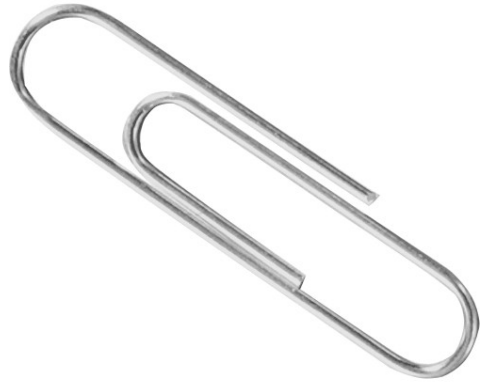
Surfaces to watch out for:

- Overhead pipes
- I-beams
- lighting
- storage racks
- interstitial spaces
- access tunnels
- pipe chases

Dust Layers

Dust deflagration hazard *= areas with* ***sufficient*** *combustible dust and potential for an ignition source, suspension mechanism, and oxidizing atmosphere*

So what is sufficient?



Layer depth criterion method evaluates surface coverage as % and dust layer depth.

- 1/32” (thickness of a paperclip) and 5% coverage of footprint area
- Depth adjusted for material density (range from 1/100” to >1/2”)
- 1/8” dust layer can present serious potential for secondary explosion

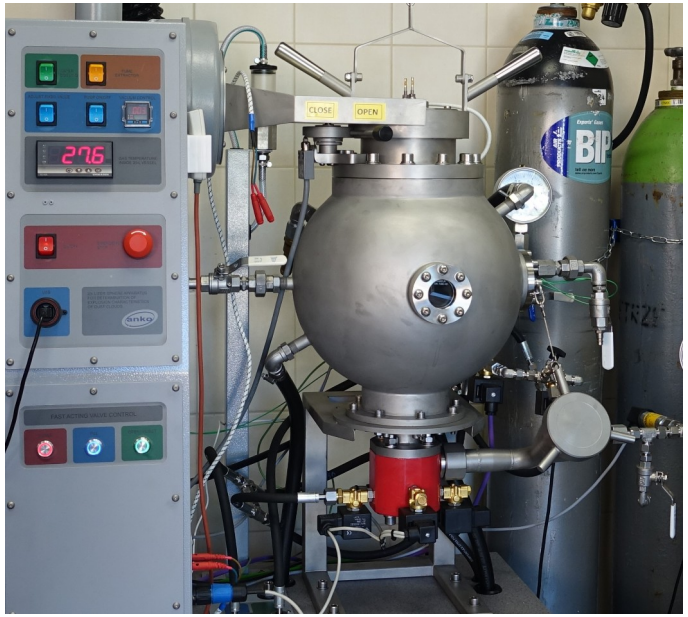

icon
FOODS

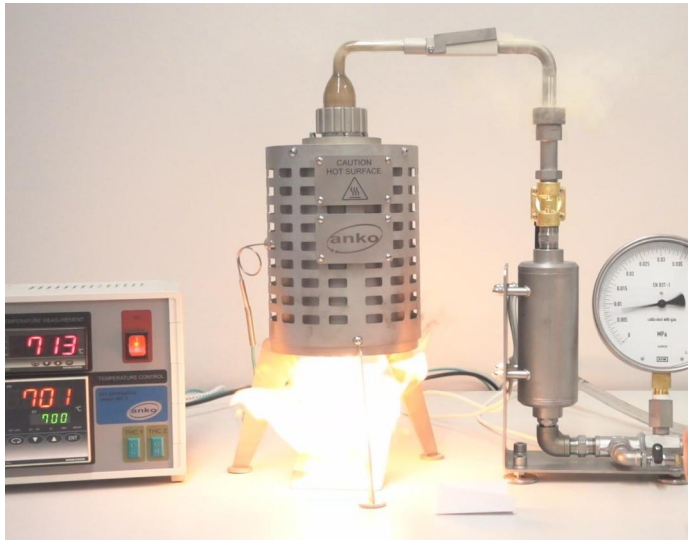
Ignition Sources

- Static electricity
- Overheated equipment bearings
- Electrical arcing / overheating
- Hot work
- Smoking

Dust Testing

- Go / No-Go
- Severity (Kst, Pmax)
- Minimum Ignition Energy (MIE)
- Minimum Explosible Concentration (MEC)
- Minimum Ignition Temperature (MIT)
  - Cloud
  - Layer





Dust Testing

- Collect samples without creating a dust cloud
  - Dust collectors
  - Elevated surfaces with dust accumulations

KST 0	0	No explosion
KST 1	> 0 and ≤ 200	Weak explosion
KST 2	> 200 and ≤ 300	Strong explosion
KST 3	> 300+	Very strong explosion

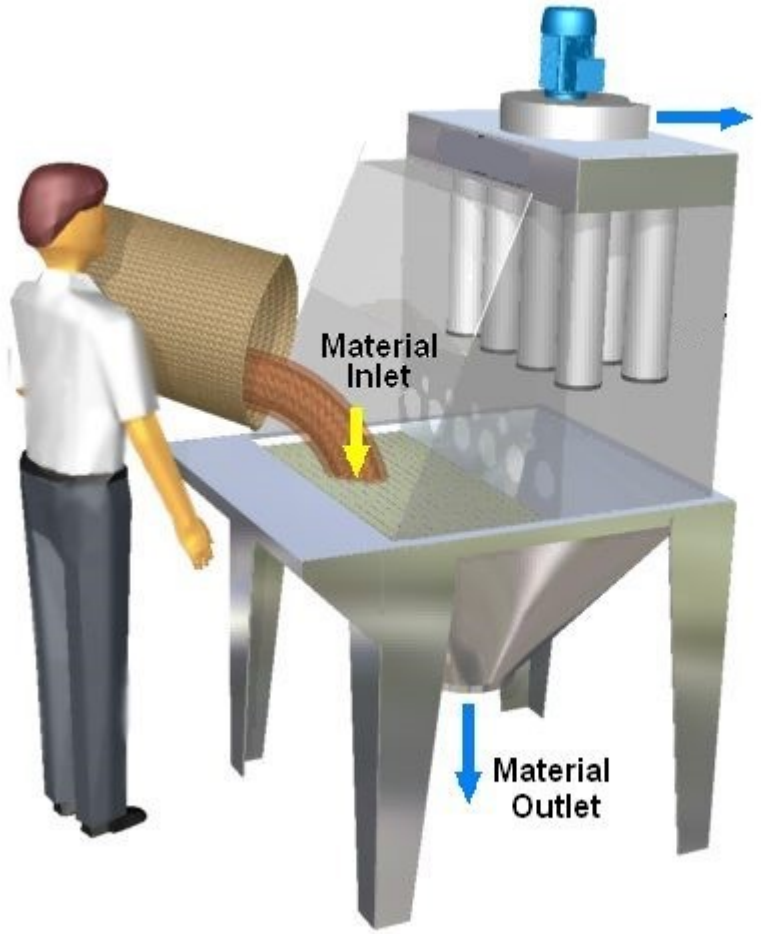
KST Categories & Explosiveness

Controls

Controls Overview

- Fuel – dust collection, housekeeping
- Ignition Sources – rated electrical equipment, bonding and grounding, preventative maintenance
- Explosion Protection – explosion venting, isolation, suppression

Dust Collection and Housekeeping

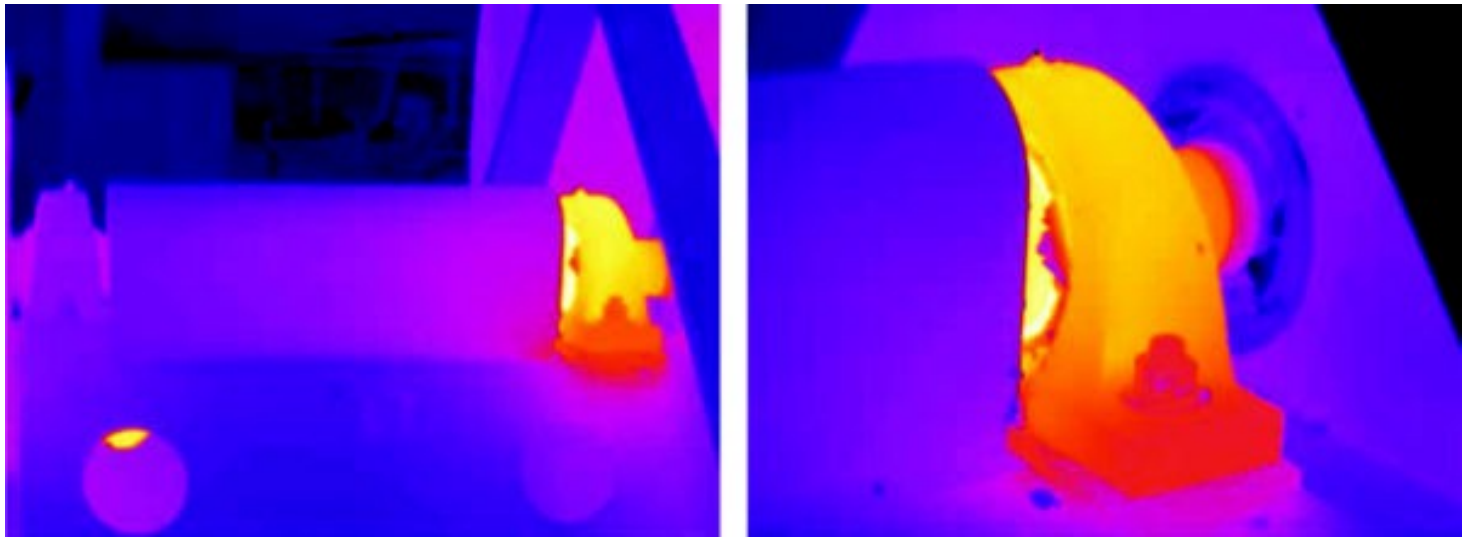


Ignition Sources - Rated Electrical Equipment

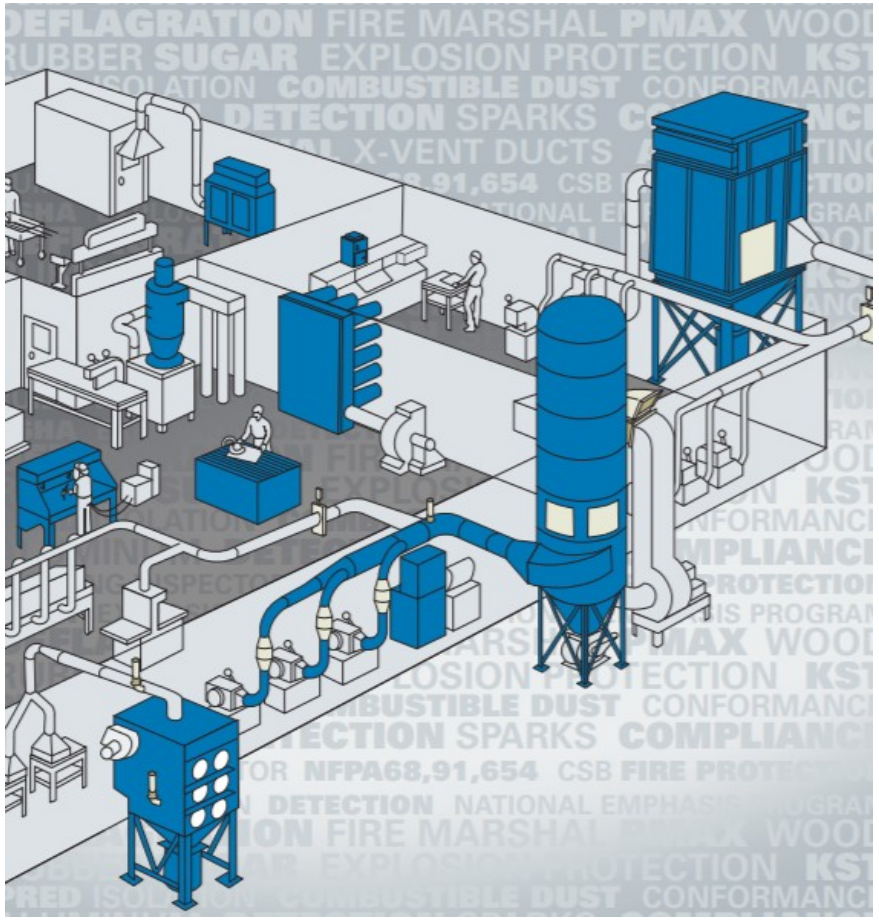
Motors, Lighting, Receptacles, Junction boxes, Switches - NEMA 4X or NEMA 7

Ignition Sources - Bonding and Grounding

Ignition Sources – Preventative Maintenance

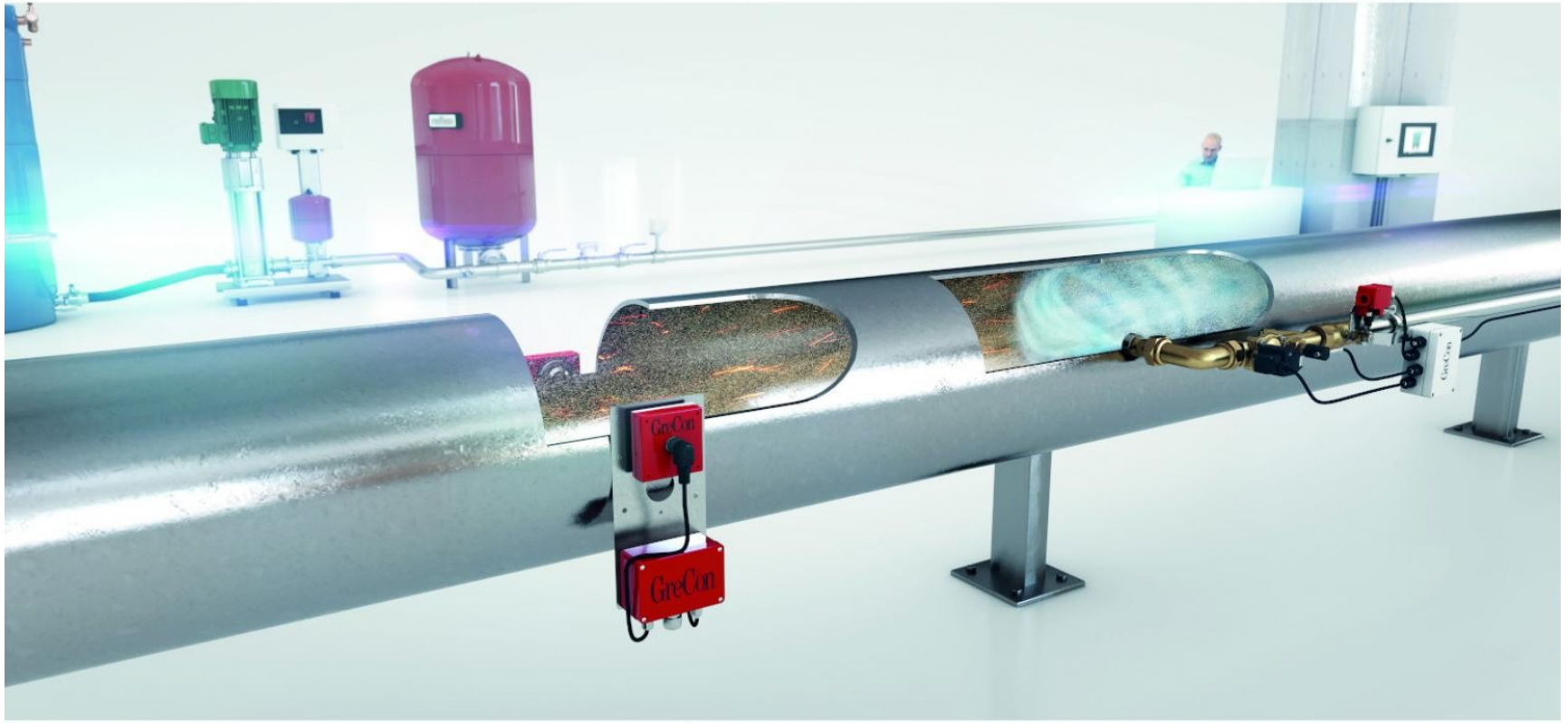


Dust Collectors - number one culprit



Explosion Protection of Dust Collectors - Suppression

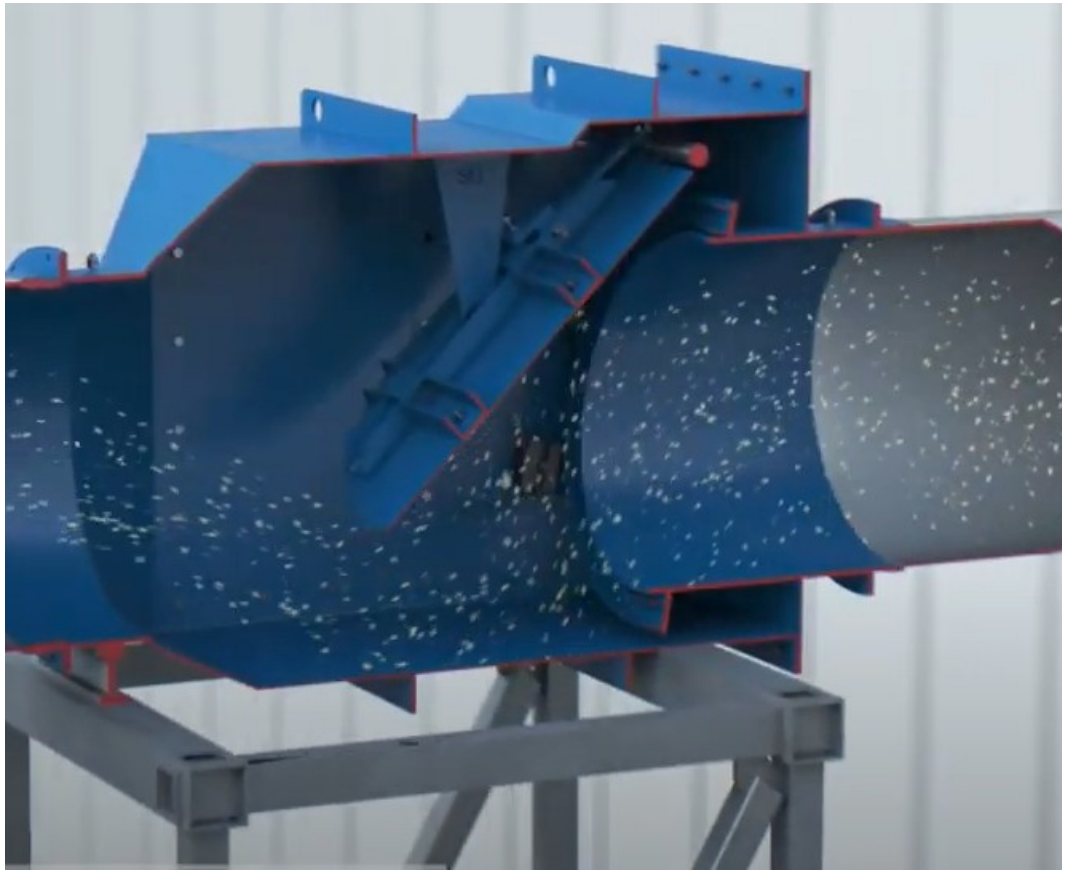
Explosion Protection of Dust Collectors – Spark Detection

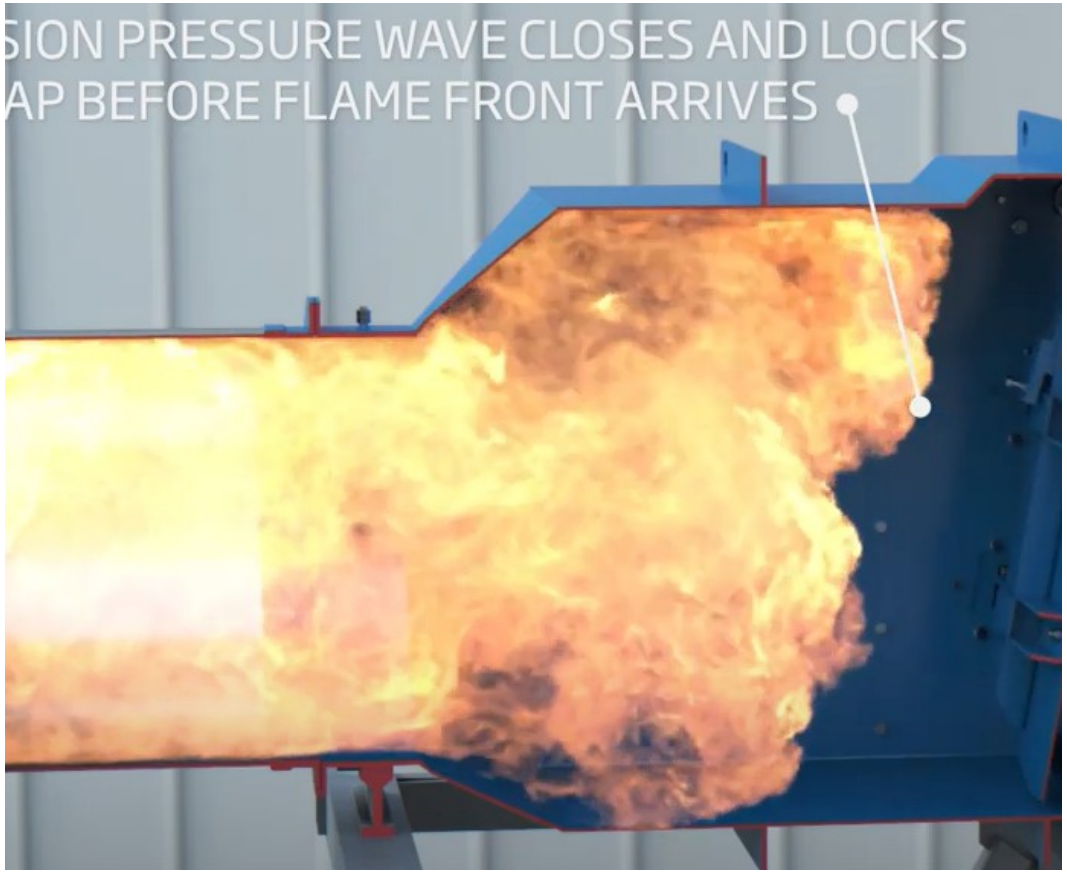


Explosion Protection of Dust Collectors - Isolation

Explosion Protection of Dust Collectors - Isolation

Valve Open ← Valve Closed →





Explosion Protection of Dust Collectors - Venting

Explosion Protection of Dust Collectors - Venting

Area Classifications

- Class II – Dust or particles
  - Division I – Hazard during normal operating conditions
  - Division II – No hazard during normal conditions (DHA must also consider abnormal conditions)

(2) *Class II, Division 2*. A Class II, Division 2 location is a location where:
(i) Combustible dust will not normally be in suspension in the air in quantities sufficient to produce explosive or ignitable mixtures, and dust accumulations will normally be insufficient to interfere with the normal operation of electric equipment or other apparatus, but combustible dust may be in suspension in the air as a result of infrequent malfunctioning of handling or processing equipment; and

Class II, Division I = explosible levels of dust present during normal conditions – NEMA 7 or 9

Class II, Division II = normal conditions do not present explosible levels of dust – NEMA 4X

49 CFR § 1910.399

Case Studies

Imperial Sugar - 2008

Taiwan Festival - 2015

Explosion when colored powder was released at an outdoor music and color festival at the Formosa Fun Coast

School Woodshop Fire

- Dust collection system without explosion protection system
- Underpowered, wood dust accumulated inside ductwork
- Spark was drawn into the duct collector where a fire started

Questions?

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