Combustible Dust
Presentation for IHs

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Combustible Dust Presentation for IHs

Presentation Outline

- **Introduction**
  - Conditions for Dust Explosions

- **Management of Flash Fire and Explosion Hazards**
  - Explosion characteristics of dusts
  - Control of flammable atmospheres
  - Elimination/control of potential ignition sources
  - Application of explosion safeguards
    - Explosion protection (containment, relief venting, suppression, isolation)

- **Discussion**
Fire Triangle

- **FUEL** - Liquid (vapor or mist), gas, or solid capable of being oxidized. Combustion always occurs in the vapor phase; liquids are volatized and solids are decomposed into vapor prior to combustion.

- **OXIDANT** - A substance which supports combustion – Usually oxygen in air.

- **IGNITION SOURCE** - An energy source capable of initiating a combustion reaction.
Conditions for a Dust Explosion

- Dust must be explosible (flammable, combustible)
- Dust must be airborne
- Concentration must be within explosible range
- Particle size distribution capable of propagating flame
- The atmosphere must support combustion
- An ignition source must be present
### Examples of Combustible Materials

<table>
<thead>
<tr>
<th>Agricultural Products</th>
<th>Cottonseed</th>
<th>Soybean dust</th>
<th>Chemical Dusts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg white</td>
<td>Garlic powder</td>
<td>Spice dust</td>
<td>Adipic acid</td>
</tr>
<tr>
<td>Milk, powdered</td>
<td>Gluten</td>
<td>Spice powder</td>
<td>Anthraquinone</td>
</tr>
<tr>
<td>Milk, nonfat, dry</td>
<td>Grass dust</td>
<td>Sugar (10x)</td>
<td>Ascorbic acid</td>
</tr>
<tr>
<td>Soy flour</td>
<td>Green coffee</td>
<td>Sunflower</td>
<td>Calcium acetate</td>
</tr>
<tr>
<td>Starch, corn</td>
<td>Hops (malted)</td>
<td>Sunflower seed dust</td>
<td>Calcium stearate</td>
</tr>
<tr>
<td>Starch, rice</td>
<td>Lemon peel dust</td>
<td>Tea</td>
<td>Carboxy-methylcellulose</td>
</tr>
<tr>
<td>Starch, wheat</td>
<td>Lemon pulp</td>
<td>Tobacco blend</td>
<td>Dextrin</td>
</tr>
<tr>
<td>Sugar</td>
<td>Linseed</td>
<td>Tomato</td>
<td>Lactose</td>
</tr>
<tr>
<td>Sugar, milk</td>
<td>Locust bean gum</td>
<td>Walnut dust</td>
<td>Lead stearate</td>
</tr>
<tr>
<td>Sugar, beet</td>
<td>Malt</td>
<td>Wheat flour</td>
<td>Methyl-cellulose</td>
</tr>
<tr>
<td>Tapioca</td>
<td>Oat flour</td>
<td>Wheat grain dust</td>
<td>Parafomaldehyde</td>
</tr>
<tr>
<td>Whey</td>
<td>Oat grain dust</td>
<td>Wheat starch</td>
<td>Sodium ascorbate</td>
</tr>
<tr>
<td>Wood flour</td>
<td>Olive pellets</td>
<td>Xanthan gum</td>
<td>Sodium stearate</td>
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<tr>
<td></td>
<td>Onion powder</td>
<td>Sulfur</td>
<td>Sulfur</td>
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<tr>
<td></td>
<td>Parsley (dehydrated)</td>
<td>Carbonaceous Dusts</td>
<td>Epoxy resin</td>
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<tr>
<td></td>
<td>Peach</td>
<td>Charcoal, activated</td>
<td>Melamine resin</td>
</tr>
<tr>
<td></td>
<td>Peanut meal and skins</td>
<td>Charcoal, wood</td>
<td>Melamine, molded</td>
</tr>
<tr>
<td></td>
<td>Peat</td>
<td>Coal, bituminous</td>
<td>(phenol-cellulose)</td>
</tr>
<tr>
<td></td>
<td>Potato</td>
<td>Coke, petroleum</td>
<td>Melamine, molded</td>
</tr>
<tr>
<td></td>
<td>Potato flour</td>
<td>Lampblack</td>
<td>(wood flour and</td>
</tr>
<tr>
<td></td>
<td>Potato starch</td>
<td>Lignite</td>
<td>mineral filled phenol-</td>
</tr>
<tr>
<td></td>
<td>Raw yucca seed dust</td>
<td>Peat, 22%H₂O</td>
<td>formaldehyde)</td>
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<tr>
<td></td>
<td>Rice dust</td>
<td>Soot, pine</td>
<td>(poly) Methyl acrylate</td>
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<tr>
<td></td>
<td>Rice flour</td>
<td>Cellulose</td>
<td>(poly) Methyl acrylate,</td>
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<tr>
<td></td>
<td>Rice starch</td>
<td>Cellulose pulp</td>
<td>emulsion polymer</td>
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<td></td>
<td>Rye flour</td>
<td>Cork</td>
<td>Phenolic resin</td>
</tr>
<tr>
<td></td>
<td>Rye starch</td>
<td>Corn</td>
<td>(poly) Propylene</td>
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<tr>
<td></td>
<td>Semolina</td>
<td></td>
<td>Terpene-phenol resin</td>
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<tr>
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<td>Urea-formaldehyde/</td>
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<td></td>
<td></td>
<td></td>
<td>cellulose, molded</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>(poly) Vinyl acetate/</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>ethylene copolymer</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>(poly) Vinyl alcohol</td>
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<td>(poly) Vinyl butyral</td>
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<tr>
<td></td>
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<td></td>
<td>(poly) Vinyl chloride/</td>
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<td>ethylene/vinyl</td>
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<td></td>
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<td>acetylene suspension</td>
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<td></td>
<td>copolymer</td>
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<td></td>
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<td>(poly) Vinyl chloride/</td>
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<td>vinyl acetylene</td>
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<td>emulsion</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>copolymer</td>
</tr>
</tbody>
</table>

### Agricultural Dusts
- Alfalfa
- Apple
- Beet root
- Carrageen
- Carrot
- Cocoa bean dust
- Cocoa powder
- Coconut shell dust
- Coffee dust
- Corn meal
- Cornstarch
- Cotton

### Chemical Dusts
- Adipic acid
- Anthraquinone
- Ascorbic acid
- Calcium acetate
- Calcium stearate
- Carboxy-methylcellulose
- Dextrin
- Lactose
- Lead stearate
- Methyl-cellulose
- Paraformaldehyde
- Sodium ascorbate
- Sodium stearate
- Sulfur

### Metal Dusts
- Aluminum
- Bronze
- Iron carbonyl
- Magnesium
- Zinc

### Plastic Dusts
- (poly) Acrylamide
- (poly) Acrylonitrile
- (poly) Ethylene
  - (low-pressure process)
Range of explosible dust concentrations in air at normal temperature and atmospheric pressure for a typical natural organic dust (maize starch), compared with typical range of maximum permissible dust concentrations in the context of industrial hygiene, and a typical density of deposits of natural organic dusts (Eckhoff).
Formation of Explosible Dust Cloud

Illustration of the potential hazard of even thin dust layers. A 1mm layer of a dust of bulk density 500Kg/m$^3$ will generate a cloud of average concentration 100g/m$^3$ if dispersed in a room of 5m height. Partial dispersion up to only 1m gives 500g/m$^3$ (Eckhoff)

\[ C = P_{\text{bulk}} \times \frac{h}{H} \]

- $C$ is dust cloud concentration
- $P_{\text{bulk}}$ is powder bulk density
- $H$ is dust layer thickness
- $H$ is dust cloud height in the room
Secondary Explosion

Illustration of how the blast wave from a primary explosion entrains and disperses a dust layer, which is subsequently ignited by the primary dust flame (Eckhoff)

a. PRIMARY EXPLOSION
   - DUST LAYER

b. BLAST WAVE
   - DUST CLOUD FORMED

c. EXTENSIVE SECONDARY EXPLOSION RESULTS
Are These Materials Explosive?

- Sugar
- Metal
- Coal
- Plastics
- Medicines
- Wood
Potential Ignition Sources

- Lightning strikes
- * Open flames
- * Welding [torch or arc]
- * Cutting [torch or arc]
- * Electric arcs and sparks
- Electrostatic discharges
- Frictional heating
- Smoking [rule violation]
- Self-heating / decomposition / spontaneous combustion
- * Grinding
- Hot surfaces
- Exothermic runaway chemical reactions
- Mechanical impacts

* Electrical Classification or Hot-Work Permit required
2003 - West Pharmaceutical, North Carolina
6 Killed, 37 Injured
2008 - Imperial Sugar, Georgia
14 Killed, > 40 injured
2008 - Imperial Sugar, Georgia
14 Killed, > 40 injured
## Notes from CSB Report - US Dust Incidents 1980 to 2005

<table>
<thead>
<tr>
<th>Industry</th>
<th>Percent of Incidents Reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Products</td>
<td>24</td>
</tr>
<tr>
<td>Lumber &amp; Wood Products</td>
<td>15</td>
</tr>
<tr>
<td>Chemical Manufacturing</td>
<td>12</td>
</tr>
<tr>
<td>Primary Metal Industries</td>
<td>8</td>
</tr>
<tr>
<td>Rubber &amp; Plastic Products</td>
<td>8</td>
</tr>
<tr>
<td>Electric Services</td>
<td>8</td>
</tr>
<tr>
<td>Fabricated Metal Products</td>
<td>7</td>
</tr>
<tr>
<td>Equipment Manufacturing</td>
<td>7</td>
</tr>
<tr>
<td>Furniture &amp; Fixtures</td>
<td>4</td>
</tr>
<tr>
<td>Other</td>
<td>7</td>
</tr>
</tbody>
</table>
Overall awareness and understanding of dust explosion hazards is lacking; training is needed,

Secondary explosions are most often responsible for damage and injuries,

Existing Codes and Standards are good but not understood nor applied consistently,

MSDS do not provide enough information to adequately assess dust explosion hazards.

Ref: The United States Chemical Safety Board (CSB) Investigation Report: Combustible Dust Hazard Study Nov 9, 2006
Management of Flash Fire and Explosion Hazards

- Understanding of the flammability and explosion characteristics of the fuel(s)
- Site Audit:
  - Understanding of process operations and review of all available information (drawings, specifications, process/operation descriptions)
  - Identification of locations where flammable atmospheres (gas, vapor, dust) are or could be present during normal and abnormal operating conditions
  - Identification of potential ignition sources that could be present under normal and abnormal conditions
  - On-site electrostatic measurements (electrical field, electrical continuity measurements, etc.), where applicable
- Proper process and facility design to prevent and/or minimize the occurrence of flash fires and explosions and protect people and facilities against their consequences
- Regular inspection and maintenance of equipment to minimize ignition sources and fuel releases
Assessing Explosion Characteristics of Dusts

- **How easily will it ignite?**
  - Explosibility Screening (Go/No Go) - ASTM E1226
  - Minimum Ignition Energy (Dust Clouds) - ASTM E2019
  - Minimum Ignition Temperature (Dust Clouds) - ASTM E1491
  - Minimum Ignition Temperature (Dust Layers) - ASTM E2021
  - Thermal Instability

- **What will happen if it does ignite?**
  - Maximum Explosion Pressure - ASTM E1226
  - Maximum Rate of Pressure Rise - ASTM E1226

- **Ensuring Safety by Avoiding/Controlling Flammable Atmospheres?**
  - Minimum Explosible Concentration (Dust Clouds) - ASTM E1515
  - Limiting Oxygen Concentration - ASTM E2931

- **Electrostatic Properties**
  - Conductivity / Resistivity - ASTM D257
  - Electrostatic Chargeability - ASTM D257
Flammability Characteristics

- Specific testing
- Prior material testing
- Manufacturer MSDS
- Generic MSDS
- Literature sources
  - NFPA
  - Industry Associations
  - Internet sites
  - Other

Increasing Level of Confidence in Data
Factors Affecting Flammability Data

- Temperature
- Pressure
- Oxidant
- Turbulence
- Particle Size
- Moisture Content
- Hybrid Mixtures
STEP ONE:

COMPLIANCE WITH CODES AND STANDARDS,
A Minimum Standard of Good Practice
Codes and Standards - Combustible Solids

- NFPA 1, Uniform Fire Code
- NFPA 61, Standard for the prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities
- NFPA 68, Guide for Venting of Deflagrations
- NFPA 69, Standard on Explosion Prevention Systems
- NFPA 70, National Electrical Code
- NFPA 77, Recommended Practice on Static Electricity
- NFPA 484, Standard for Combustible Metals
- NFPA 499, Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas
- NFPA 654, Standard for the prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids
- NFPA 655, Standard for Prevention of Sulfur Fires and Explosions
- NFPA 664, Standard for the prevention of Fires and Explosions in Wood Processing and Woodworking Facilities
Basis of Safety

- Avoidance of flammable atmospheres
- Elimination of ignition sources
- Provision against consequences of ignition
Management of Flash Fire and Explosion Hazards

- **Control of flammable atmospheres:**
  - Proper plant design (containment / source reduction)
  - Maintaining fuel below its minimum explosible concentration (dust cloud) or lower flammable limit (vapors & gases)
  - Management of liquid spills and dust deposits (housekeeping)
  - Exhaust ventilation
  - Inert Gas Blanketing

- **Elimination/control of potential ignition sources including:**
  - Electrostatic discharges
  - Electrical Arcs / Sparks
  - Mechanical friction and sparks
  - Thermal decomposition

- **Application of Explosion Safeguards:**
  - Explosion protection (containment, relief venting, explosion suppression)
Control of Combustible Dust Atmospheres
Control of Combustible Dust Atmospheres

- Some companies do have them!
Control of Combustible Dust Atmospheres

- Equipment should be maintained and operated in a manner that minimizes the escape of dust.
- Continuous local exhaust ventilation should be provided for processes where combustible dust is liberated in normal operation so as to minimize the escape of dust.
  - The dust should be conveyed to dust collectors.
- Regular cleaning frequencies should be established for floors and horizontal surfaces, such as ducts, pipes, hoods, ledges, and beams, to minimize dust accumulations within operating areas of the facility.
Air Hose Shall NOT be Used for Cleaning

- Do not blow down dust deposits:
  - Generates dust clouds
  - Causes the finest, most hazardous particles to be deposited on ledges, joists and other high places
Main methods of ventilation for controlling flammable atmospheres:

- **Dilution Ventilation**
  - Provides a flow of fresh air into and out of the building
  - Background concentration of the flammable atmosphere in the working area is reduced, but there is no control at the source of release
  - This method is seldom used to control the concentration of dust cloud atmospheres

- **Local Exhaust Ventilation**
  - Intercepts the flammable atmosphere at the source of release and directs it into a system of ducting connected to an extract fan
  - Less expensive to run than dilution ventilation because less air is used
Local Exhaust Ventilation

- A good exhaust-ventilation system:
  - The air velocity is everywhere and always sufficient to prevent accumulation of combustible dust and to re-suspend any dust that might settle at exhaust-system shutdown
    - An air velocity of 3,500 to 4,000 feet per minute [40 to 45 MPH] usually is sufficient
  - The air flow is everywhere and always sufficient to maintain the combustible-dust concentration to less than 25% of the MEC
  - Dust-pickup rate [g./min.]/Air rate [cu.m./min.] < 0.25 MEC
  - An excellent preventive-maintenance/mechanical-integrity program and excellent Management of Change practices are essential
Management of Flash Fire and Explosion Hazards

- Control of flammable atmospheres:
  - Proper plant design (containment / source reduction)
  - Maintaining fuel below its minimum explosible concentration (dust cloud) or lower flammable limit (vapors & gases)
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- Elimination/control of potential ignition sources including:
  - Electrostatic discharges
  - Electrical Arcs / Sparks
  - Mechanical friction and sparks
  - Thermal decomposition

- Application of Explosion Safeguards:
  - Explosion protection (containment, relief venting, explosion suppression)
Electrostatic Discharges

Codes and Standards Related to Static Electricity

USA
- **NFPA 77**, Recommended Practice on Static Electricity
  The purpose of NFPA 77 is to provide assistance in controlling the hazards associated with the generation, accumulation, and discharge of static electricity by providing:
  - A basic understanding of the nature of static electricity
  - Guidelines for identifying and assessing the hazards of static electricity
  - Techniques for controlling the hazards of static electricity
  - Guidelines for controlling static electricity in selected industrial applications

EU
- **CLC/TR 50404 (2003), Electrostatics – Code of practice for the avoidance of hazards due to static electricity**, CENELEC
Electrostatic charges are usually generated when any two materials make and then break contact, with one becoming negative and the other positive.

- The build up of the charge on electrically isolated conductors and/or on insulating materials, can give rise to electrostatic discharges.
- Depending on the incendivity (energy) of the discharge, a flammable atmosphere can be ignited.
Electrostatic Charge Generation

Examples

- **Powder handling**
  - Pouring
  - Sieving
  - Mixing
  - Milling
  - Pneumatic transfer

- **Liquid handling**
  - Liquid transfer through hoses and pipes
  - Agitation of two phase mixtures
  - Settling of two phase mixtures
  - Filtration
Controlling Electrostatic Hazards - Summary

- **Metal Plant**
  - Resistance to ground should be checked. If R > 10 ohm, direct ground connection is required
  - Ground connections should be checked regularly

- **Personnel**
  - During normal activity, the potential of the human body can reach 10kV to 15kV, and the energy of a possible spark can reach 20mJ to 30mJ
  - Personnel should be grounded so that their resistance-to-ground < $1 \times 10^8$ ohm

- **Bulk Powder**
  - Highly charged insulating powder entering a vessel can give rise to “Bulk”/”Cone” discharges on the surface of the powder during filling of vessels
  - Depending on powder “Volume Resistivity”, “Electrostatic Chargeability”, “particle size”, and “vessel dimensions” maximum discharge energy is about 25mJ
  - Installation of inert gas blanketing, explosion protection, or reduction of electrostatic charges may be required

- **Non-Conductive (Insulating) Materials (e.g. plastic hoses, bags, liners, drums)**
  - Grounding of non-conductive materials would not facilitate the relaxation of electrostatic charges to ground
  - Consider conductive or static dissipative materials
Controlling Electrostatic Ignition Sources

Metal Drums

- Metal containers must be grounded during filling and emptying operations.
- Grounding should be done with a clamp having hardened steel points that will penetrate paint, corrosion products, and accumulated material.
- Clamp should be applied prior to filling and emptying operations.
Controlling Electrostatic Ignition Sources

Fiberboard Drum - Metal Chime Must be Grounded
Controlling Electrostatic Ignition Sources

Internal metal spiral to ensure electrical continuity and shielding
Controlling Electrostatic Ignition Sources - Personnel

- Electrostatic charge can accumulate on personnel
  - Personnel can typically attain potentials of 10 to 15kV
  - Maximum discharge energy 20mJ to 30mJ
Standard insulating (polyethylene) liners should be used ONLY if they are essential, e.g. for reasons of chemical compatibility between the container and the product.

The ignition risk and the possibility of physiological shock from “propagating brush” discharges depends on:
- Thickness of liner
- Resistivity of liner
- Handling procedure
- Electrical properties of the product
- Nature of flammable mixture that may be present

Electrically grounded antistatic or conductive liners with Surface Resistivity less than $10^{11}$ ohm/square should be used.
Control of Friction and Impact Sparks

- Prevent overheating due to misalignment, loose objects, belt-slip/rubbing etc. by regular inspection and maintenance of plant.
- Prevent foreign material from entering the system when such foreign material presents an ignition hazard. Consider use of screens, electromagnets, pneumatic separators, etc.
- Floor sweepings should not be returned to any machine.
- Minimize the likelihood of impact sparks through:
  - Proper tool selection
  - Techniques to prevent dropping tools e.g. wrist straps
  - Operator training
- Hot work operations should be controlled by a hot work permit system in accordance with NFPA 51B, Standard for Fire Prevention During Welding, Cutting and Other Hot Work:
  - Formation of dust clouds should be prevented, and dust deposits should be removed
  - A gas/vapor detector may be used to ensure flammable vapors/gases are not present.
Thermal Instability (Self-Heating)

- Ignition of bulk powders can occur by a process of self-heating.
- Ignition occurs when the temperature of the powder is raised to a level at which the heat liberated by the exothermic reaction is sufficient to exceed the heat losses and to produce runaway increase in temperature.
- The minimum ambient temperature for self-ignition of a powder depends mainly on the nature of the powder and on its dimensions.

- If the material is subjected to heat as part of the normal process (e.g. during drying), the temperature should be maintained below the self-heating temperature (for solids).
Why a Concern with Electrical Apparatus?

- Arcs and sparks occur during normal operation of many electrical equipment.
- Consumption of energy produces hot surfaces.
- Malfunction creates (more) potential ignition sources.
- Electrical apparatus must be selected and installed carefully to ensure there is no risk of ignition.
- Hazardous Area Classification was developed as a means to optimize equipment selection.
  - Electrical area classifications is defined under Article 500 of the National Electrical Code (NFPA 70).
  - The intent of Article 500 is to prevent electrical equipment from providing a means of ignition for an ignitable atmosphere.
### Electrical Area Classification

<table>
<thead>
<tr>
<th>North America</th>
<th>IEC (Europe)</th>
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</thead>
<tbody>
<tr>
<td><strong>Class –Division</strong></td>
<td><strong>Zones</strong></td>
</tr>
<tr>
<td>Class I – Gas or vapor</td>
<td>Zone 0 (Gas) / Zone 20 (Dust)</td>
</tr>
<tr>
<td>Division 1: Explosive atmosphere is present or likely to be present during normal operation</td>
<td>Explosive atmosphere is continually present or present for long periods of time.</td>
</tr>
<tr>
<td>Class II – Dust</td>
<td>Zone 1 (Gas) / Zone 21 (Dust)</td>
</tr>
<tr>
<td>Division 2: Explosive atmosphere is not present in normal operation, could be present in abnormal operation</td>
<td>Explosive atmosphere is likely to occur in normal operation</td>
</tr>
<tr>
<td>Class III – Fiber or flying (No Group Designation)</td>
<td>Zone 2 (Gas) / Zone 22 (Dust)</td>
</tr>
<tr>
<td>Division 2: Explosive atmosphere is not likely to occur in normal operations and, if it does occur, will exist for only a short time.</td>
<td></td>
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</tbody>
</table>
Determination of Extent of Divisions

Extent of division affected by:

- Working practices
- Ventilation
- Housekeeping
- Maintenance
- Plant structure and layout

Dust deposits are sources of release
Extent of Classified Locations

- Dust-tight equipment and good maintenance reduces the extent of classified areas.
- Effective dust removal (ventilated hoods and pickup points) and excellent housekeeping reduces the extent of a classified area.
- Where there are walls that limit the travel of the dust particles, area classifications do not extend beyond the walls.
Examples of Bad Practices

Source of dust release into plant

Open transfer point releases dust

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Basis of Safety

- Avoidance of flammable/explosible atmospheres
- Elimination of ignition sources
- Provision against consequences of ignition
  - Preventative measures alone may not ensure adequate level of safety. Protective measure should be taken as well
  - These measures are:
    - Containment by explosion resistant construction, Design based on ASME Boiler and Pressure Vessel Code, Section VIII, Division I
    - Explosion suppression by injecting a suppressant, NFPA 69
    - Explosion venting to a safe place, NFPA 68
Explosion Protection Techniques - Containment

- Must withstand the maximum pressure that is expected
- All parts of the plant made strong
  - includes pipes, ducts, flanges, covers, etc.
- Maintain strength over lifetime
- Strong plant is expensive to build and can be difficult to operate
Explosion Protection Techniques - Suppression

- Relies on early detection of an explosion and rapid injection of suppressant
- Typically at moment of detection, explosion pressure is 35 to 100 m bar g
- Suppressant extinguishes the flame within approximately 50msec.

Components of explosion suppression system;
- Explosion Detector
- Control Unit
- Suppressor
- Suppressant

1. Ignition - 0.000 Seconds
2. Detection - 0.020 Seconds
3. Control - 0.025 Seconds
4. Suppression - 0.060 Seconds

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Explosion Suppression - Examples

Fluid bed Dryer

Dust Collector
Explosion Protection Techniques - Venting

- Relies on rapid opening of panel(s) or door(s) hence allowing the release of hot gases and un-burnt product from within a process component or room.

- Advantages and disadvantages:
  + Relatively low cost
  + Simple to install in most cases
  + Not suitable for toxic materials
  + Venting to inside of buildings is usually unacceptable
**Explosion Protection Techniques - Venting**

- **Commonly used to protect**
  - Dust collectors
  - Silos and hoppers
  - Dryers
  - Cyclones
  - Sack tipping stations
  - Pipelines
Volume of fireball is many times the volume of the dust collector.
Explosion Relief Venting and Ducting to a Safe Place
An explosion, initiated in one plant item should be prevented from propagating along pipes, chutes, conveyors etc. and starting a subsequent explosion in other plant items.

The simplest isolation method is avoidance of unnecessary connections. If this is not possible, special measures should be taken to create barriers to avoid propagation of an explosion.

- Mechanical Isolation (Barriers)
- Chemical Isolation (Barriers)
Summary - Management of Flash Fire and Explosion Hazards

- Understanding of the flammability and explosion characteristics of the fuel(s)

- Site Audit:
  - Understanding of process operations and review of all available information (drawings, specifications, process/operation descriptions)
  - Identification of locations where flammable atmospheres (gas, vapor, dust) are or could be present during normal and abnormal operating conditions
  - Identification of potential ignition sources that could be present under normal and abnormal conditions
  - On-site electrostatic measurements (electrical field, electrical continuity measurements, etc.), where applicable

- Proper process and facility design to prevent and/or minimize the occurrence of flash fires and explosions and protect people and facilities against their consequences

- Regular inspection and maintenance of equipment to minimize ignition sources and fuel releases
About Chilworth Technology

Chilworth Technology

Global Experts in Process Safety Excellence
Chilworth Technology - An Overview

- One of the principal providers of specialist process safety services in the world - since 1986
- Over 150 staff including Engineering Professionals, Scientists and Laboratory Technicians with specialist process safety expertise
- Independent, practical advice and ‘niche’ valuable services
DEKRA SE - One of the Leading International Expert Organizations

- Headquarters in Stuttgart
- Active in more than 50 countries
- Around 40% of employees work outside of Germany
- Organized into 3 business units
  + Automotive
  + Industrial
  + Personnel
- 15 strategic service lines
- Revenues of more than 2.0 billion Euros
- More than 25,000 employees
Process Safety - Definition

- **Process safety** - The prevention and control of fires, explosions, and accidental chemical releases in chemical & process industries

- Such incidents may result in serious injury, property damage, lost production, and environmental impact

2003 - West Pharmaceutical, N. Carolina
6 Killed, 37 Injured

2008 - Imperial Sugar, Georgia
14 Killed, > 40 injured
Chilworth Technology - Global Locations

- **USA**
  - Chilworth Technology Inc
  - Safety Consulting Engineers Inc

- **Europe**
  - Chilworth Technology (UK)
  - John Chubb Instruments (UK)
  - Chilworth Spain
  - Chilworth France
  - Chilworth Italy
  - Chilworth Netherlands

- **India**
  - Chilworth Technology (pvt) Ltd
  - New Delhi
  - Mumbai

- **China**
  - Chilworth/DEKRA Insight - Process Safety
Safe operation of plants requires

- **Solid programs** (safety management systems),
- **Proficiency** among the staff (competency, know-how, experience),
- **Culture of people that encourages excellence** in process safety practice.
Of course, systems created and skills developed:

- Need to be suitable and correctly applied;
- Need to be monitored; and
- Must be embedded and sustainable in the long term.

Doing these things well is not easy, but when successful will create **PROCESS SAFETY EXCELLENCE** and generate wealth for all stakeholders involved”
### Chilworth Technology - **Global Process Safety Portfolio**

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**www.chilworth.com**
Chilworth Technology - Expert Witness and Litigation Support

Our Services
- Expert advice for litigation support
- Laboratory investigations
- Origin & cause investigation

Our Clients
- Law firms
- Manufacturing companies
- Insurance carriers
- Origin & cause investigators
- Government agencies
Chilworth Technology - *Electrostatic Applications and Problems*

**Laboratory Testing and Analysis**
- Electrostatic Applications
  - Coatings (powder, liquid)
  - Atomisation
  - Separation
  - R&D
- Electrostatic Problems
  - Powder adhesion/flow
  - Cling
  - Nuisance shocks
  - Product quality loss
  - Laboratory Testing/Measurements

ISO/IEC 17025 & GLP Accredited Laboratories

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Chilworth Technology - Process Design

- Process Evaluation – New & Existing
- Review of Scale-up Operations
- Laboratory Studies
  + Process Development/Optimization
- Process Design
  + Lab Simulations
  + Basic Process Design (layouts, P&ID, equipment, SOP...)
  + Detailed Process Design
Chilworth Technology - Specialist Laboratory Testing

ISO/IEC 17025 & GLP Accredited Laboratories

- Combustible Dust Fire & Explosion
  + OSHA Combustible Dust NEP
- Gas & Vapor Flammability
- Thermal Stability
- Chemical Reactivity
- Electrostatic
  + Conductivity, Resistivity, Chargeability, Discharge Incendivity
- DOT & UN Transportation of Hazardous Materials
- Explosivity / Energetic Materials
- Customized & Large-Scale Testing
Chilworth Technology - Specialist Laboratory Testing

ISO/IEC 17025 & GLP Accredited Laboratories

- Chemical Reaction Hazards & Calorimetry
- Chemical Process Development & Optimization
- Handling Toxic and Highly Active Materials
- Customized & Large-Scale Testing
Chilworth Technology - Specialist Laboratory Testing

Energetic Materials and Specialized Testing
- Transportation of Dangerous Goods - Small & Large-Scale Testing & Letters of Recommendation
- Explosion & Propulsion Analysis & Testing
- Propellants & Explosives Formulation, Analysis, Initiation Sensitivity & Performance Output Testing & Analysis
- Waste Explosive Propellant Pyrotechnics Disposal Remediation & Recovery
- Engineering & System Hazard Analysis
Chilworth Technology - Specialist Laboratory Testing

Regulatory Support
- UN Transportation
- Classification, packaging, labelling (CHIP)
- NONS (notification of new substances)
- REACH
- ATEX (DSEAR)
- SEVESO (COMAH)
- IEC 61508 (IEC 61511)
- Material Safety Data Sheet
Chilworth Technology - Specialist Laboratory Testing

Fire Service Testing
- Fire Litigation Support
- Fire Research & Engineering
- Fire Modeling
- Standard & Custom Fire Testing
- Mattress & Furniture Fire Testing
- ICAL Construction
- Performance Based Design Consulting
- Product Development Support
- Fire Test Apparatus / Instrumentation Development
- Fundamental Fire Research

ISO/IEC 17025 & GLP Accredited Laboratories
Chilworth Technology - Specialist Instruments

- BAM Friction & Fallhammer Apparatus
- Minimum Ignition Energy Apparatus
- Powder Volume Resistivity
- Powder Charge Relaxation
- Electrostatic Field Meter
- Charge Decay Analyzer

*JCI Chilworth is a specialty instrument company dedicated to electrostatic measurement*
Chilworth Technology – Client Industries

- Bulk & Fine Chemicals
- Agro-Chemical
- Energy / Power Sector
- Food & Drink
- Flavor & Fragrance
- Machine/Equipment Mfg
- Government Agencies
- Engineering / Consultants
- Legal/Insurance/Risk

- Primary Metals & Machining
- Automotive & Aviation
- Personal & Household Products
- Oil & Petrochemical
- Pharmaceuticals
- Plastics & Rubber
- Pulp & Paper
- Wood / Forestry
- Consumer Electronics
Thank you!

Chilworth Technology
Global Experts in Process Safety Excellence