Understanding Combustible Dust Hazards: Basic Measures you can take to Ensure Safety

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Mike Snyder PE CSP CFPS
Executive Vice President, Process Safety
Email: process-safety-usa@dekra.com
Phone: (609) 799-4449

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Outline for Today's Discussion:

- Introduction
- Combustible Dust Basics
  - Assessing Flash Fire & Explosion Dust Hazards
  - What Makes a Dust Become a Combustible Hazard?
- Data & Information for Combustible Dust Classification
- Establishing a "Basis of Safety" for Combustible Dust Ops
- New (and Old) Requirements in IFC (2018)
- Introduce the Table of References
- Discussion & Questions

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DEKRA Process Safety: Serving as a Trusted Safety Advisor

- **Integrated Solutions Provider**
  - Process Safety Consulting, Engineering and Laboratory Testing
  - Combustible Dust Testing & Analysis
  - Data Management & Analytics
  - Organizational Safety
  - Organizational Reliability (Human Error & Fatigue)

For more information:

www.Dekra.us/process-safety

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US Chemical Safety Board's Drivers of Critical Chemical Safety Change

- **Key Focus Areas of CSB Recommendations & Improvement Need**
- **5 Targeted Areas:**
  - **Combustible Dust Safety**
  - Process Safety Management for the 21st Century
  - Emergency Planning & Response
  - Preventative Maintenance
  - Safe Hot Work Practices
- Each Area "Championed" by CSB Board Member
- Web Information: https://www.csb.gov/mostwanted/

CSB'S DRIVERS OF CRITICAL CHEMICAL SAFETY CHANGE

U.S. Chemical Safety and Hazard Investigation Board

Combustible Dust Safety

The U.S. Chemical Safety Board (CSB) had identified combustible dust as a critical issue in industrial safety. The CSB has issued numerous recommendations to address safety gaps in Federal and state regulations; industry codes and standards; and best practices. The CSB initiated a study on the hazards of combustible dust following a series of major explosions and fires that resulted in the loss of lives and many burn injuries; making its first recommendations in 2006. The CSB found companies either ignore the hazard, fail to take adequate action to mitigate the danger, or are simply unaware of the hazard in their facilities. The CSB study concluded that while good engineering and safety practices to prevent dust explosions have existed for decades, there is no comprehensive Federal standard requiring adherence to those practices.

The CSB has issued four recommendations to OSHA calling for the issuance of a comprehensive general industry standard for combustible dust as the Board's first "Driver of Critical Chemical Safety Change."

The CSB issued a formal recommendation to the Occupational Safety and Health Administration (OSHA) to promulgate a comprehensive combustible dust standard to address the existing safety gap. The Board recommended the standard be based on existing National Fire Protection Association (NFPA) dust explosion standards. NFPA standards address critical topics such as dust hazard analysis, engineering controls, housekeeping, building design, explosion protection, operating procedures, and worker training.

Combustible dust-fueled fires and explosions continue to injure and claim the lives of workers across a broad spectrum of industries, including food processing, oil production, fuel storage, waste treatment, and pulp and paper manufacturing. The 2006 Combustible Dust Study reviewed three combustible dust-related incidents over a two-year period, and identified 281 combustible dust incidents between 1980 and 2005 that killed 119 workers, injured 718, and extensively damaged industrial facilities. Since 2006, the CSB has conducted five additional investigations into dust-related incidents. These five incidents alone have taken the lives of 27 workers and injured 61 others.

CSB Imperial Sugar Investigation, 2008

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Combustible Dust Hazard Basics

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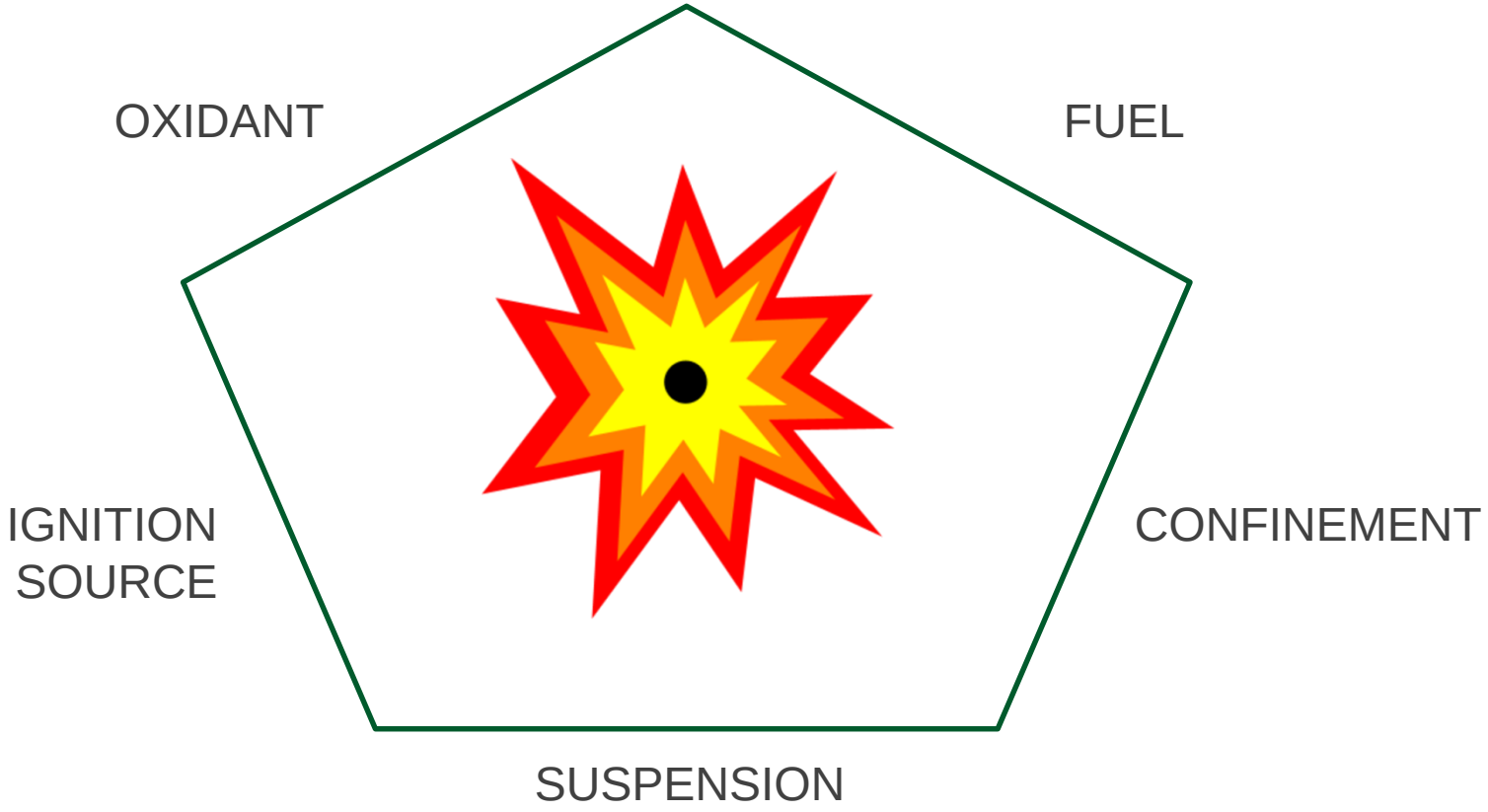
Conditions for a Combustible Dust Explosion



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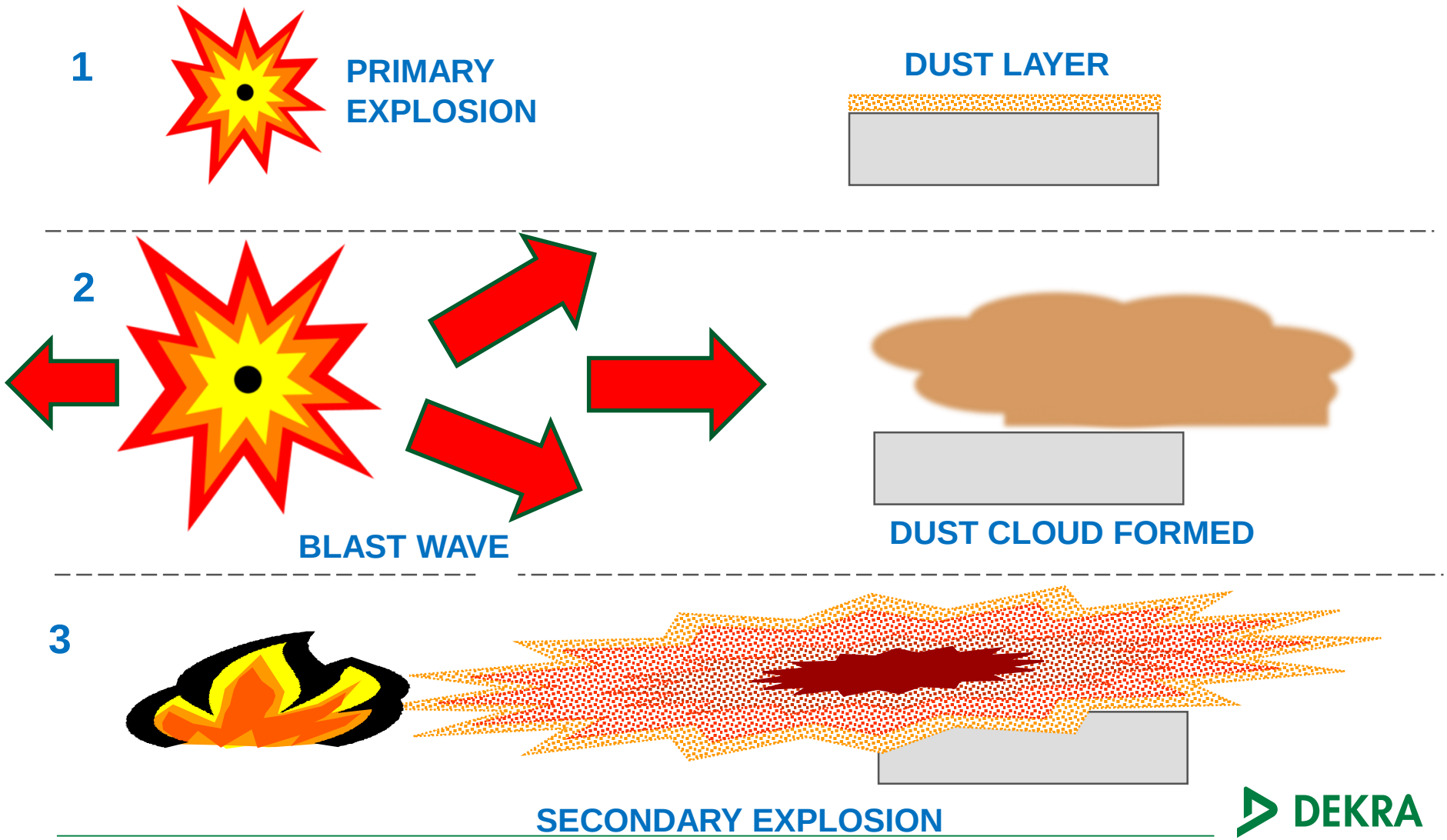
Secondary Explosions Present Additional Risks



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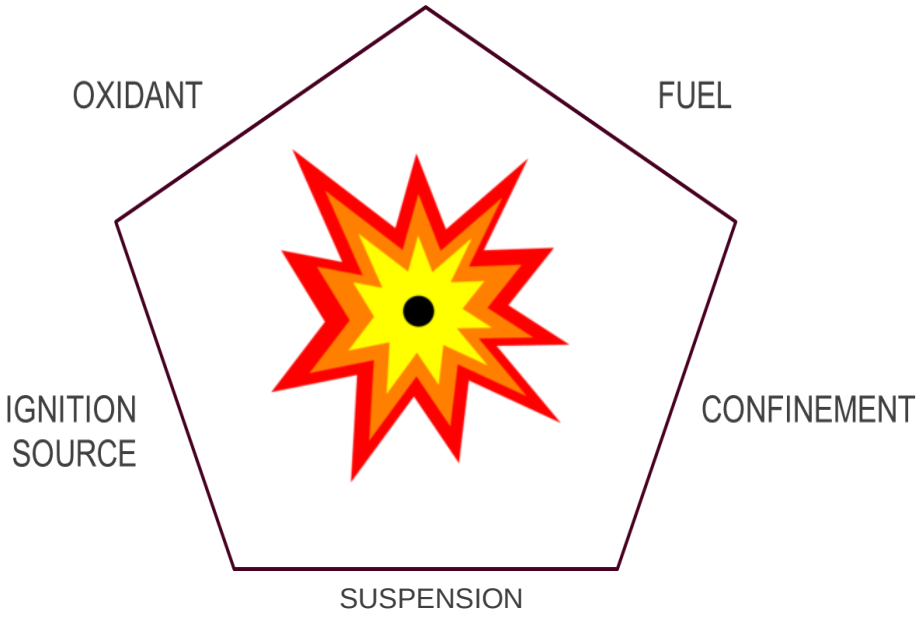
Combustible Dust Fire or Dust Explosion?



Remove the CONFINEMENT Leg ➔ **Flash Fire**
Remove the SUSPENSION Leg ➔ **"Regular" Fire**
Remove any other Leg ➔ **NO Explosion or Fire!**

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Assessing Combustible Dust Hazards

Cost Effectively Collecting Proper Data

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Examples of Combustible Materials
Focus is on particles < 500 microns (35 mesh)

Agricultural Products
Egg white
Milk, powdered
Milk, nonfat, dry
Soy flour
Starch, corn
Starch, rice
Starch, wheat
Sugar
Sugar, milk
Sugar, beet
Tapioca
Whey
Wood flour

Agricultural Dusts
Alfalfa
Apple
Beet root
Carrageen
Carrot
Cocoa bean dust
Cocoa powder
Coconut shell dust
Coffee dust
Corn meal
Cornstarch
Cotton
Cottonseed
Garlic powder
Gluten
Grass dust
Green coffee
Hops (malted)
Lemon peel dust
Lemon pulp
Linseed
Locust bean gum
Malt
Oat flour
Oat grain dust
Olive pellets
Onion powder
Parsley (dehydrated)
Peach
Peanut meal and skins
Peat
Potato
Potato flour
Potato starch
Raw yucca seed dust
Rice dust
Rice flour
Rice starch
Rye flour
Semolina
Soybean dust
Spice dust
Spice powder
Sugar (10x)
Sunflower
Sunflower seed dust
Tea
Tobacco blend
Tomato
Walnut dust
Wheat flour
Wheat grain dust
Wheat starch
Xanthan gum

Carbonaceous Dusts
Charcoal, activated
Charcoal, wood
Coal, bituminous
Coke, petroleum
Lampblack
Lignite
Peat, 22%H_20
Soot, pine
Cellulose
Cellulose pulp
Cork
Corn

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)
Epoxy resin
Melamine resin
Melamine, molded (phenol-cellulose)
Melamine, molded (wood flour and mineral filled phenol-formaldehyde)
(poly) Methyl acrylate
(poly) Methyl acrylate, emulsion polymer
Phenolic resin
(poly) Propylene
Terpene-phenol resin
Urea-formaldehyde/ cellulose, molded
(poly) Vinyl acetate/ ethylene copolymer
(poly) Vinyl alcohol
(poly) Vinyl butyral
(poly) Vinyl chloride/ ethylene/vinyl acetylene suspension copolymer
(poly) Vinyl chloride/ vinyl acetylene emulsion copolymer

Source: OSHA Combustible Dust Poster

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Combustibility / Explosibility of Dusts

- Determination of combustibility or explosibility shall be permitted to be based on the following:
  - **Historical facility data or published data that are deemed to be representative of current materials & process conditions**
  - Laboratory analysis of representative samples
    - Permitted to test a sample sieved to <75µm
    - Permitted to test the as-received sample
    - Permitted to assume a material is explosible, forgoing the laboratory analysis
- Absence of previous incidents shall not be used as basis for deeming a particulate non-combustible or non-explosible

Note:

- **Test results strongly influenced by particle size, moisture content, presence of contaminants**
- **Be sure test results are representative for your material!**

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Typical Combustible Dust Tests

Test	Hazard Evaluated
Go/No Go Test (ASTM E1226)	Does the Dust Explode? (with a High Energy Ignition Source)
Minimum Ignition Energy (MIE)	The energy required to ignite a dust cloud under fairly ideal conditions.
Minimum Explosible Concentration (MEC)	The minimum amount of dust (dispersed in air) for an explosion.
Maximum Pressure Rise (Pmax) and Max Rate of Pressure Rise (Kst)	Dust Explosion Pressure Factors for Design of Containment and Relief Systems
Minimum Ignition Temperature (MIT) for Clouds and Layer	Used for Electrical Area Classification and for Dust Analysis if handled at Elevated Temperatures
Limiting Oxygen Concentration	Ignition prevention below what level of oxygen (used for inerting system design)
Electrostatic Chargeability	Determines How Easily a Material Develops and Retains Charge

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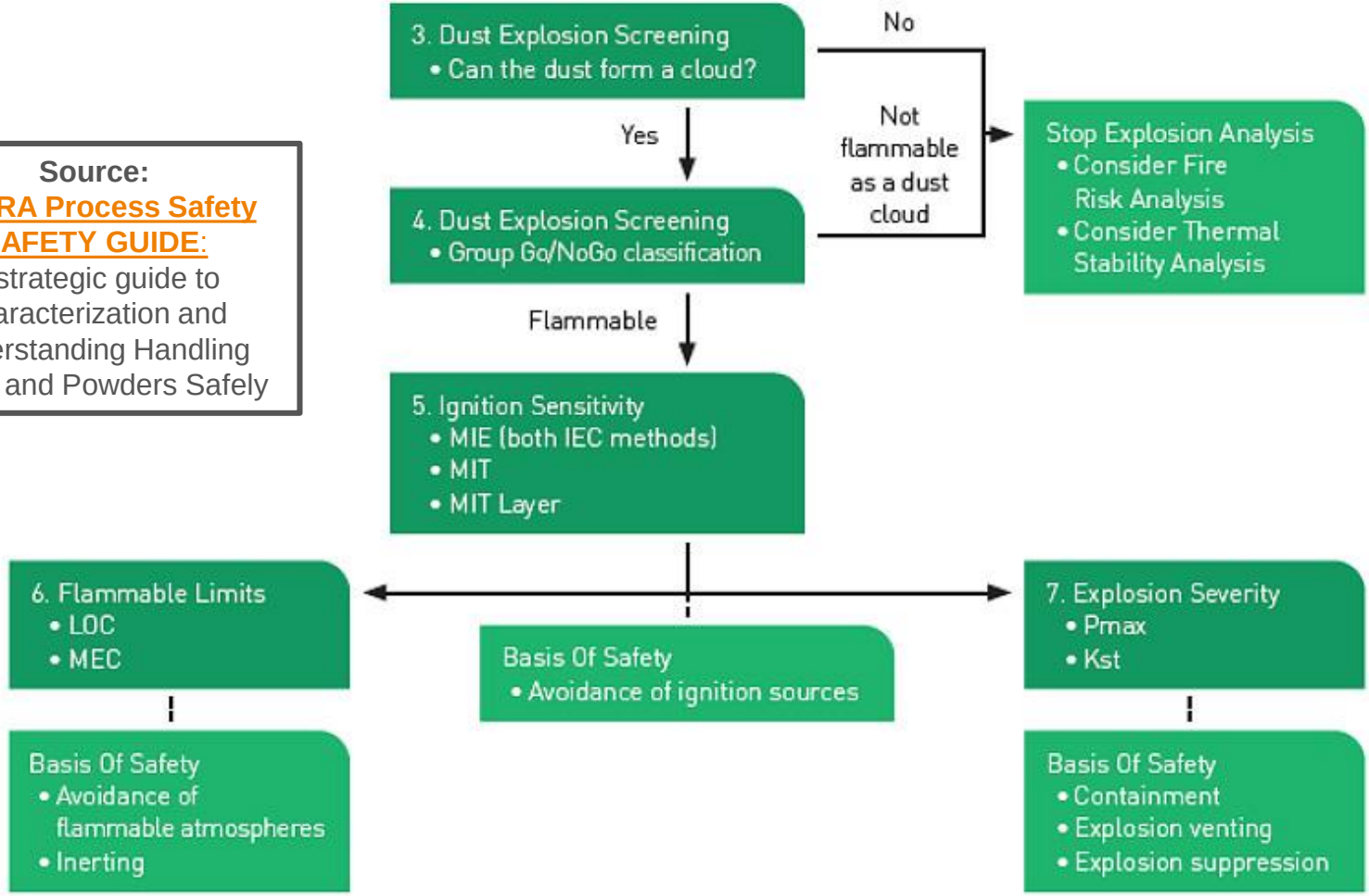
Strategy for Dust Explosion Testing & Implications for Basis of Safety

Source:
DEKRA Process Safety SAFETY GUIDE:
A strategic guide to characterization and understanding Handling Dusts and Powders Safely



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Case Study:
Hazards of Color Runs

June 27, 2015 Flash Fire (Formosa Fun Coast, Taiwan)

- Colored Corn Starch Deployed using Air Blowers
- “An Extremely Dense Dust Cloud over the Stage and its Immediate Vicinity”
- People near the Stage were “Ankle Deep” in Corn Starch
- **What Hazards Existed with Air Dispersed Corn Starch?**
- **497 People Injured; 15 Fatalities**

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An Overview of Dust Hazard Analysis (DHA)

Establishing a Basis of Safety

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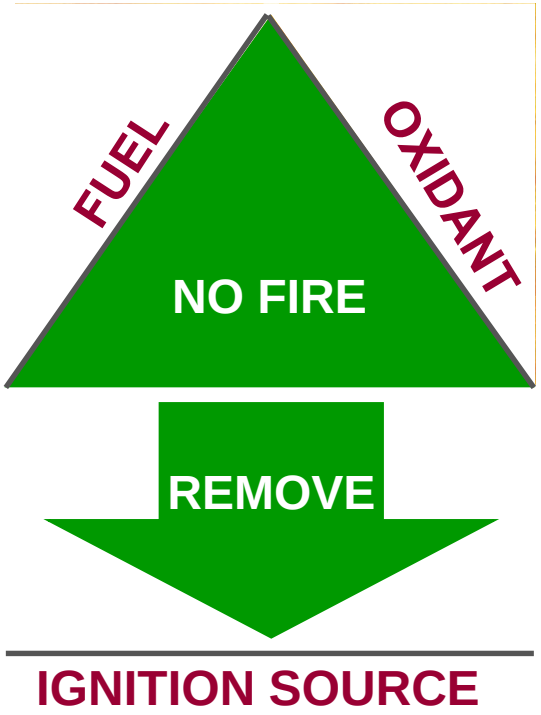
Hazard Management: Prevention & Mitigation

Basis of Safety

- Avoidance of flammable atmospheres
- Elimination of ignition sources
- Provision against consequences of ignition



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Managing Combustible Dust Fire and Explosion Hazards Requires…

Detailed knowledge of:

- Combustible material properties
- Process equipment
- Operating conditions
- Maintenance practices
- Existing controls (safeguards)
- and More…
- **These are Generally Collected and Analyzed through a Dust Hazard Analysis (DHA), using NFPA 652**

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NFPA 652 (2019) Compliance Requirements: A Framework for Dust Hazard Management

- Owner/operator of facility with potentially combustible dust shall be responsible for:
  - Determining combustibility and explosibility hazards of materials (Chapter 5)
  - Conducting a Dust Hazard Analysis (DHA) - Identifying and assessing fire, flash fire, and explosion hazards (Chapter 7)
  - Managing identified fire, flash fire, and explosion hazards
    - Prescriptive Approach (Chapters 5, 7, 8, 9)
    - It shall be permitted to use performance-based alternative designs for a building, equipment, ignition source control, and explosion protection in lieu of prescriptive requirements in Chapter 9 (Chapter 6)
- Establishing Safety Management Systems (Chapter 8)

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NFPA 652 (2019): Updates & Changes

- **Issued as Consent Document (April 2018)**
- **Changes to DHA Timelines**
  - DHA must be completed for Existing Processes by Sept 7, 2020
    - 2 Year Extension from NFPA 652 (2016)
  - 5 Year Revalidation Schedule
- **Coordination with other NFPA Dust Standards**
  - 2020 Edition of NFPA 654 proposes same Deadline
  - 2020 Editions of NFPA 61 and 664 will also be extending deadlines also
- **Rearrangement of Chapter 8 & Chapter 9**
  - Hazard Management: Mitigation & Prevention
  - Management Systems

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Control of Combustible Dust Atmospheres (Control of Fugitive Emissions)

- 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 **(1/32 inch; 0.8 mm – with adjustments)**
  - **Warning Indicators that your Dust Accumulations are too large:**
    - **Can you tell the color of the surface below the dust?**
    - **Can you write your name in the dust?**

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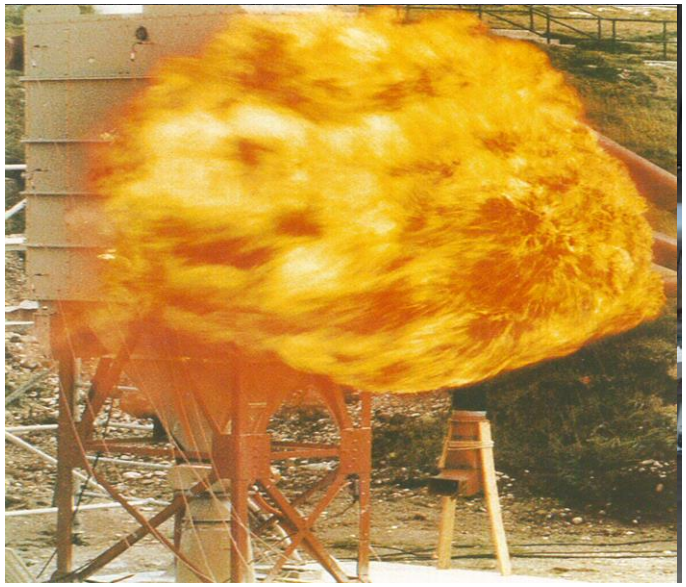
The Important Role of Dust Collectors



- Prevents Dust Accumulations
  - Collection & Removal of Fugitive Dusts
  - Controls Fugitive Dust Accumulations
- Key Design Considerations
  - Adequate Air Transport Velocity in Ductwork
    - Need to Prevent Dust Settling & Accumulation
  - Proper Design (and Direction) of Explosion Venting
  - Typically Installed Outdoors
  - Specific design features required to recirculate air
  - Never Store Dust in the Hopper

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Implications of International Fire Code (2018) on Combustible Dust Operations

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Sources of Requirements for Managing Combustible Dust

- **OSHA**
  - CPL 00-03-08 – Combustible Dust NEP
- **Non-Regulatory Requirements**
  - Insurance Company Standards (e.g. FM Global)
  - NFPA Codes & Standards
- **Building & Fire Codes**
  - Typically Adopted at Local & State Level
  - Applied for Issuance of Building Permits
  - Routine Inspections
  - Post-Incident

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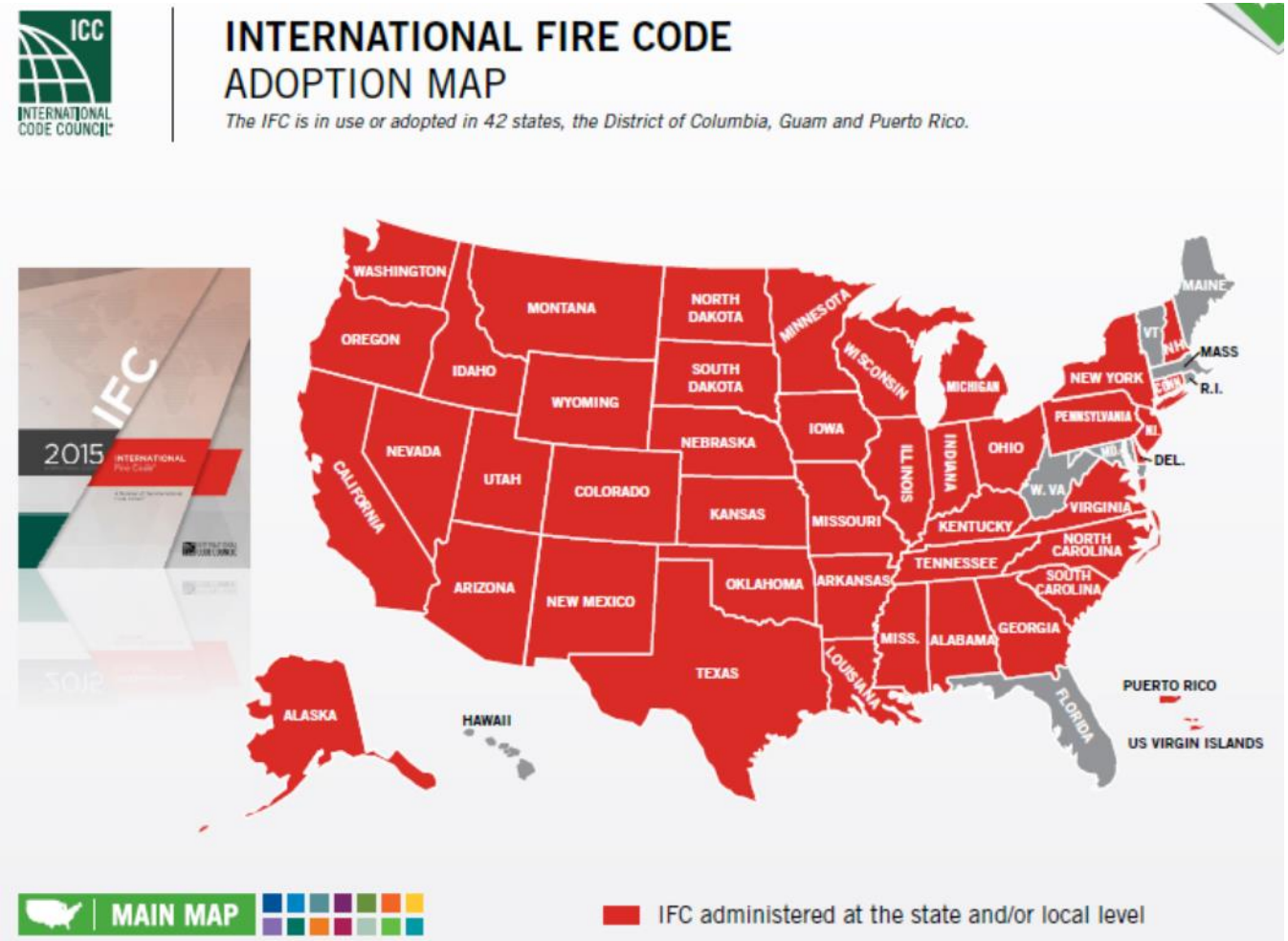
Regulatory Landscape: International Fire Code

Source: https://www.iccsafe.org/wp-content/uploads/Code_Adoption_Maps.pdf



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What is an Occupancy Classification?

- A classification of buildings and structures that manages the use and occupancy
- To provide a rationale criteria that is relative to fire hazard and life safety considerations
- Implications on Building Construction, Size, & Layout

- Typical Classifications
  - Group F: Factory Industrial
  - Group S: Moderate- and Low-Hazard Storage
  - Group H: High Hazard

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International Fire Code (2018)

- **Group H Occupancy Classification**
  - Uses Tables in Chapter 50, Section 5003
  - General Rule based on “Exempt Amounts” for Storage & Use.
    - Amounts Greater than these levels become Group H
  - Adjustments allowed for Sprinkler Protection
- **Combustible Dust Classification (2012)**
  - No “Exempt Amounts”
  - Dust Manufactured or Used in a Fashion Presenting a Fire or Explosion Hazard (Table 5003.1.1(1))
    - Occupancy Group H2 Classification
  - Engineering Evaluation in Section 104.7.2 is required to quantitatively document risk analysis to <u>not</u> classify as Group H2

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Chapter 22:
Combustible Dust-Producing Operations

- **Existing Requirements**
  - Forced air or similar methods shall not be used to remove dust from surfaces
    - More stringent than existing NFPA requirements
  - Operational permits required for operations producing combustible dusts, such as flour mills and grain elevators
- **New Requirements in 2018 Edition**
  - Dust Hazard Analysis Required (NFPA 652)
    - 3 Year Implementation Cycle
  - Explosion Protection per NFPA Industry- or Commodity- Specific Standards

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References

Sources of Recognized and Generally Accepted Good Engineering Practices (RAGAGEP)

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- **National Fire Protection Association (NFPA)**
  - NFPA 652 (2019), Standard on the Fundamentals of Combustible Dust.
  - NFPA 654 (2017), Standard for the Prevention of Fires and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids.
  - NFPA 499 (2017), Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemicals Process Areas.
  - NFPA 68 (2018), Explosion Protection by Deflagration Venting
  - NFPA 69 (2019), Standard on Explosion Prevention Systems
  - NFPA 61 (2017), Dusts in Agricultural and Food Processing Facilities
  - NFPA 484 (2019), Standard for Combustible Metals
  - NFPA 655 (2017), Standard for Prevention of Sulfur Fires and Explosions
  - NFPA 664 (2017), Dusts in Wood Processing and Woodworking Facilities

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- **OSHA Dust Resources**
  - OSHA Combustible Dust National Emphasis Program
  - Firefighting Precautions at Facilities with Combustible Dust
- **FM Global**
  - FM Global, Data Sheet No. 7-76, Prevention and Mitigation of Combustible Dust Explosions and Fire (2017 Edition).
- **United Kingdom Health & Safety Executive**
  - Safe handling of combustible dusts: Precautions against explosions
- **DEKRA Process Safety**
  - **SAFETY GUIDE** : A strategic guide to characterization and understanding Handling Dusts and Powders Safely

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Thank you for Participating in Today's Presentation

Process-safety-usa@dekra.com
Mike.Snyder@dekra.com

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We help our clients to adapt PSM to their needs & to build internal PS competence

Consulting

Process Safety Engineering

- Dust Flash Fire & Explosion Hazards
- Gas & Vapor Flammability Hazards
- Electrostatic Hazards
- Chemical Reaction Hazards

Process Safety Management

- Program Implementation & Improvement
- Gap Analysis
- Process Hazard Analysis
- Quantitative Risk Assessments
- Consequence Modeling
- Incident Investigations

Laboratory Testing

- Combustible Dust Fire & Explosion
- Gas & Vapor Flammability
- Thermal Instability
- Chemical Reactivity
- Static Electricity
- DOT & UN Transportation of Hazardous Materials
- Explosivity / Energetic Materials
- Customized & Large-Scale Testing

Competence Development

- Courses Covering all Key Aspects of Process Safety
- Continuing Education Units (CEU's)
- Multiple Languages
- Multimedia
- Instructor-Led Content
- Computer-Based Training

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