Combustible Dust: What Testing Can Tell You About Your Facility's Combustion Hazards

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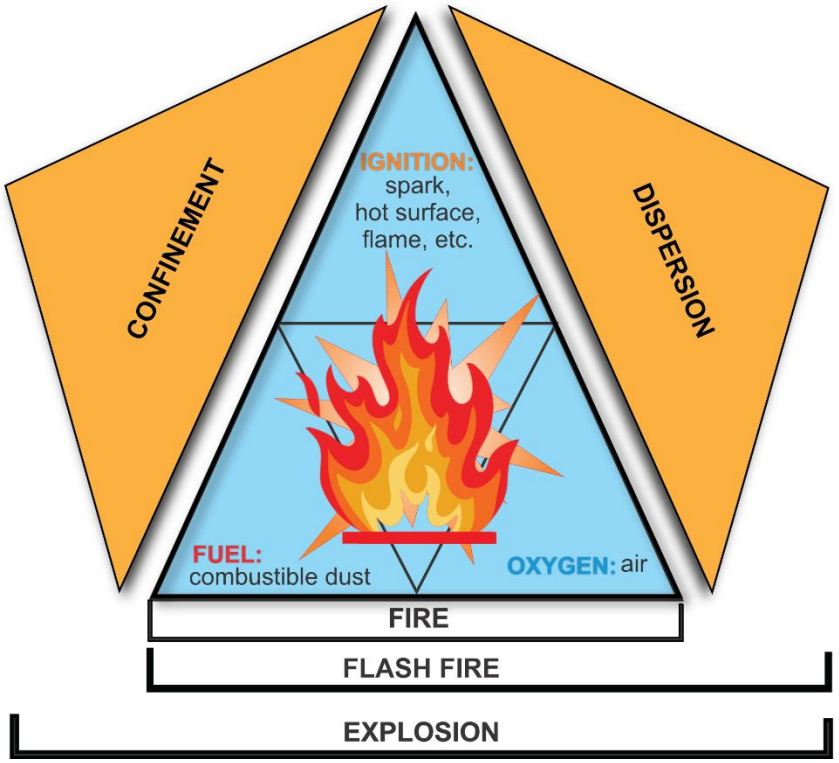
Combustible Dust

- What can be a combustible dust?
  - Organic materials, plastics, metals,
  - Small enough and dry enough



Stage 1:
Material Investigation

Stage 2: Sample Identification and Characterization

Stage 3a: Reactivity as a Cloud (Deflagration)

Stage 3b: Reactivity as a Pile or Layer (combustion)

Stage 4a: Deflagration Testing

Stage 4b: Combustion Testing

Stage 1:
Material Identification

Material Identification

What materials at your facility are potentially combustible?

- Organics usually, several different metals or anything that can oxidize rapidly and produce heat.

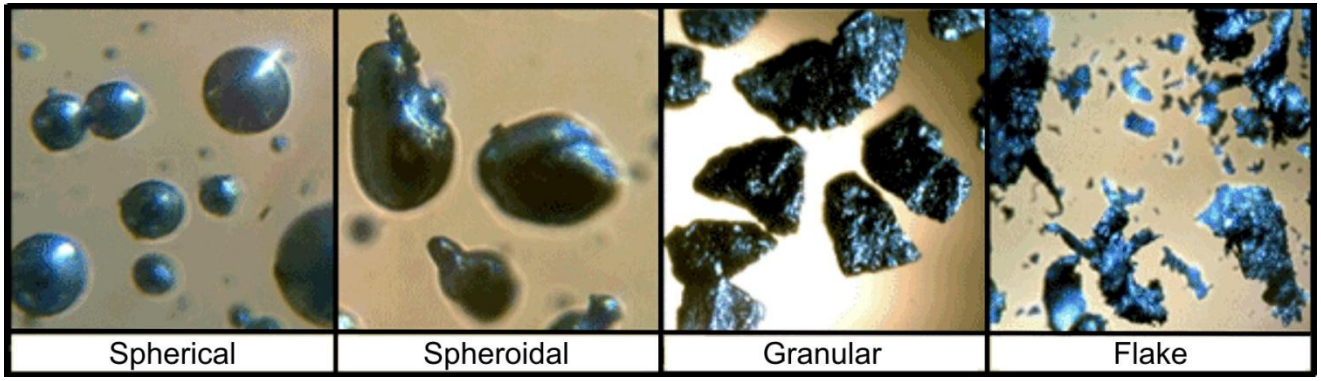
Stage 2:
Sample Identification & Characterization

Sample Identification & Characterization

Representative sample
- Where was this dust tested?
- What hazard are we concerned with?
- Is this sample representative of the area we are concerned with?

Sample characterization
- Particle morphology (shape)
- Particle size
  - <75 µm
- Moisture content
  - <5% moisture content

Increase of	MEC	$(dP/dt)_{max}$	MIE
Temperature	↓	↑	↓↓
Pressure	↓	↑	↓
Particle Size	↑	↓↓	↑
Moisture Content	↑	↓	↑

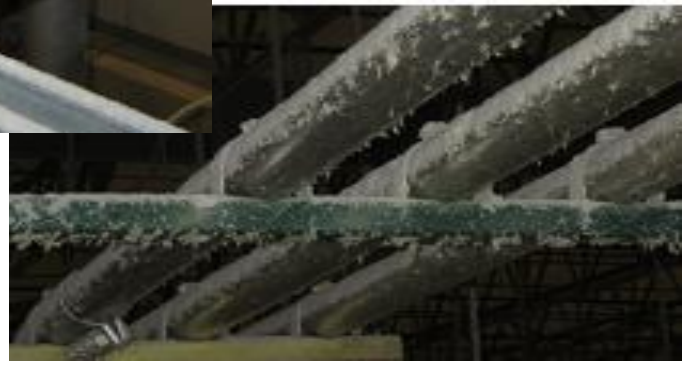


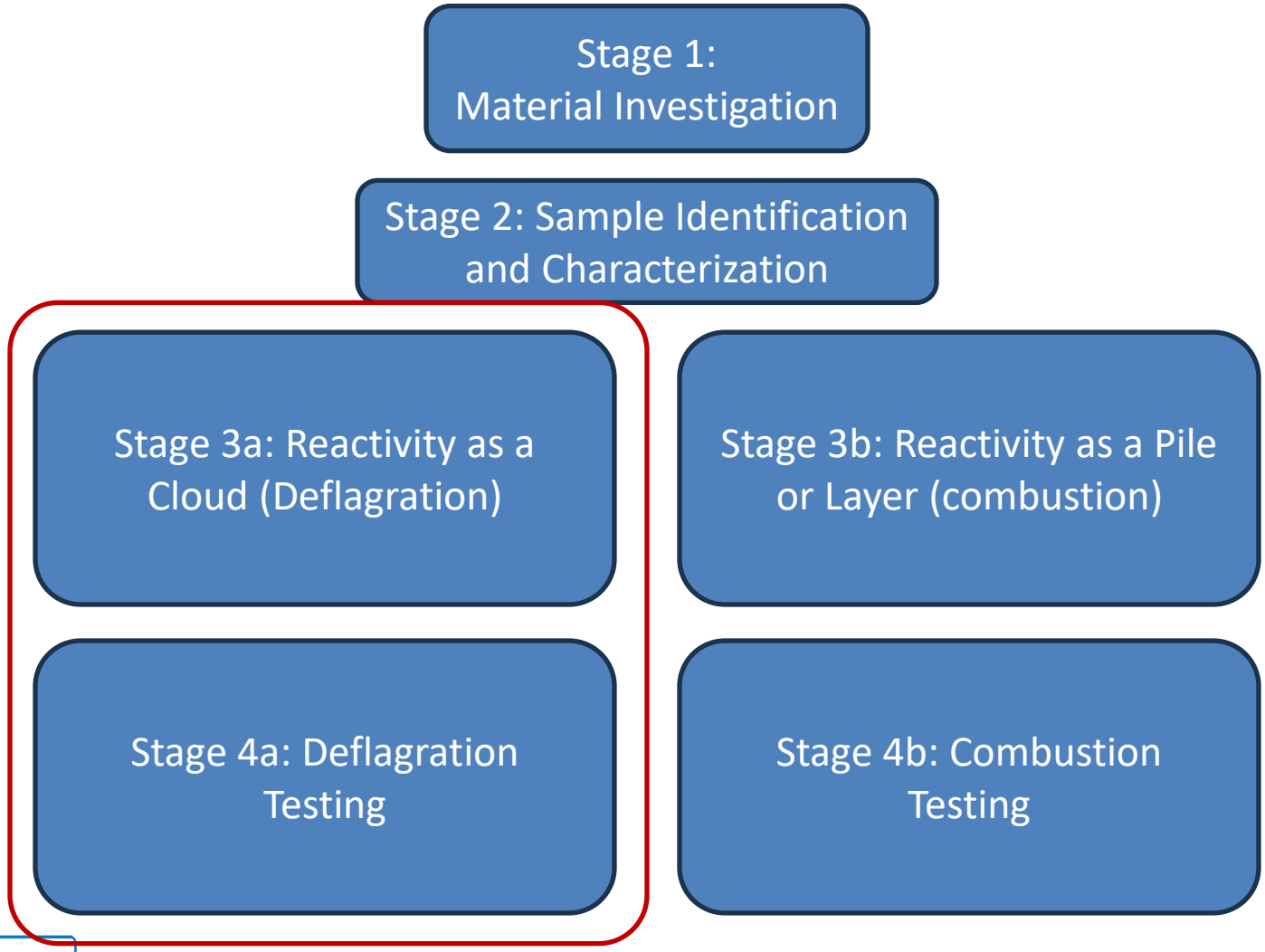
Sample Identification & Characterization

For best use of testing data, its important to record where the sample was collected and under what conditions

- Elevated surfaces (beams, light fixtures, tends to be very small)
- Dust collectors (can have large particles, but the dust off the filters is often very fine
- Process equipment (mills, screens, pneumatic conveying, usually a mix of all the possible sizes. 5% and sub-75 µm may be too conservative)

Source: Robovent





Stage 3a:
Reactivity as a Cloud

10

Stage 3a: Go/No Go Test

Modified Hartman Tube

20 L Spherical Apparatus

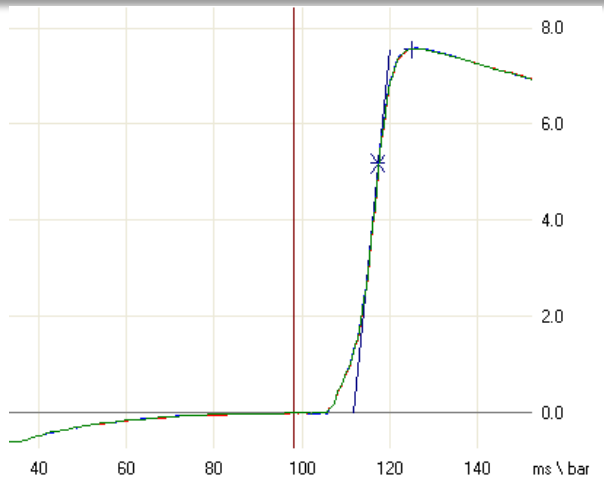
Cubic Meter Spherical Apparatus

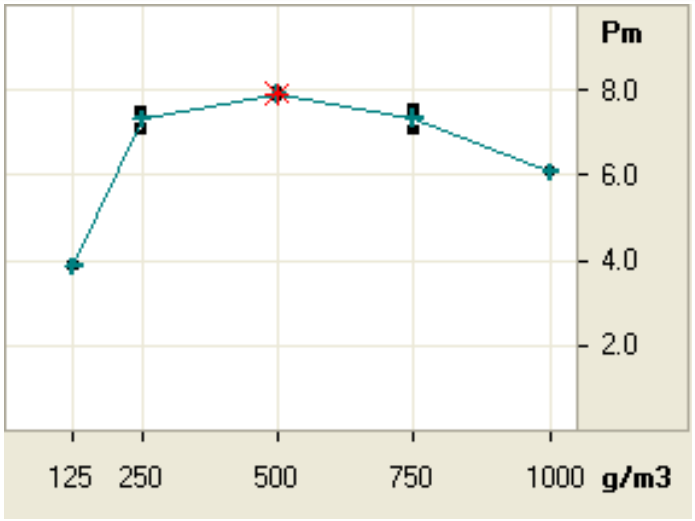
Test	Method
Modified Hartmann Tube Apparatus	• VDI 2263 Part 1 *"Dust Fires and Dust Explosions Hazards – Assessment – Protective Measures: Test Methods for the Determination of the Safety Characteristics of Dusts"* • ISO/IEC 80079 -20-2 *"Explosive atmospheres – Part 20-2: Material characteristics – Combustible dusts test methods"*.
Spherical apparatus 20-L or 1-m^3	• ASTM E1226 Section 13, • VDI 2263 Part 1 • ISO/IEC 80079 -20-2 • CEN/CENELEC

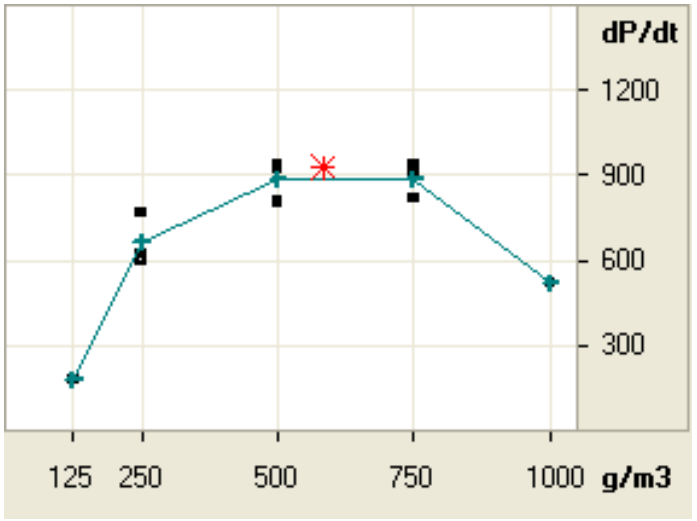
Stage 4a:
Deflagration Testing

Explosion Severity (P_{max} & K_{St})

- Determined in a 20-L or 1-m^3 chamber
- Indication of the severity of an explosion
  - P_{max} = maximum pressure
  - $K_{St} = (dP/dt)_{max} \times V^{1/3}$
- Applications:
  - Explosion Protection (Vent sizing)







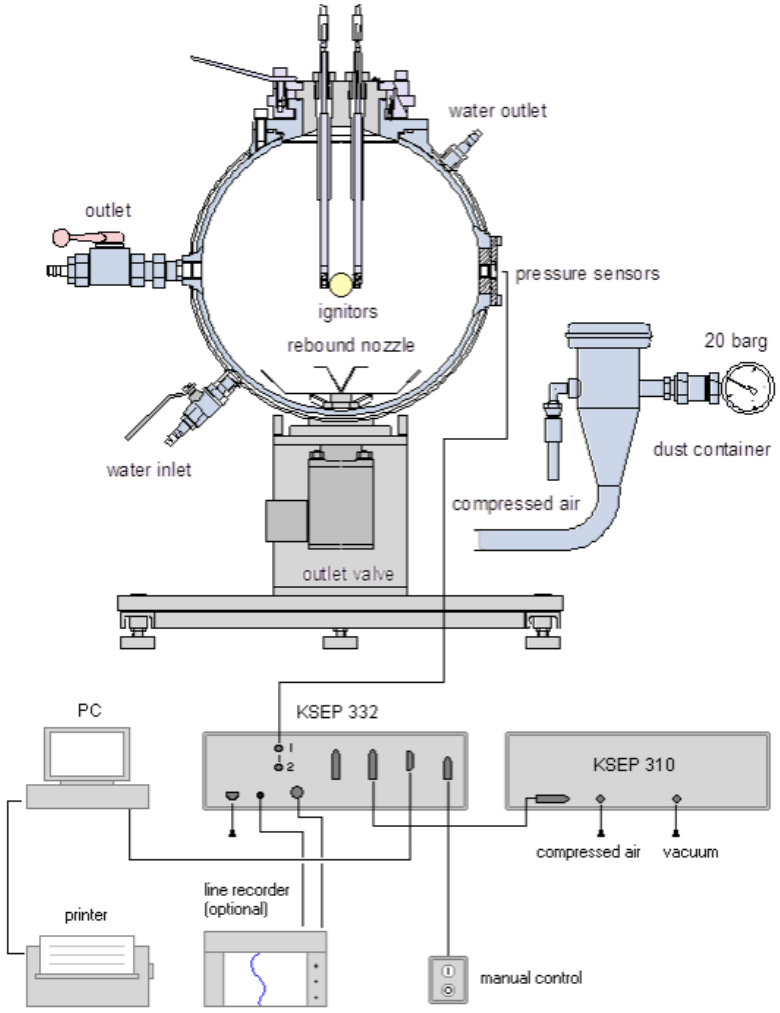
Additional 20 L Testing

Minimum Explosion Concentration (MEC)

- Applications
  - Determining hazardous equipment (exceptions are allowed below 25% of MEC)
  - Determining Area Hazards

Limiting Oxygen Concentration (LOC)

- Applications:
  - Used for inert systems



Minimum Ignition Energy (MIE)

Test	Method
Minimum Ignition Energy of a Dust Cloud in Air	• ASTM E2019-03 • Capacitive spark ignition source • Material dispersed over ignition source

- Minimum spark energy needed to ignite a dispersed dust cloud
- Predicts the ease and likelihood of ignition of a dispersed dust cloud
  - A capacitive discharge spark is used for this test
  - Test can be run with or without inductance
- Applications:
  - Bonding and grounding measures (personnel)
  - FIBC usage

Minimum Ignition Temperature of a Dust Cloud (MIT)

Test	Method
Minimum Ignition Temperature of a Dust Cloud	• ASTM E1491-06 • BAM Oven Apparatus • Material dispersed through preheated oven

- What surface temperature would ignite a dust cloud?
- Applications:
  - hot equipment like dryers or ovens
  - hot spots like bearings, mechanical parts

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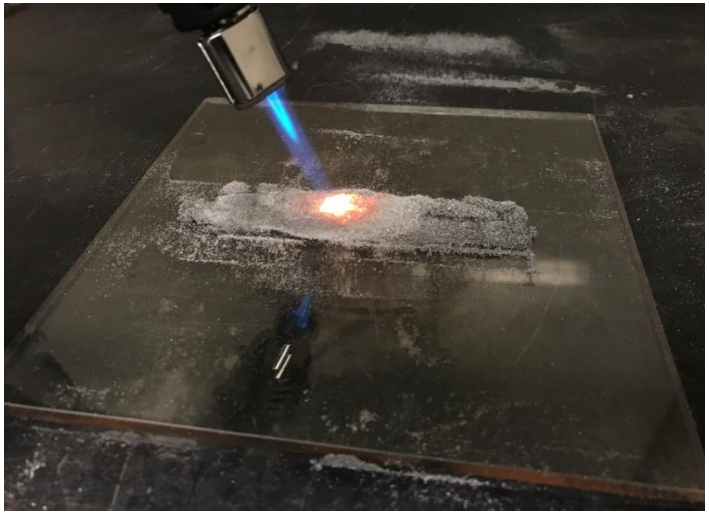
Stage 3b:
Reactivity as a Pile or Layer

Stage 3b

- Watch for Propagation

Test	Method
Burning Behavior Test	• VDI 2263 Part 1 • Mold powder into a pile using a standard mold • Flame or platinum wire ignition source
Burn Rate Screening Test	• UN Transportation of Dangerous Goods test Method • Longer mold than the VDI test



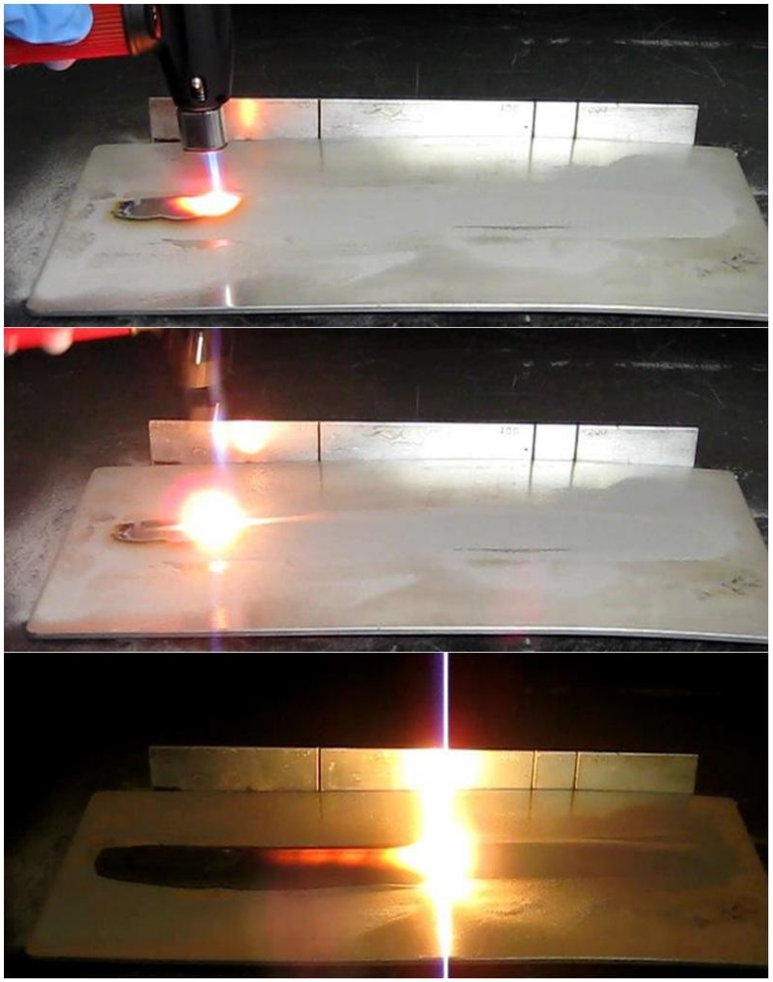
Source: *Methods in Chemical Process Safety*

Test Result	Observed Flame Propagation	Combustion Class (CL#)
No Ignition (No flame or embers) (Discoloration or hardening)	NO	1
Brief Ignition, Rapid Extinction (flame extinguishes in < 10 sec)		2
Localized combustion or glowing with practically no spreading (embers or flame hold in place for > 10 sec)		3
Glowing without sparks (smoldering) or slow decomposition without flame (takes > 30 sec for embers/smoldering to propagate length of powder train)	YES	4
Burning like fireworks or slow quiet burning with flames (takes > 30 sec for flame to propagate length of powder train)		5
Very rapid combustion with flame propagation or rapid decomposition without flame (takes < 30 sec to propagate length of powder train)		6

Stage 4b:
Combustion Testing

Burn Rate

- UN Manual of Tests and Criteria for Transportation of Dangerous Goods, Section 33, Classification Procedures, Test Methods and Criteria Relating to Class 4, *Test N.1: Test Method for Readily Combustible Solids*
- Looking for packing group II or III, difference is if a wetted spot will stop the propagation
  - Failure of wetted spot stopping the propagation can indicate that sprinkler systems would be ineffective in case of a fire



Source: *Methods in Chemical Process Safety*

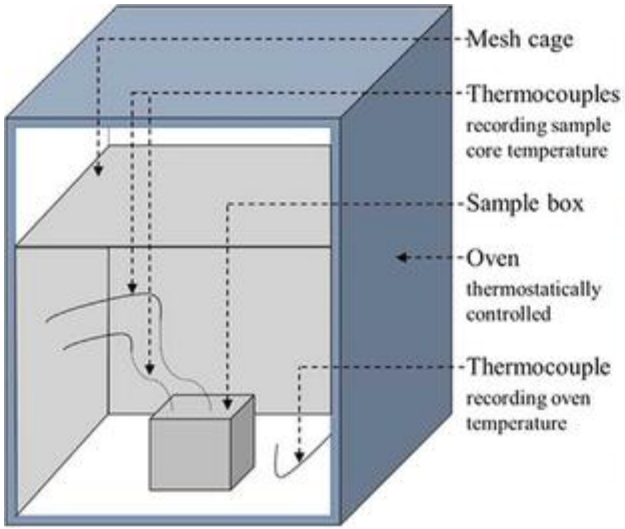
Layer Ignition Temperature

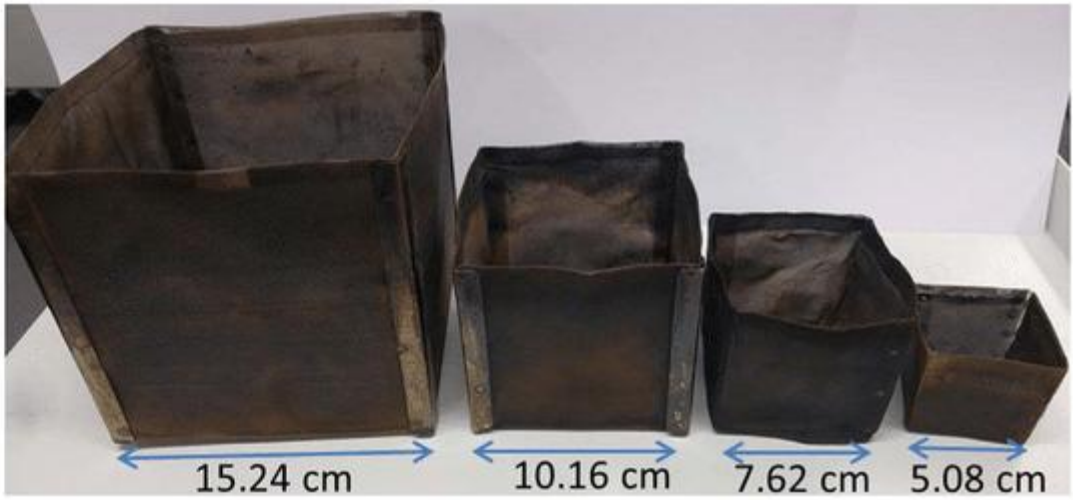
- ASTM E2021
  - Similar to:
    - VDI 2263 Part 1 (1990)
    - ISO/IEC 80079-20-2 (2016)
    - EN 50281-2-1:1999
- Other methods use a thinner layer (12.7 mm vs 5 mm).
- Ignition criteria:
  - Visible combustion
  - Temp difference greater than 50°C
- Applications:
  - Conveyors
  - Bucket Elevators
  - Motors

Source: *Methods in Chemical Process Safety*

Hot Storage Screening

- VDI2263 Part 1 Section 1.4.2
- Applications:
  - Bulk Storage
- Similar to LIT, the greater the volume, the lower the self-heating temperature
- Testing with multiple volumes can create a correlation to extrapolate temperatures for larger volumes





Source: *Prime Process Safety*

Conclusions

- Hazards exist for both dust layers AND dust clouds
- Knowing your dust characteristics allows for safer design
- Testing allows you to estimate the probability and consequence to determine the risk level

FAUSKE & ASSOCIATES

Thank you!

Any questions?

Contact me at
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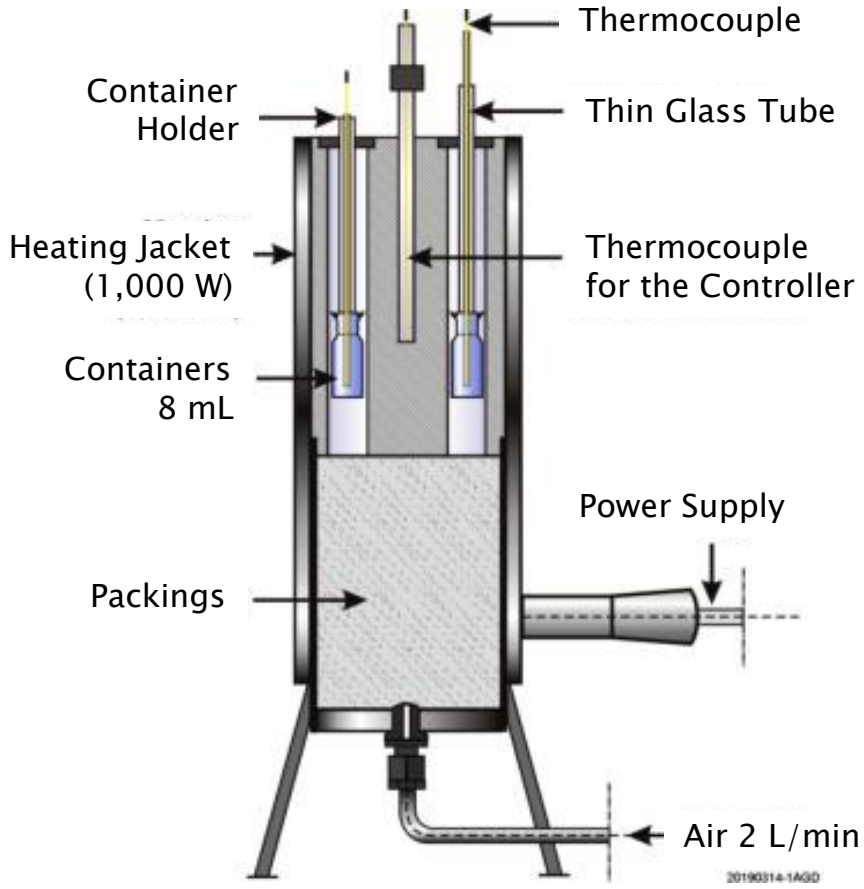
Additional Testing

Auto Ignition Screening (Grewer)

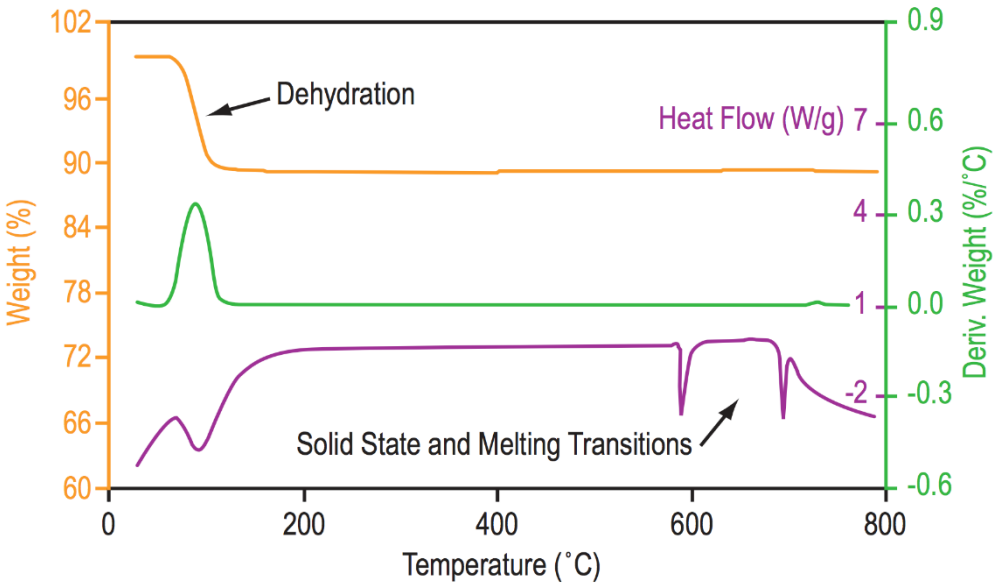
- VDI2263 Part 1 Section 1.4.1
- Two containers, one with sample, one with reference material
- Test Conditions
  - Heat (constant ramp)
  - Air flow (low air flow)
  - Up to 300°C
- Applications
  - Spray dryers
  - Ovens
  - silos



Exothermic Decomposition Screening

Test	Method
Test Method for Thermal Stability by Thermogravimetry	• ASTM E2550 • Mass of sample is measured as temperature increases
Standard Test for the Thermal Stability of Chemicals by Differential Scanning Calorimetry	• ASTM E537 • Measure of heat change during a chemical process

- TGA or DSC, together or separate
- Determine temperature at which thermal decomposition occurs
- Can use air or an inert atmosphere
- Ramping temp
- Determines Onset temp and Peak temp



Smoldering Gas Evolution (Lütolf)

- VDI2263 Part 1 Section 1.5.1.
- Heated at a ramp and then repeated isothermally
- Can measure the gas generation or test the flammability of the gas
- 5-hour test