

Dust Risks without Borders:
Combustible Dust Management &
Dust Hazard Analysis (DHA) Developments across Asia

Effective Management Systems
Approaches to Combustible Dust Hazards

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Today's Agenda

1. The Combustible Dust Challenge
2. Global & Asian Regulatory Landscape
3. Incident Lessons Across Regions
4. High-Risk Industry Sectors
5. DHA as a Proactive Risk Tool
6. Key Takeaways & Action Steps

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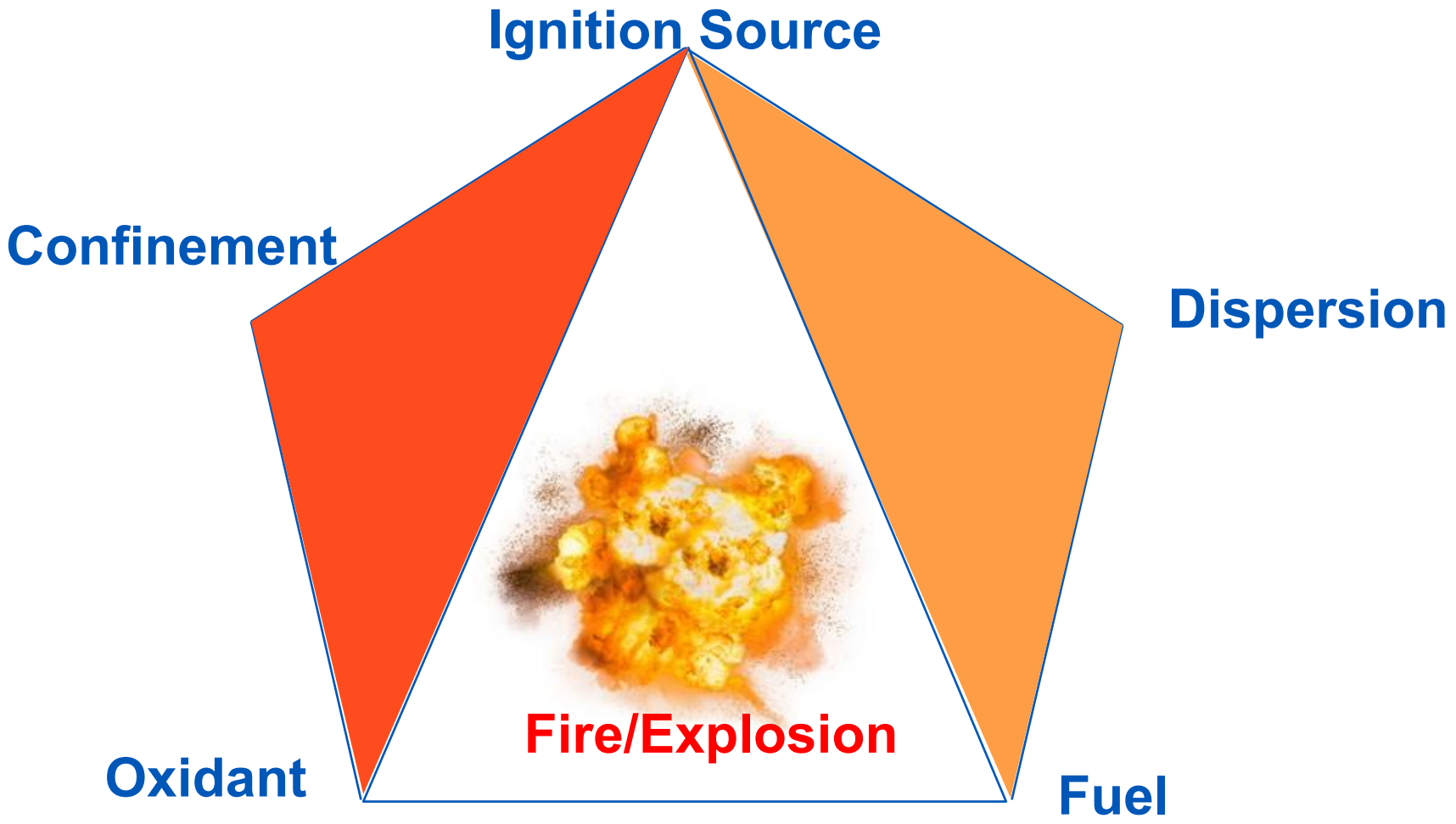
1. The Combustible Dust Challenge



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Elements for Dust Fire and Explosions



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A Persistent, Underrecognized Hazard

62	94	263	53
Fatalities	Injury	Fire	Explosion

01 **The "invisible" risk:** accumulated dust

02 **Asia's growth amplifies risk:** expanding manufacturing, new materials

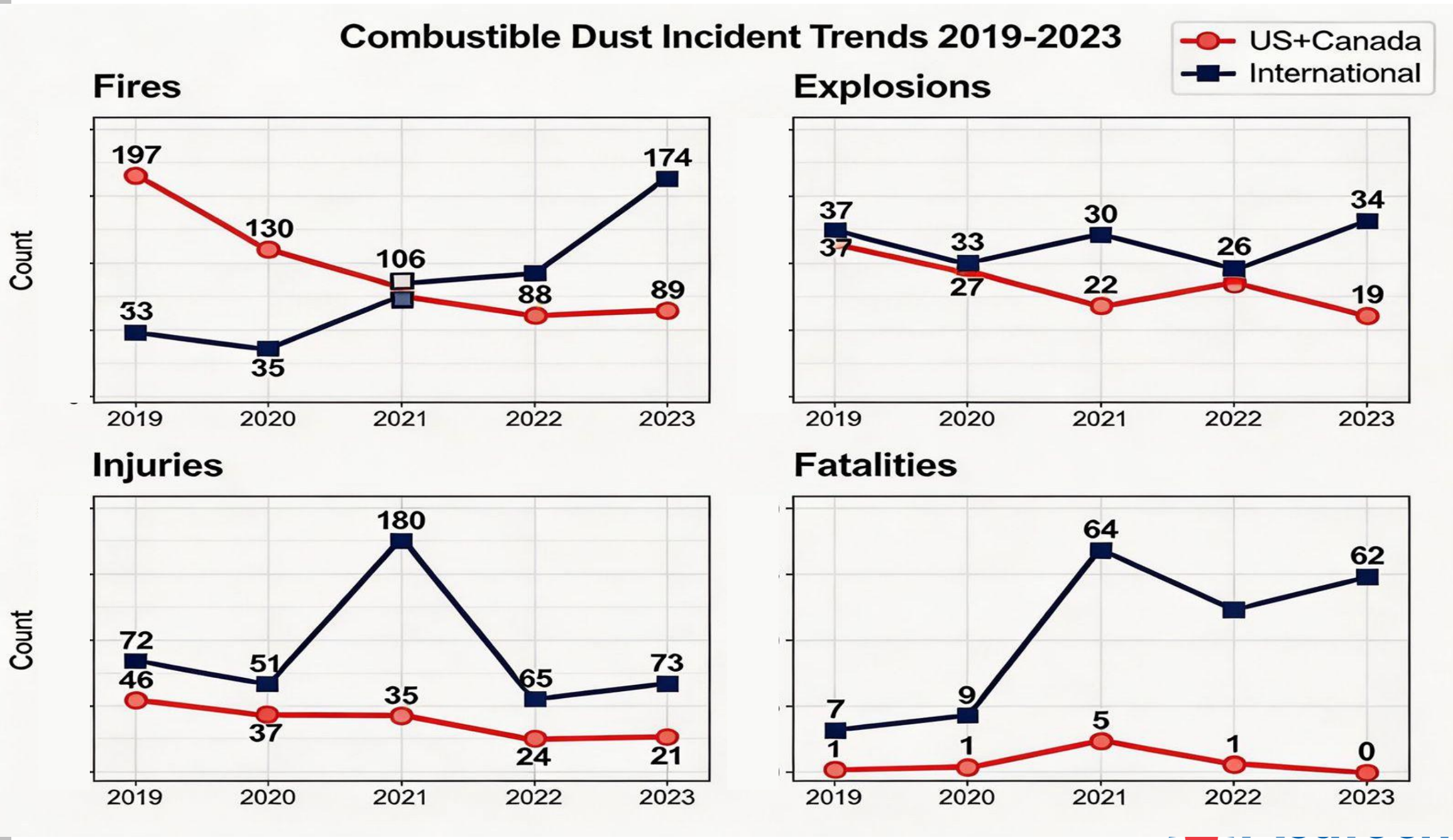
03 **Beside agricultural/food industries:** pharmaceutical, specialty chemicals, metals, and emerging energy.

PRIMARY	→	SHOCK WAVE	→	DUST CLOUD	→	SECONDARY
Explosion		Re-suspends settled dust		Massive flammable volume		Catastrophic explosion

*Sources: **2023 report from** https://dustsafetyscience.com/combustible-dust-incident-report/*

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来源：2023 年，https://dustsafetyscience.com/combustible-dust-incident-report/

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2. Global & Asian Regulatory Landscape







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Global Regulatory Benchmarks: US NFPA Standards

Standard	Title
NFPA 660 ★	Standard for Combustible Dusts and Hazardous Locations
NFPA 652 ★	Fundamentals of Combustible Dust
NFPA 654	Prevention of Fire & Dust Explosions from the Manufacturing, Processing and Handling of Combustible Particulate Solids
NFPA 484	Combustible Metals
NFPA 68	*Explosion Protection by Deflagration Venting*
NFPA 69	Prevention Systems

★ *Cornerstone standard*
DHA required by 2020

Consensus-based · Most referenced technical framework globally

NFPA: Consensus-based technical standards; DHA mandated via 652 (deadline Sep 2020); consolidated into NFPA 660 (2024)

Sources: NFPA (652/654/484/68/69/499/660 etc)

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Global Regulatory Benchmarks: US

Standard	Title
NFPA-655	Prevention of Sulfur Fires and Explosions
NFPA-664	Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities
NFPA-496	Purged and Pressurized Enclosures for Electrical Equipment
NFPA-70	National Electrical Code
NFPA-499	Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas

Sources: NFPA (655/664/496/70/499)

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Global Regulatory Benchmarks: EU

Standard	Scope
Directive1999/92	Minimum requirements, improving protection, explosive atmospheres
ATEX 2014/34	Equipment and protective systems, explosive atmospheres
EN 60079-10-2	Dust zone classification
EN 1127-1★	Explosion prevention and protection including dust hazard
EN 14034	Dust characteristics
EN 15089	Explosion isolation systems
EN 14491	Venting protection system
EN 14373	Explosion suppression systems

★ *Cornerstone directive*
EU-wide legal mandate

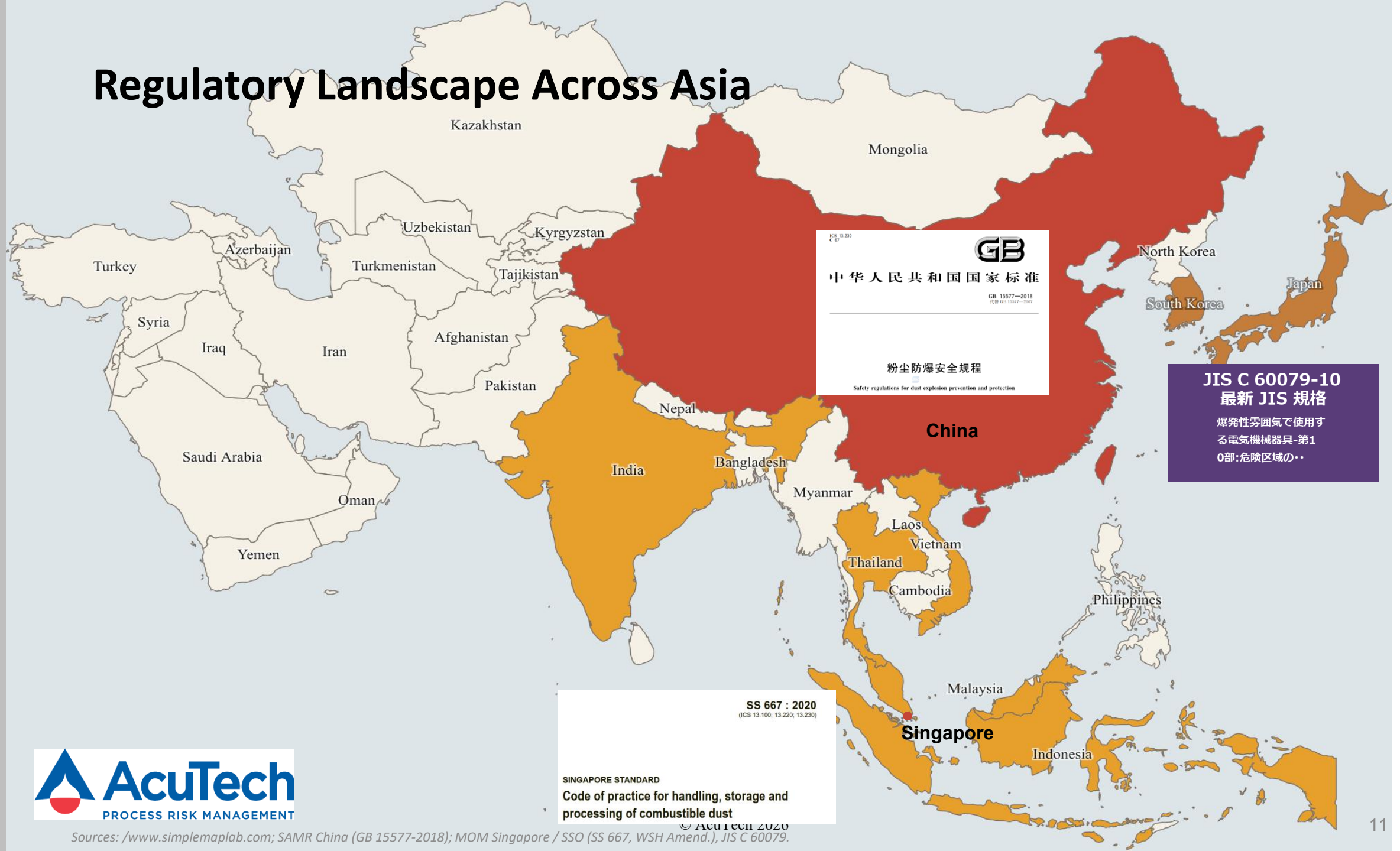
Mandatory directives + harmonized standards · Market access to site operation

Sources: EUR-Lex ATEX directives; CEN EN 1127-1/14034/15089/14491

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Regulatory Landscape Across Asia



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Sources: /www.simplemaplab.com; SAMR China (GB 15577-2018); MOM Singapore / SSO (SS 667, WSH Amend.), JIS C 60079.

Regulatory Landscape Across Asia

China	Singapore	Japan	Korea	India and SE Asia (VN, TH, ID, MY)
GB 15577-2018 Dust Explosion Prevention	**SS 667: 2020** Combustible Dust COP	Industrial Safety and Health Act (ISHA) **JIS C 60079** Dust Explosion Protection	ISHA Art.36 KOSHA technical guidance KS IEC dust standards	Rapid alignment Catch-up phase
Mature *Mandatory*	**MATURE** *Mandatory*	**ESTABLISHED** *Stable compliance base*	**ESTABLISHED** *Stable compliance base*	No explicit regulation or codes on Dust Hazard Management

Sources: SAMR China (GB 15577-2018); MOM Singapore / SSO (SS 667); JISC Japan

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3. Incident Lessons Across Regions



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Incident Lessons: Mature Markets

2017 Didion Milling Explosion

Material	Corn Milling
Outcome	**5 fatalities/14 injuries, facility destroyed (15M loss)**
Root cause	Poor housekeeping; unventilated conveyors; no MOC; secondary explosion amplified disaster
Lesson	Process hazard recognition, dust hazard analyses (DHA), fugitive dust management, process safety leadership, and regulatory coverage of combustible dust

Sources: US CSB investigation report

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Incident Lessons: Emerging Markets

2025 Shandong Qingdao Qianbaiwei Food Ingrdient Ltd

青岛仟佰味食品配料有限公司

Material	Food powder and Foreign metal powder
Outcome	**5 fatalities, facility destroyed (8.4M RMB loss)**
Root cause	Metal debris mixed into reactor, Poor housekeeping; unventilated workshop; no dust protection
Lesson	Safety awareness and training, formal DHA, control measurement (PTW, housekeeping, grounding etc), assign competent personnel, equipment with safe design and protection.

Sources: 2025青岛千佰味调查报告

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Incident Lessons: Emerging Markets

2025 Shanghai Meiyuan Dynamics Technology Pte Led

上海镁源动力科技有限公司

Material	Magnesium powder
Outcome	**5 Injuries, facility damage (400K RMB loss)**
Root cause	Static charge from Vacuum cleaner ignited Mg powder; poor housekeeping; fail in implementing DHA safeguard
Lesson	Identify dust hazard and training, formal DHA, equipment with safe design and protection.

Sources: 2025上海镁源调查报告

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Lessons Learned from Dust Incidents

Incident	Key Findings
Didion Milling (2017) Corn dust explosion	1. Classic **secondary explosion** pattern 2. Facility destroyed despite routine ops **3. Fine powder scatted** in work area 4. Dust hazard not in prior hazard review 5. Electrical equipment not dust-rated **6. Insufficient DHA** 7. Lacking in understand of **dust characterization** 8. lack of **awareness of dust hazard** 9. Lack of training and risk management
Qingdao Qianbaiwei (2025) Starch explosion	
Shanghai Meiyuan (2025) Magnesium powder explosion	

Universal Lesson: Start understand the dust hazard and conduct DHA.

Secondary explosions — not the primary event — cause most fatalities and destruction.

Sources: US CSB investigation report; 2025青岛千佰味调查报告； 2025上海镁源调查报告; AcuTech training materials

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4. High-Risk Industry Sectors

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High-Risk Sectors

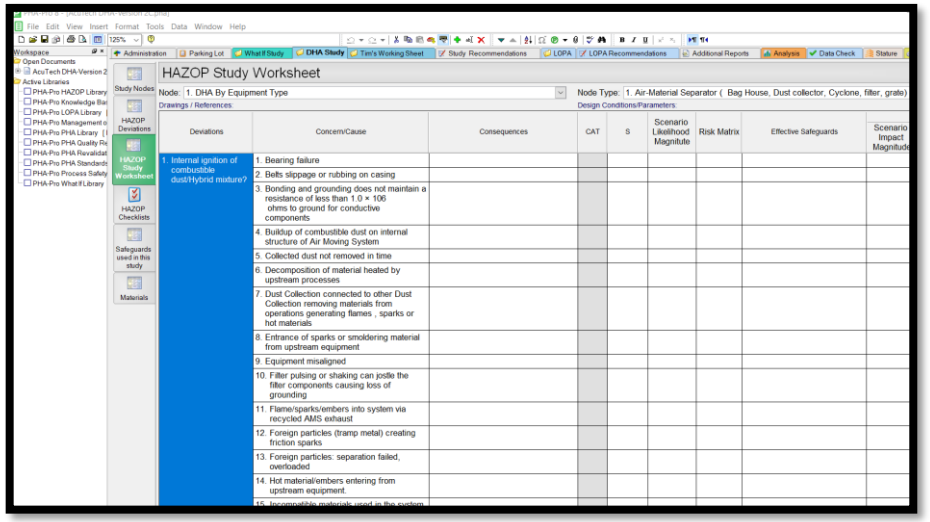
Fastest-growing dust risks in Asia today:

Pharma (API)	Manual handling of Fine API powders in supersack/drums; some with very low MIE
Specialty Chemicals, inc. Plastics & Resins	Calcium stearate, sulfur, paraformaldehyde dusts PE, PVC, rubber powders; bulk storage & conveying
Metal Processing	Aluminum, titanium, alkali metal dusts; recycling
New Energy	Battery cathode/anode, silicon powder; ultra-fine

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5. DHA as a Proactive Risk Tool



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DHA Approaches

What-if/Checklist

Equipment based Nodes

Risk Matrix

DHA-LOPA

Layer of Protection Analysis
(Risk Assessment)

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DHA Flow Chart (SS667)

Define scope & process boundary

Material Hazard Identification

Identify credible hazard scenario: causes & consequences

Assess the risk

Identifying Safeguards/IPLs

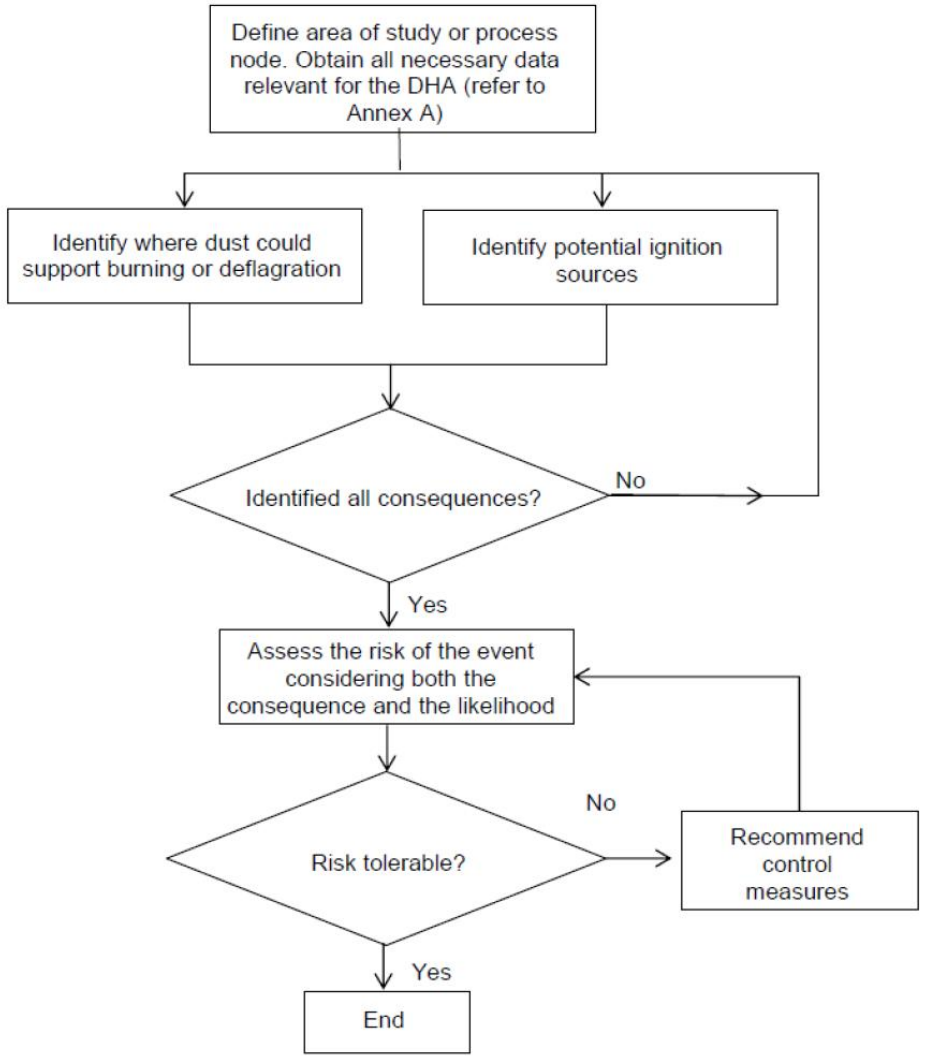


Figure 2 – Dust hazard analysis (DHA)

Sources: AcuTech training materials

DHA Consequence Severity - Sample

Event	Typical Consequence Severity	Clarifications
Primary explosion	C4 or C5	Depending on equipment location and team evaluation during DHA
Propagating explosion	C4 or C5	Depending on equipment location and team evaluation during DHA
Secondary explosion	C5	Secondary dust explosions always result in the highest consequence
Flash fire	C3 or C4	Depending on team evaluation during DHA
Smoldering fire	C2 or C3	Depending on team evaluation during DHA (consider damaging effects of smoke)
Layer/Spreading fire	C2 or C3	Depending on team evaluation during DHA

Sources: AcuTech training materials

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DHA Initiating Cause Likelihood

Initiating Cause	Likelihood of Failure (events/year)	Negative Log Value (-log ICL)	Comments/Guidance
Combustible Dust-Related Causes			
Ignition - electrostatic	10^{-2}	2	MIE ≥ 100 mJ
Ignition - electrostatic	10^{-1}	1	MIE > 10 mJ but </= 100 mJ
Ignition - electrostatic	10^{0}	0	MIE value </= 10 mJ
Ignition – Electrical discharge and arcs	10^{-2}	2	For electrically classified areas (Class II Div 1, 2; Zone 20, 21; Zone 10, 11 or better)
Ignition – Electrical discharge and arcs	10^{0}	0	For electrically unclassified areas
Ignition – friction	10^{0}	0	External testing can be done to confirm if friction is a potential ignition source
Ignition – impact	10^{0}	0	If impact testing was positive using the Bruceton statistical analysis
Ignition-smoldering or burning nest	10^{0}	0	Depends on minimum hot surface ignition temperature
Ignition-self heating	10^{0}	0	If material self-heats and no scale up analysis was done
Ignition-self heating	10^{-1}	1	If material self-heats, and (T_{onset} - $T_{operating}$) is <25 °C
Ignition-self heating	10^{-2}	2	If material self-heats, and (T_{onset} - $T_{operating}$) is >/= to 25°C and < 50°C

Initiating Cause	Likelihood of Failure (events/year)	Negative Log Value (-log ICL)	Comments/Guidance
Ignition-self heating	10^{-3}	3	If material self-heats and (T_{onset} - $T_{operating}$) is ≥50°C, not a credible scenario for ignition by self-heating
Ignition-Open flames, welding	10^{0}	0	This ignition sources should not normally be present during operation
Ignition- Hot surfaces	10^{0}	0	When MIT data indicates that the T hot surface > (MIT 40°C)
Ignition-Fires and Explosions	10^{-3}	3	This value should be used if no frequency is developed for fire or explosion scenarios during the CDA
Ignition-Hot Air Stream	10^{0}	0	When temperature of hot air stream is > (MIT – 40°C)
Powder or dust accumulation above unacceptable levels	10^{0}	0	1/32 inch thick used as initial guideline.

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DHA IPL List

Independent Protection Layer (IPL)	Probability of Failure on Demand (PFD)	Negative Log Value (-log PFD)	Comments/Guidance
Combustible Dust-Related IPLs			
Administrative control - Control of small dust cloud formation during manual charging	10^{-1}	1	There must be a written procedure that states specific steps that prevent or minimize the formation of dust clouds during charging or discharging operations. Training must be provided and documented.
Bonding and Grounding Program	10^{-1}	1	Written bonding and grounding procedure developed in accordance with Mechanical Integrity require2ments. This includes documentation of tests and results kept on file, all systems components must be conductive or made to be conductive for this credit to be taken. For dusts with MIE <30mJ operator grounding is required as part of the bonding and grounding program.
Containment	10^{-2}	2	Mechanical Integrity of the vessels should be evaluated in accordance to the Mechanical Integrity program.
Deflagration Vents	10^{-2}	2	1) The emergency relief system, needs to be properly sized and the following must be documented: • Relief requirement calculations for the specific powders or dust being used in the system. When ducting exists, it must be considered in the calculations. • The source of all Process Safety Information utilized in the calculations. 2) Deflagration vents that are being used to protect rooms or buildings should also be designed according to the guidelines detailed above. 3) For use in secondary dust explosion mitigation, the design must ensure that the primary explosion deflagration vents are located to discharge to outside locations where they will not present a hazard.

Sources: AcuTech training materials

Real-World Best Practices: Safeguards & IPLs

Prevention IPLs

- ❖ Inerting (oxygen reduction below LOC)
- ❖ Bonding & grounding program
- ❖ Housekeeping program (combustible dust layers)
- ❖ Local exhaust ventilation / dust collection
- ❖ Spark detection & ignition source control

Multiple independent IPLs required — no single safeguard is sufficient.

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Real-World Best Practices: Safeguards & IPLs

Mitigation IPLs

- Deflagration venting (per NFPA 68)
- Explosion isolation in interconnecting ducts
- Suppression systems in protected equipment
- Pressure-resistant construction where needed

Multiple independent IPLs required — no single safeguard is sufficient.

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6. Key Takeaways & Action Steps

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Action Steps: Start Your DHA Journey

Assess	Implement	Risk management and Sustain
1. Conduct full DHAs	1. Implement DHA recommendations/actions	1. Reassess under every MOC
2. Scope all dust-handling sites	2. Venting & isolation upgrade	2. Revalidate every 3-5 years
3. Collect MSDS & existing data	3. MOC includes dust review	3. Audit housekeeping discipline
4. Kst / MIE gap testing	4. Train operators & maintenance	4. Track near-miss indicators
5. Prioritize highest risks	5. Review incident history	5. Benchmark NFPA 652 / ATEX

The biggest failure is treating DHA as a one-time checkbox — embed it into your PSM / MOC system for sustained results.

Framework based on NFPA 652 DHA requirements, BakerRisk 7-step methodology, and AcuTech project experience

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Key Takeaways

Four principles that apply across every industry, facility type, and region

1	**Dust hazards are borderless and are present across many industries**
2	**Secondary explosions kill**
3	**Test your dust**
4	**Carry Out DHA**

Start today — the cost of prevention is always less than the cost of an incident.

Synthesis of NFPA 652/654/484, CSB incident investigations, China MEM reports, and AcuTech consulting experience

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Questions & Discussion

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Thank you for your attention

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