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How to Complete a Dust Hazard Analysis (DHA)

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Who am I?

Chris Giusto, PE

Regional Manager – South Atlantic
Director – Combustible Dust Safety

BEME Youngstown State University (Ohio)

2005 – Started working with Combustible Dust Hazards & NFPA standards, designing equipment handling combustible dusts

2012 – Moved to consulting, specifying equipment and systems & ensuring NFPA compliance

2018 – Launched Hallam-ICS Combustible Dust Safety Service Line

2021 – Instructor – NC Industrial Ventilation Conference

Extensive experience with material handling and dust collection systems

Licensed PE in 27 states

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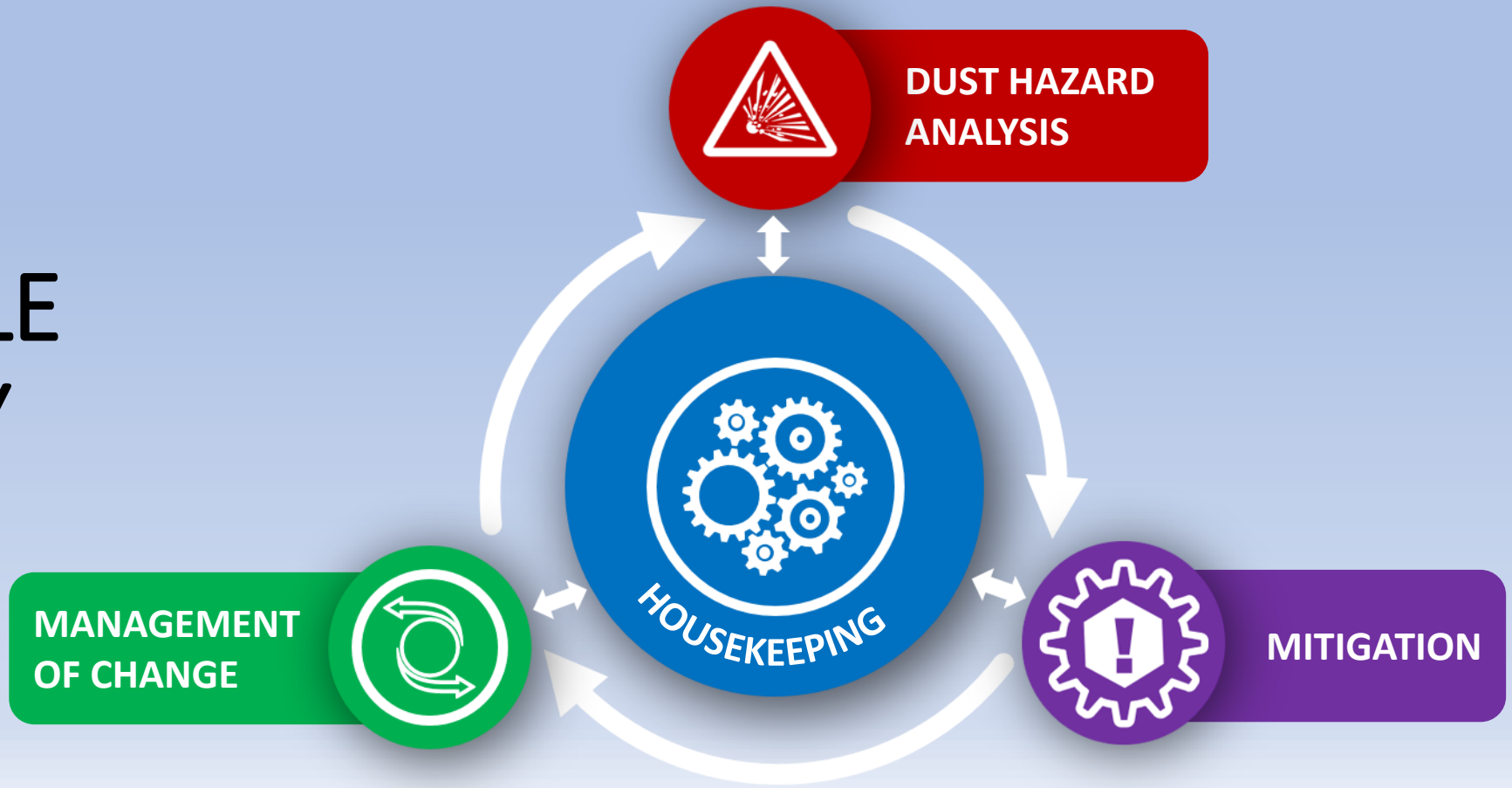
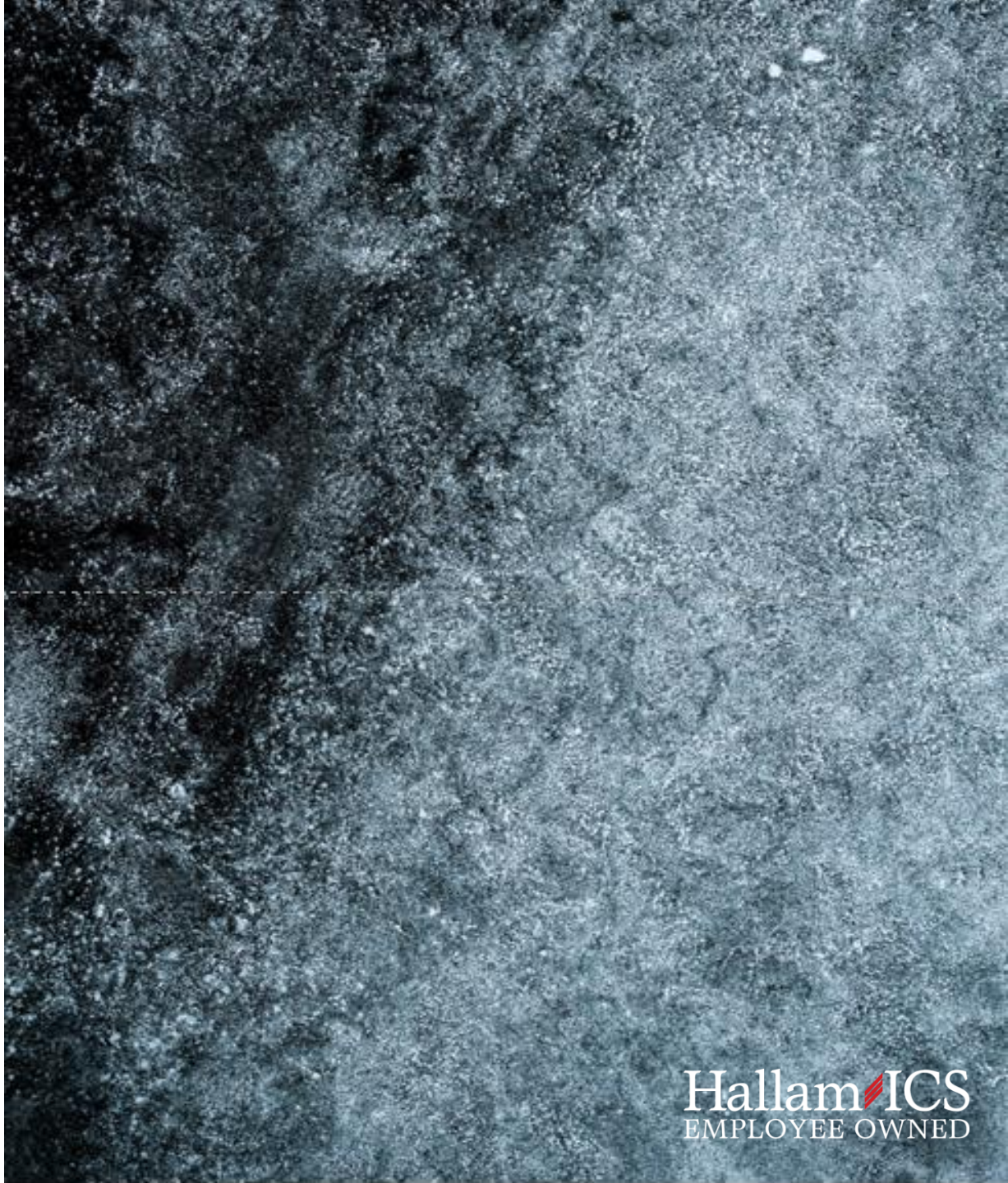
COMBUSTIBLE DUST SAFETY CYCLE



Fundamentals

How do I know if my dust is combustible?

- “Common” Industry Knowledge
- Safety Data Sheets (sometimes!)
- Published Data (NFPA/OSHA)
- Testing



Fundamentals

- FIRE TRIANGLE
- FLASH FIRE “SQUARE”
- EXPLOSION PENTAGON

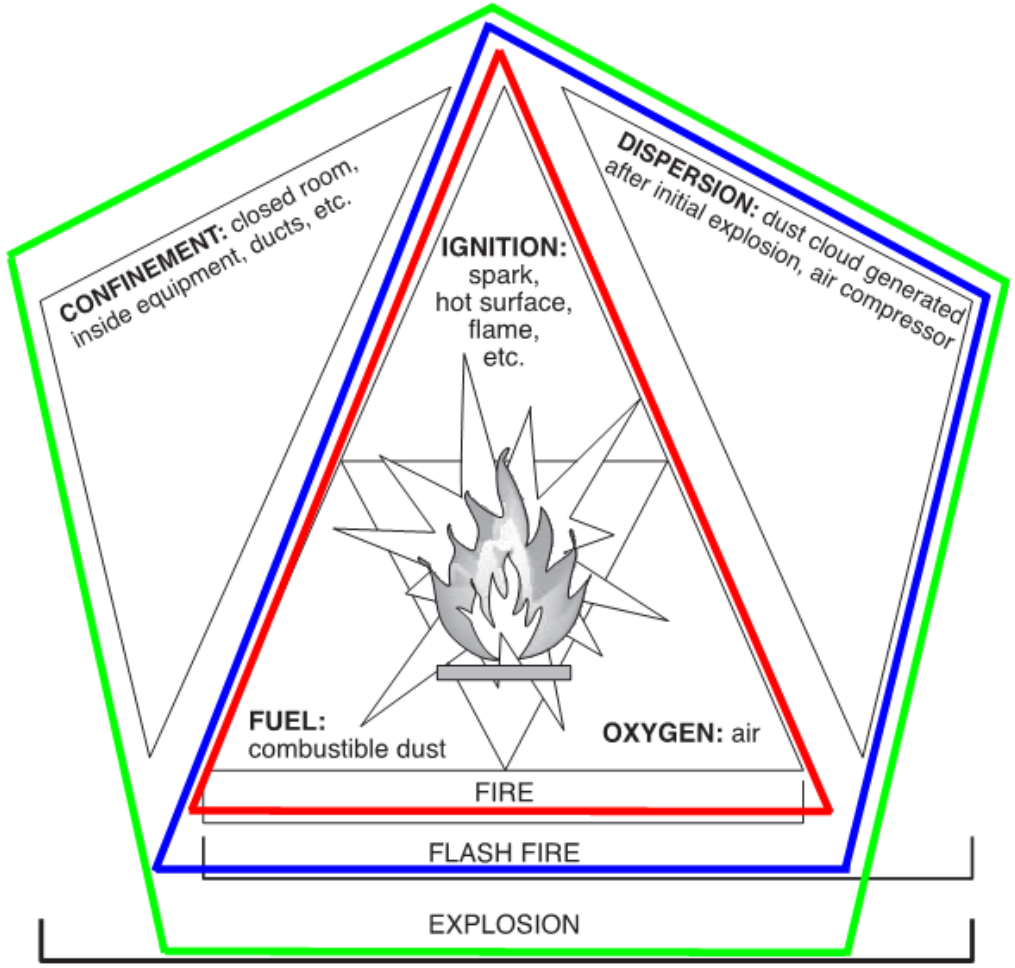
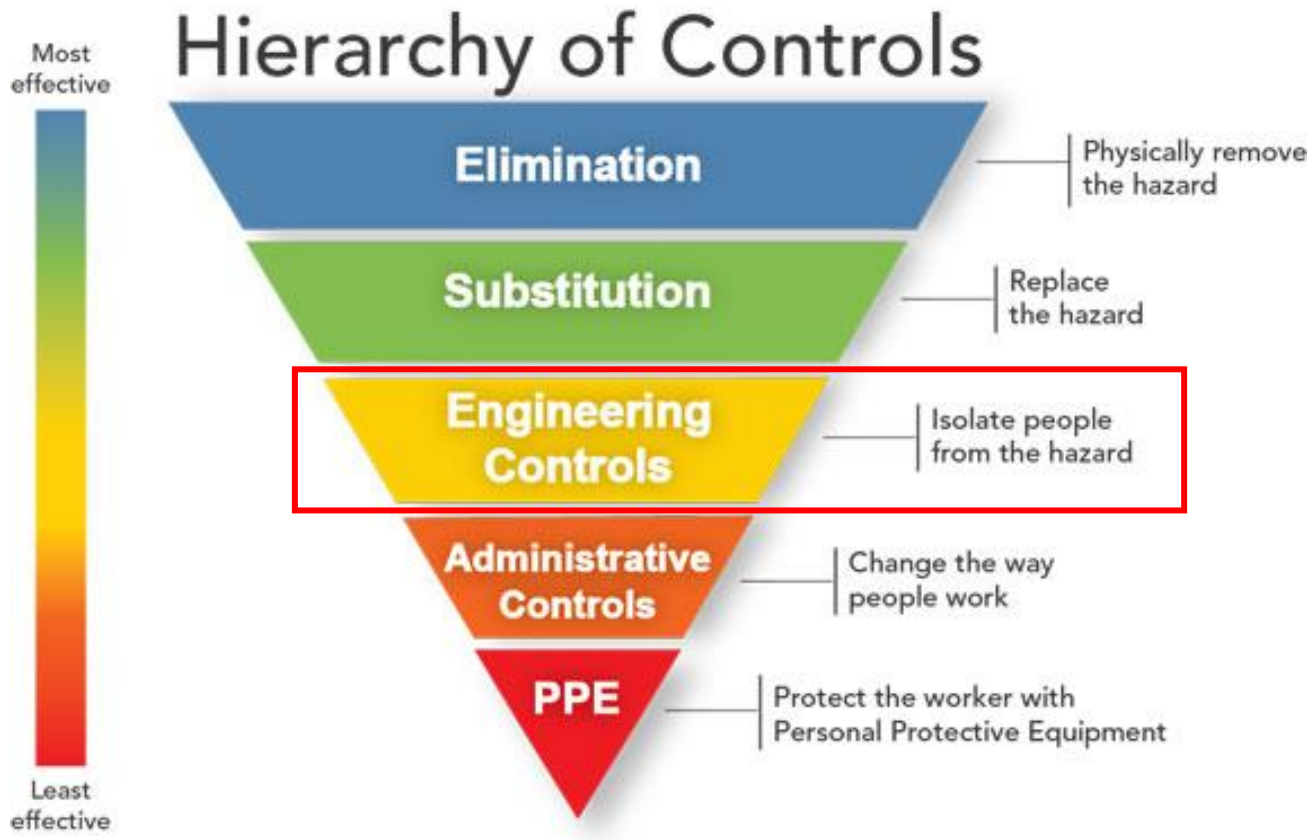


FIGURE A.5.2 Elements Required for Fires, Flash Fires, and Explosions.

Fundamentals

From the National Institute for Occupational Safety and Health (NIOSH)



Fundamentals

What is a Dust Hazard Analysis (DHA)?

A systematic review of the processes and areas of a facility where combustible dusts are present.

The analysis aims to identify the

- Fire
- Flash Fire
- Explosion

hazards that exist in the facility.

<u>Especially</u> the hazards that were previously unrecognized!

Fundamentals

What is a Dust Hazard Analysis (DHA)?

A DHA does NOT evaluate health hazards such as employee exposure.

The scope of a DHA is limited to the physical hazards associated with

- Fires
- Flash Fires
- Explosions

However, IH Reports can provide information that is useful in conducting the DHA.

7 Steps to Complete a DHA

1. Acquire Documentation
2. Field Verify/Survey
3. Assemble DHA Team
4. Identify Hazards & Evaluate Compliance
5. Prioritize Hazards
6. Document Results
7. Repeat

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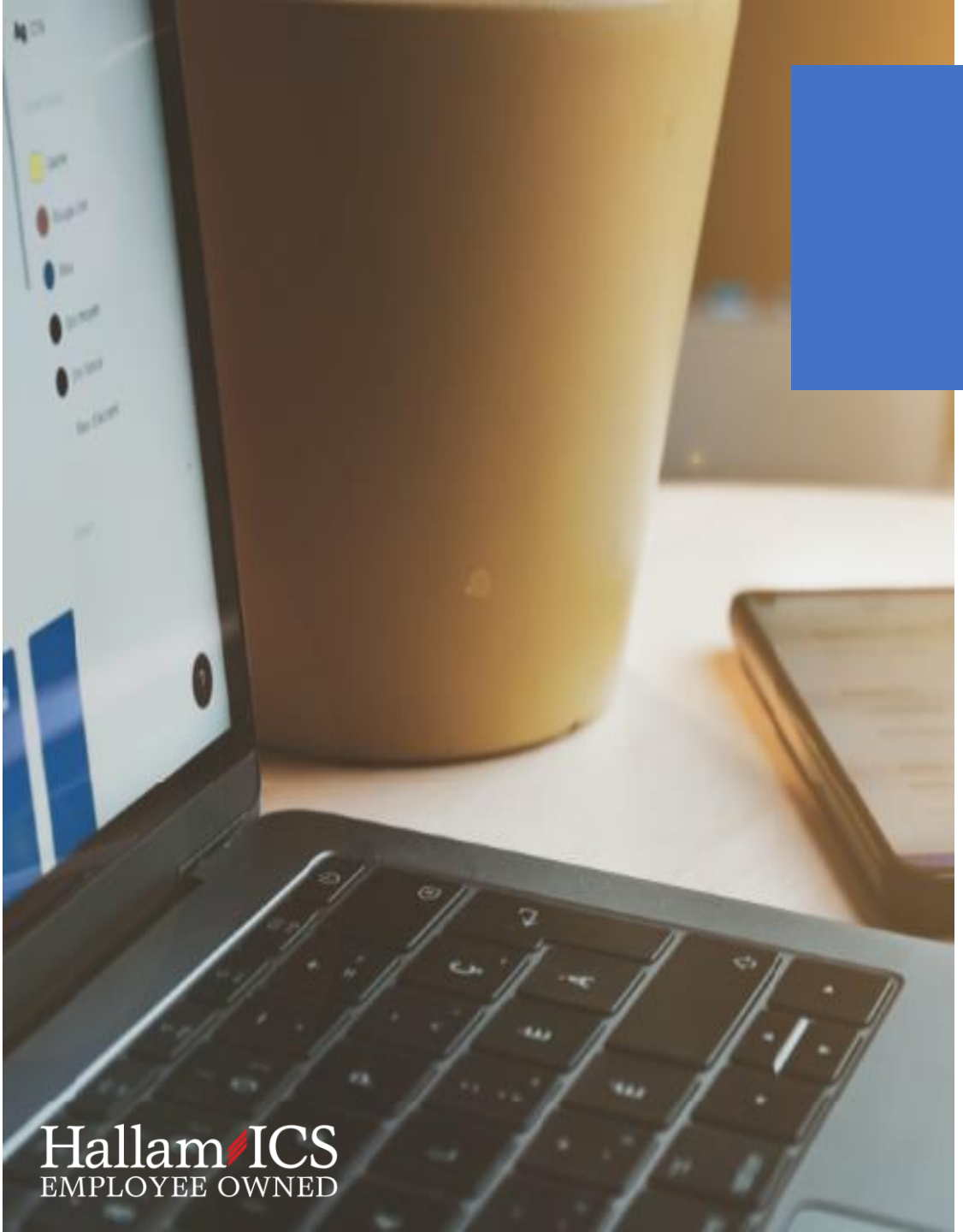


1. Acquire Documentation

Begin by collecting relevant process, equipment, and operating data, for example:

- Process Flow Diagrams (PFDs)
- Piping and Instrumentation Diagrams (P&IDs)
- Mass & Energy Balance
- General Arrangement Drawings (GAs)
- Building Plans
- Equipment Manufacturer Drawings, Data Sheets, Manuals, etc.
- Electrical Hazard Classification Drawings

1. Acquire Documentation

Documenting and understanding the materials involved in the process and their properties at each stage is also required.

When considering combustible dusts, we especially pay attention to:

- Particle Size
- Particle Size Distribution
- Moisture Content

Dust test reports (if any testing has been conducted) should also be collected

1. Acquire Documentation

Applicable NFPA Standards:

NFPA 652 – Standard on the Fundamentals of Combustible Dust

NFPA 61 – Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities

NFPA 655 – Standard for Prevention of Sulfur Fires and Explosions

NFPA 484 – Standard for Combustible Metals

NFPA 654 – Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids

NFPA 664 – Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities

NFPA 68 – Standard on Explosion Protection by Deflagration Venting

NFPA 69 – Standard on Explosion Prevention Systems

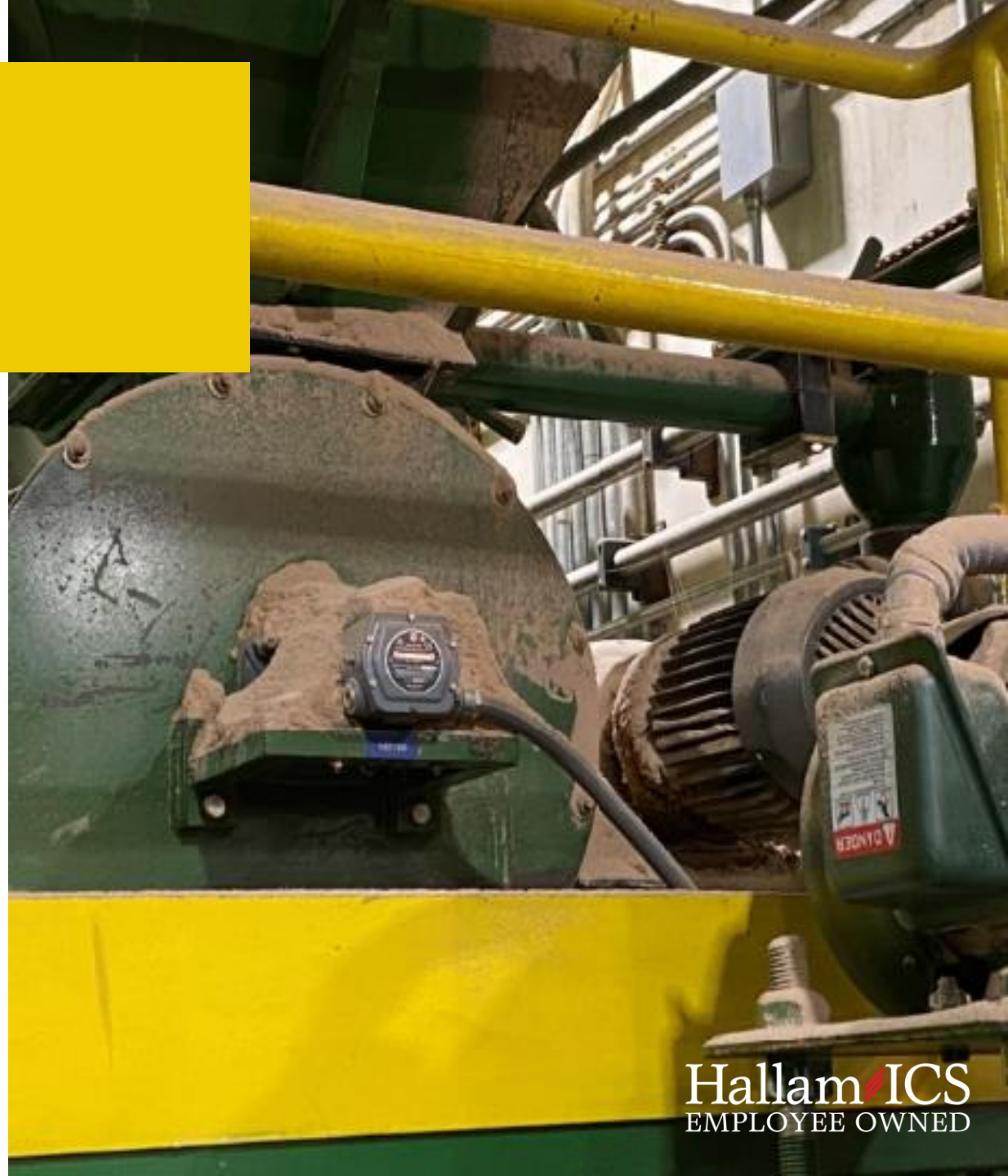
NFPA 660 – Combustible Dust “Code” (2024?)

2. Field Verify/Survey

The balance of verify/survey will depend on the quantity and quality of available documentation.

Existing documentation is often out-of-date or incomplete.

Due diligence should be exercised to verify the information that will serve as the basis for the DHA.



2. Field Verify/Survey

Extensive efforts may be required to sufficiently document larger, older facilities to support a thorough DHA.

Virtual site visits became popular during Covid, but there are disadvantages to this approach, that must be considered.

3. Assemble DHA Team

NFPA 652 recommends (but does not require) that a DHA be completed by a team and requires that the DHA be led by a *qualified person*.

Teams can be as few as 2 people or as many as you want, but more than about 5-6 can become difficult to manage.

3. Assemble DHA Team

Who should be on the team?

- EHS personnel
- Plant engineers
- Operations
- Maintenance
- Management

All representatives bring different and valuable perspectives.

Ideally, the entire team works through the analysis together, but this is often not feasible.

4. Identify Hazards & Evaluate Compliance

This step is the heart of the DHA—and the primary reason the process is mandated by NFPA 652.

This step is the part of the process where you systematically review and think critically about the process and facility to identify the potential hazards.

4. Identify Hazards & Evaluate Compliance

Different approaches and formats can be used.

There is no mandated approach.

- Good – allows for flexibility
- Bad – can be confusing

Goal is the same, regardless of method used:

- Consider every point in the process
- Identify the hazards
- Determine what measures are required to mitigate the risk

4. Identify Hazards & Evaluate Compliance

Helpful to remember the fire triangle, flash fire quadrilateral (square), and explosion pentagon.

However, we almost always have:

- Oxidizing agent (air)
- Fuel (combustible dust)

the analysis tends to focus on dust quantities/concentrations and ignition sources.

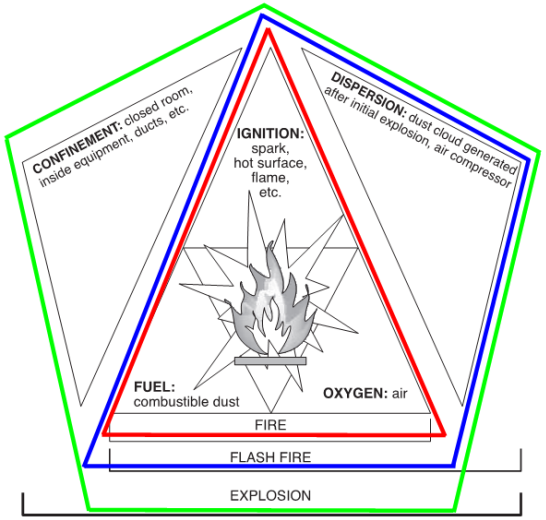


FIGURE A.5.2 Elements Required for Fires, Flash Fires, and Explosions.

4. Identify Hazards & Evaluate Compliance

How do we do this?

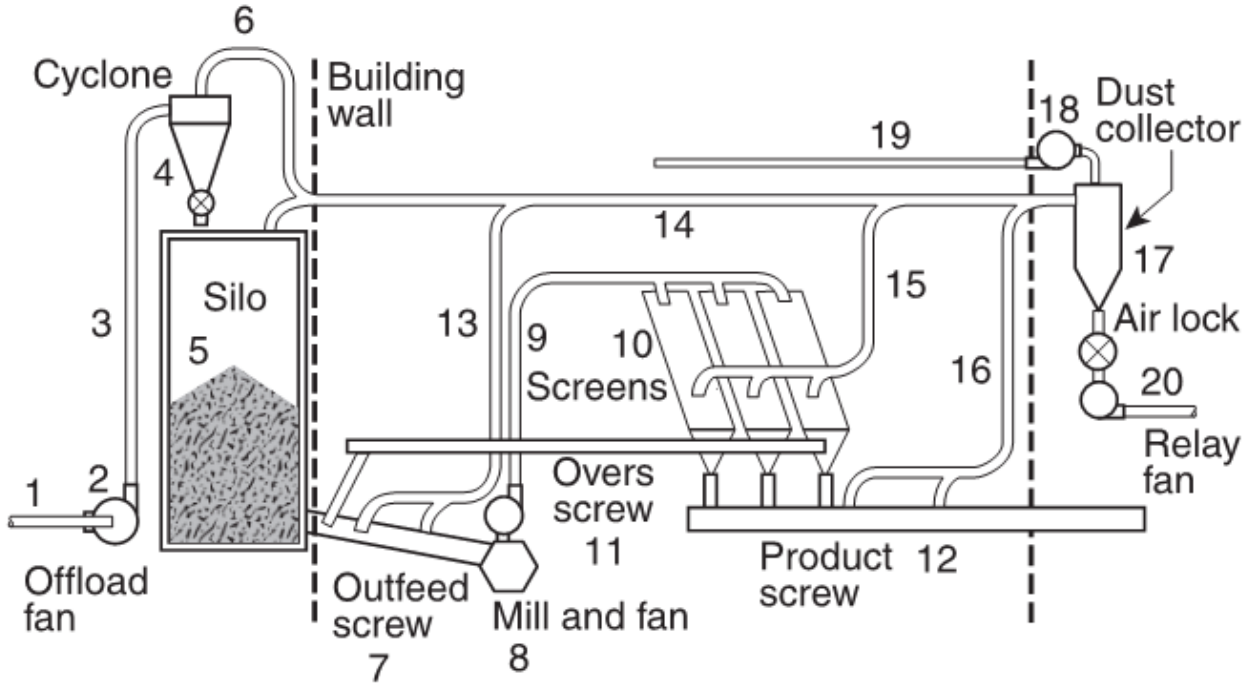
Break the process and facility down into nodes, segments, or areas.

At each point, ask the following questions:

- Is there, or might there be, enough dust to produce a combustible atmosphere?
- Are there, or might there be, any means to disperse dust in a cloud?
- Are there, or might there be, any ignition sources?
- What existing protective measures are already in place?

Example

NFPA 652 Annex B illustrates one example of how to conduct a DHA.



1 Process input
2 Offload fan
3 Duct from fan to cyclone
4 Cyclone
5 Silo
6 Duct
7 Outfeed screw conveyor
8 Mill and discharge fan
9 Discharge duct to screens
10 Screens
11 Screw conveyor
12 Product screw conveyor
13 Duct
14 Duct
15 Duct
16 Duct
17 Dust collector
18 Fan
19 Duct for return air
20 Relay fan

Δ **FIGURE B.4.5 An Example Process.** *(Source: J. M. Cholin Consultants, Inc.)*

Example

A common approach is to use a spreadsheet for the analysis.

Identify the nodes/segments/areas, and ask the questions we listed earlier

Loc. ID	Description	Is the particulate deflagrable, suspended in air, and above the MEC?	Are there competent ignitors available?	What existing hazard management is in place?
	Process Equipment			
1	Receive Raw & Component Materials	No dust is generated under normal conditions. Accidental damage to packaging of powdered materials could liberate dust.	Non-classified electrical equipment, space heaters, electric and propane forklift, scissor lift	Standard practice is to contain spills, ad clean immediately with broom and dustpan.
2	Stage & prep materials for processing	No dust is present or generated		
3	Load materials into process equipment	No dust is present or generated		
4	Iron Bird Seed production machine	No - dust generated during processing is not sufficient in quantity to exceed 25% of the MEC - see calculations in appendix	Hot Surfaces: Overheated bearings/shafts Mechanical: Sparks from metal-to-metal contact inside machine	Dust collection system captures dust at the points where it is generated
5	Iron Bird Seed Dust Collector Inlet Duct	No - dust collection rate is not sufficient in quantity to exceed 25% of the MEC - see calculations in appendix	Hot Surfaces: Overheated bearings/shafts Mechanical: Sparks from metal-to-metal contact inside machine Propagation: Embers from upstream equipment	Regular maintenance of equipment Regular inspection of equipment to ensure alignment
6	Iron Bird Seed Dust Collector	Likely, especially during filter purge	Propagation: Embers from upstream equipment Electrical: Static Discharge	Regular maintenance of equipment Regular inspection of equipment to ensure alignment Equipment is properly bonded and grounded

Example

Compare existing hazard mitigation to NFPA requirements.

Identify additional mitigation strategies required.

Options for consideration?

Additional hazard management options recommended or offered for consideration?	NOTES
None	
None	
None	
Recommend adding explosion protection per NFPA 61 § 9.7.3, and isolation per § 9.7.4. (See report for more details on recommendations.)	Addition of explosion protection and isolation will reduce the Severity Level.

5. Prioritize Hazards

At the end of Step 4, we have a list of inadequately mitigated hazards.

We also have a list of recommended mitigation actions to address those hazards.

Where do we start???

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⚠ 5. Prioritize Hazards

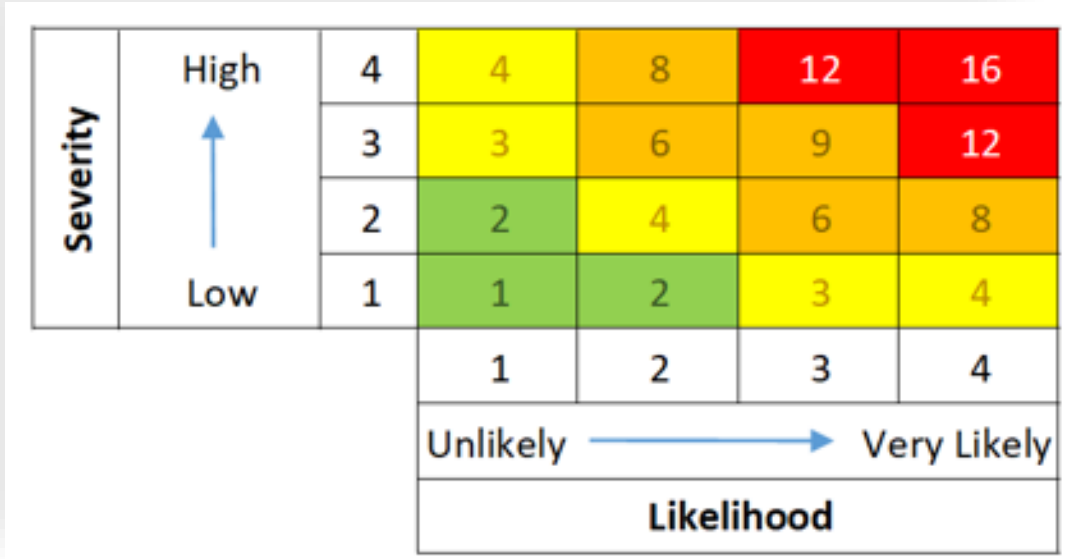
How do we do this?

Typically use some type of risk matrix and there are many different valid approaches.

Goal is a semi-quantitative approach to rank the hazards based on risk.

Think of it as an order of magnitude ranking – not a probability calculation.

⚠ 5. Prioritize Hazards



⚠ 5. Prioritize Hazards

Likelihood	
1	Extremely Unlikely: The presence of a combustible atmosphere and/or a competent ignition source is not expected to be present under any circumstances
2	Remote: The presence of a combustible atmosphere and/or a competent ignition source is only expected to be present during upset conditions
3	Reasonably Possible: The presence of a combustible atmosphere and/or a competent ignition source is expected to be present infrequently during normal operation (i.e., during startup or shutdown)
4	Frequent: The presence of a combustible atmosphere and/or a competent ignition source is expected to be present regularly during normal operation

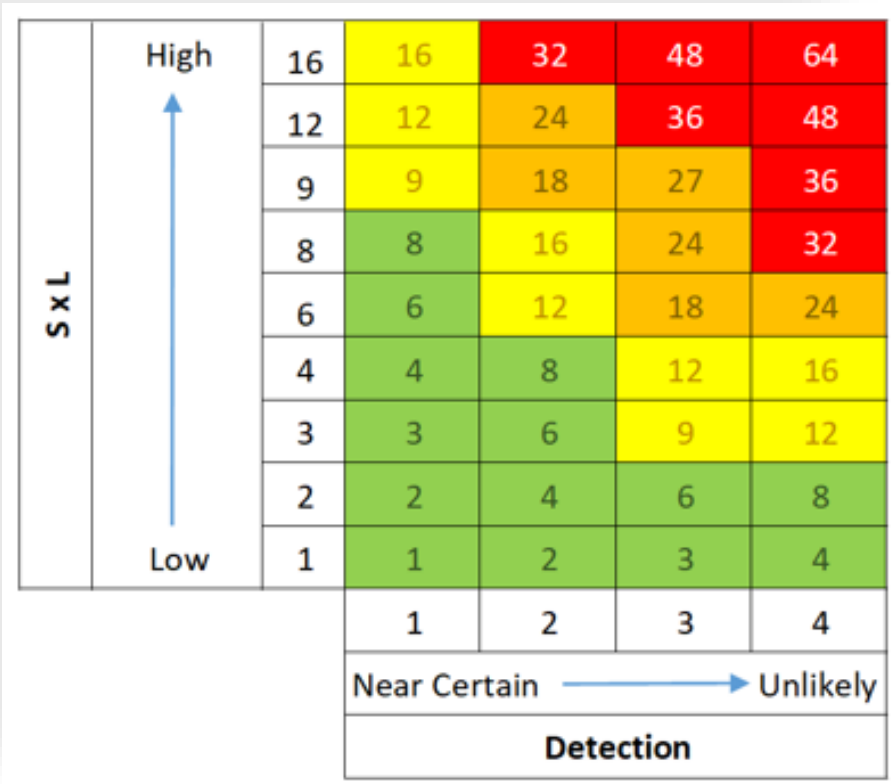
Severity	
1	Negligible: No injuries likely Minimal disruption to production expected
2	Minor: At least one lost-time injury possible Some disruption to production is expected
3	Critical: Multiple lost-time injuries are possible Significant disruption to production is expected
4	Catastrophic: At least one fatality is possible Extended disruption to production is expected

⚠ 5. Prioritize Hazards

Hallam-ICS has developed a risk evaluation methodology adapted from the risk priority number (RPN) calculation used with Failure Mode & Effects Analysis (FMEA).

Detection	
1	Conditions creating a combustible atmosphere or competent ignition source will almost certainly be detected by sensors, observed by operators, or proactively addressed by procedures/systems/controls such that action can or will be taken before an incident occurs.
2	Conditions creating a combustible atmosphere or competent ignition source are likely to be detected by sensors, observed by operators, or proactively addressed by procedures/systems/controls such that action can or will be taken before an incident occurs.
3	Conditions creating a combustible atmosphere or competent ignition source are not likely to be detected by sensors, observed by operators, or proactively addressed by procedures/systems/controls such that action can or will be taken before an incident occurs.
4	Conditions creating a combustible atmosphere or competent ignition source will almost certainly not be detected by sensors, observed by operators, or proactively addressed by procedures/systems/controls such that action can or will be taken before an incident occurs.

⚠ 5. Prioritize Hazards



⚠ 5. Prioritize Hazards

Address the highest-ranked hazards first

BUT

Do not overlook low-hanging fruit.

Some lower-ranked hazards can be relatively quick/easy/inexpensive to mitigate.

SAMPLE Dust Hazard Analysis Summary Table

ACME Corporation Anytown, USA Revision: 0 Date: 05/14/2020	**Combustible Dust(s):**	Iron Bird Seed Dust Earthquake Pills Dust & Dehydrated Boulder Dust	**Minimum Explosible Concentration (g/m^3):**	varies - see test reports
			Minimum Ignition Energy (mJ):	varies - see test reports
	K_{st} (bar-m/s):	varies - see test reports	**Minimum Ignition Temp. Cloud (°F):**	varies - see test reports
	P_{max} (bar):	varies - see test reports	**Minimum Ignition Temp. Surface (°F):**	varies - see test reports

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Loc. ID	Description	Is the particulate deflagrable, suspended in air, and above the MEC?	Are there competent ignitors available?	What existing hazard management is in place?	L	S	D	Risk Level	Additional hazard management options recommended or offered for consideration?	NOTES
	Process Equipment							0		
1	Receive Raw & Component Materials	No dust is generated under normal conditions. Accidental damage to packaging of powdered materials could liberate dust.	Non-classified electrical equipment, space heaters, electric and propane forklift, scissor lift	Standard practice is to contain spills, ad clean immediately with broom and dustpan.	2	2	1	4	None	
2	Stage & prep materials for processing	No dust is present or generated								
3	Load materials into process equipment	No dust is present or generated								
4	Iron Bird Seed production machine	No - dust generated during processing is not sufficient in quantity to exceed 25% of the MEC - see calculations in appendix	Hot Surfaces: Overheated bearings/shafts Mechanical: Sparks from metal-to-metal contact inside machine	Dust collection system captures dust at the points where it is generated	1	3	2	6	None	
5	Iron Bird Seed Dust Collector Inlet Duct	No - dust collection rate is not sufficient in quantity to exceed 25% of the MEC - see calculations in appendix	Hot Surfaces: Overheated bearings/shafts Mechanical: Sparks from metal-to-metal contact inside machine Propagation: Embers from upstream equipment	Regular maintenance of equipment Regular inspection of equipment to ensure alignment	1	2	2	4	None	
6	Iron Bird Seed Dust Collector	Likely, especially during filter purge	Propagation: Embers from upstream equipment Electrical: Static Discharge	Regular maintenance of equipment Regular inspection of equipment to ensure alignment Equipment is properly bonded and grounded	3	4	3	36	Recommend adding explosion protection per NFPA 61 § 9.7.3, and isolation per § 9.7.4. (See report for more details on recommendations.)	Addition of explosion protection and isolation will reduce the Severity Level.

13	Explosive Tennis Balls Dust Collector Inlet Duct	No - dust collection rate is not sufficient in quantity to exceed 25% of the MEC - see calculations in appendix	Hot Surfaces: Overheated bearings/shafts Mechanical: Sparks from metal-to-metal contact inside machine Propagation: Embers from upstream equipment	Regular maintenance of equipment Regular inspection of equipment to ensure alignment	1	2	2	4	None	
14	Explosive Tennis Balls Dust Collector	Likely, especially during filter purge	Propagation: Embers from upstream equipment Electrical: Static Discharge	Regular maintenance of equipment Regular inspection of equipment to ensure alignment Equipment is properly bonded and grounded	3	4	3	36	Recommend adding explosion protection per NFPA 654 § 9.7.1, and isolation per § 9.7.2. (See report for more details on recommendations.)	Addition of explosion protection and isolation will reduce the Severity Level.
25	Earthquake Pills Dust Discharge and Collection	Likely, especially during filter purge	Propagation: Embers from upstream equipment Electrical: Static Discharge	Regular maintenance of equipment Regular inspection of equipment to ensure alignment Equipment is properly bonded and grounded Explosion vent is installed Isolation device installed in ductwork	3	2	4	24	Recommend installation of explosion isolation on collector dust discharge per NFPA 68 § 7.7. (See report for more details on recommendations.)	Dust collector has an explosion vent and isolation device on the incoming ductwork. Lack of isolation could result in contents of super sack being dissipated and ignited. Collector is outdoors in area not frequently occupied by personnel. Isolation devise will reduce the Likelihood Value.
								0		
	Building General	**This section of the table is used to record hazards, observations, or other relevant items not related to the processes described above. Some columns may not be applicable.**								
48	Building Exhaust/Makeup Fans		The fans themselves are potential ignition sources - motor, overheated drive components, etc.	Filters between fans and processing areas					Recommend ensuring filter replacement is on regular PM schedule.	Building exhaust/make-up fans were observed to be enclosed by ducts and protected by filters such that any dust in the air cannot reach the fans.
49	Unit heaters in production area	Extremely unlikely - only possible in the event of a catastrophic failure of a dust collection system	The heaters themselves are potential ignition sources		1	2	4	8	Recommend adding cleaning of unit heaters to housekeeping schedule/procedures.	Heaters were not observed to be in any areas prone to combustible dust hazards other than fugitive dust accumulations. Small fires could be initiated if accumulations are not managed and the minimum ignition temperature (MIT) is exceeded. Regular housekeeping procedure to include cleaning heaters will reduce Detection number to 1 and overall Risk Level to 2.
								0		
								0		

***** This table is incomplete, completely fictitious, and only intended to serve as a sample work product and provide mild entertainment value. In no way should this SAMPLE be used as a reference for, or as part of, a Dust Hazard Analysis for a real facility. *****

6. Document Results

NFPA 652 requires that the results of the DHA be documented.

Complete and thorough documentation are important for two primary reasons:

- Evidence of compliance for AHJ
- Basis for Management of Change

6. Document Results

Any Authority Having Jurisdiction (AHJ) might request to see the DHA.

This could be a local fire marshal, an OSHA representative, or some other safety official, or an insurer.

Having a complete and well-organized report shows that you are compliant with the relevant codes and standards, or that you have identified any areas that need attention and have a plan to address them.

6. Document Results

Beyond satisfying AHJ's, the DHA report is equally important to facility owners.

The DHA is not:

- "Extra BS paperwork"
- "Expensive deliverable from an engineering jobs program"
- "Spending money to have someone tell me to spend more money"

The DHA report is a critical tool for keeping the facility and personnel safe.

7. Repeat

NFPA 652 section 7.1.4 requires a review and update of a DHA *at least* every 5 years, or whenever changes are made.

The 5-year update is a minimum requirement intended to identify minor or unrecognized changes that happen over time.

This step is critical for continuous hazard management.

7. Repeat

The DHA needs to be revisited and updated as a facility undergoes changes.

Examples might include:

- Changes to operating parameters of existing processes
- Use of new or different materials or ingredients
- Personnel changes
- Installation of new equipment or processes

All new projects should include a review of the DHA as part of a Management of Change (MOC) procedure.

7. Repeat

Management of Change (MOC)

DHA Report serves as baseline for MOC.

If facility has an existing MOC procedure, it should include review of DHA Report.

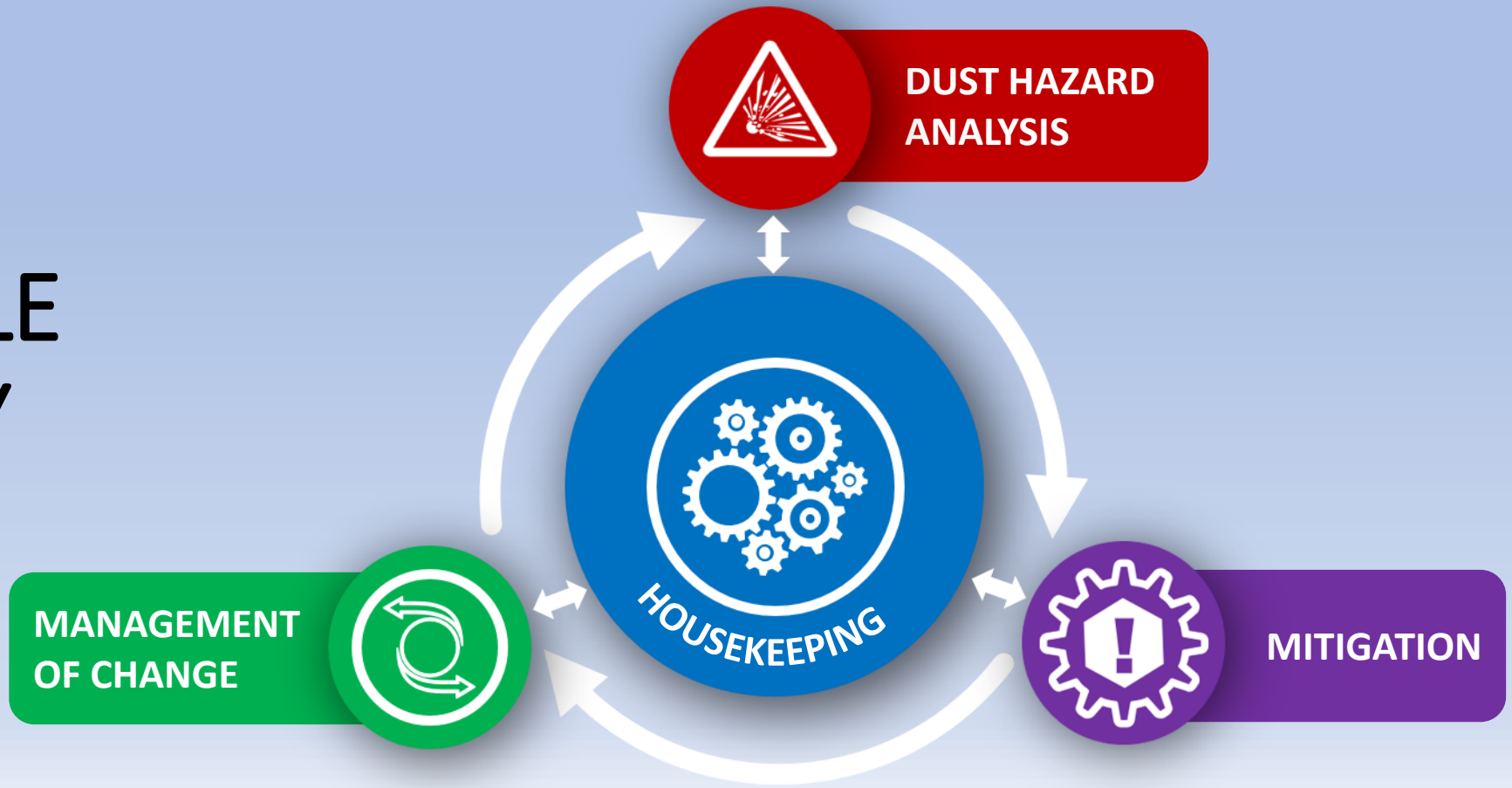
If no MOC procedure exists, someone in a position of responsibility (EH&S Manager, Plant Engineer, Plant Manger, etc.) must be familiar with the report and review it before changes are approved.

7. Repeat

MOC is critical to ensure long-term success of hazard management.

Changes can make existing mitigation methods less effective and can also introduce new hazards that must be mitigated.

COMBUSTIBLE DUST SAFETY CYCLE



SUMMARY

- A DHA is much more than a one-time exercise.
- It is a foundational component of continuous hazard management for combustible dust safety.
- Hopefully, completing a DHA will initiate a change in an organization from reactive compliance to proactive hazard management.

Questions?

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Thank You!

Additional information and resources available at www.Hallam-ICS.com

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