STREAMLINE YOUR DUST HAZARD ANALYSIS

Sigma-HSE

Author: Michelle R. Murphy

Abstract

One of the most important responsibilities of owners and operators handling combustible dusts is the conduct of a dust hazard analysis.

The DHA is conducted to identify and evaluate fire, deflagration, and explosion hazards in handling combustible dusts.

The recent CCPS book, Guidelines for Combustible Dust Hazard Analysis, presents two approaches to completing DHAs: traditional and risk-based.

In a risk-based approach, consequences and likelihood are assessed to determine the risk of an identified hazard scenario. Ignition source control is a major part of defining the likelihood of an event.

In a risk-based DHA, potential ignition sources are considered, credible ones are evaluated, with the goal of understanding the mechanism by which they are generated, their incendivity in the process equipment, and the safeguards, or barriers, protecting against them.

With most of the time in a DHA spent understanding and evaluating potential ignition sources, preparing the necessary input information ahead of time can streamline the time spent.

This paper seeks to provide the type of information, including dust characteristics, equipment, operating, and maintenance, that is often used in a thorough evaluation of ignition sources. Gathering this information for ready access during the DHA, will streamline the study and make more efficient use of the team time.

Introduction

Dust hazard analyses are required in many areas of the world. By NFPA [1] in the United States and North America, by ATEX [2], [3] in Europe and by DSEAR [4] in the UK.

Other areas, such as South America, Asia and the Middle East follow one or more of these standards.

DHAs are also often required by insurance companies and as corporate policy.

The goal of all of these studies is the same:

- Identify hazards
- Evaluate existing safeguards
- Recommend additional safeguards as needed

With so much time and money spent on these activities, it is important to get the best results for the investment made (Figure 1).

The result of a successful DHA is a set of actionable, cost-effective recommendations that achieve the necessary risk-reduction (Figure 2).

Many things impact the success of the DHA, including team makeup, preparation, availability of information, and team participation.

This paper focuses on a few key aspects: preparation, team makeup, and ignition source evaluation.

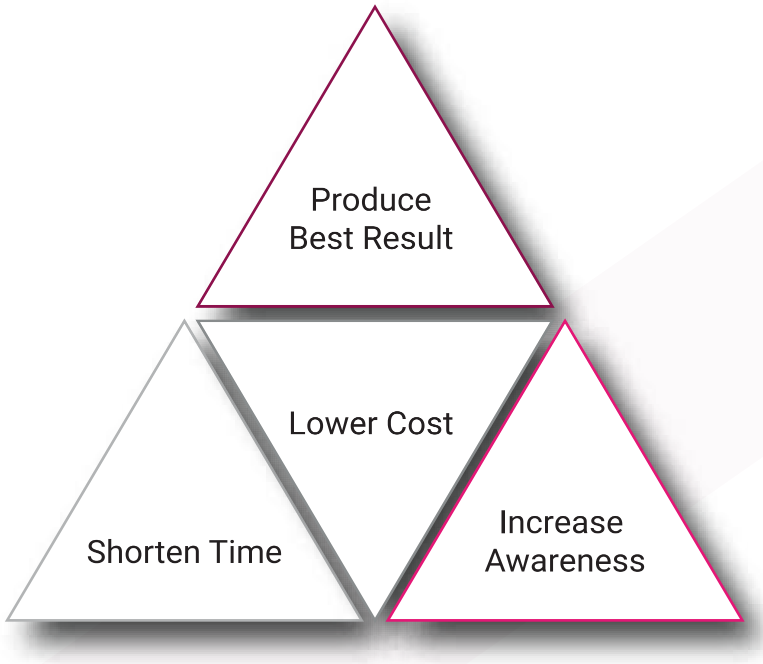

Figure 1. Successful DHAs produce the best result in the shortest time and for the lowest cost

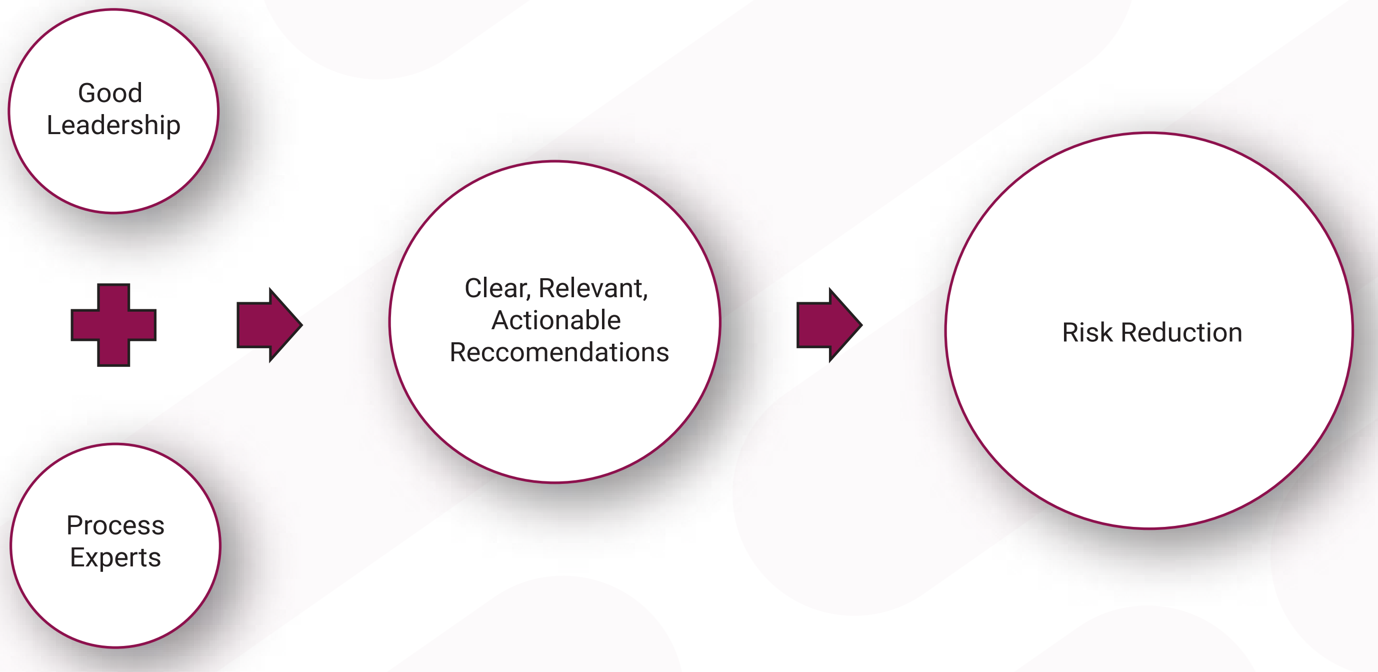

Figure 2. To achieve the desired outcome of a DHA – Risk Reduction – it is necessary to have good leadership, input from process experts, and a set of clear, relevant, actionable recommendations.

Streamlining Approach

Dust hazard analyses (DHAs) follow a typical pattern of preparation, analysis, and follow-up. The DHA approach is described in detail in Murphy and Borene [5].

In the preparation phase, there is an initial meeting with facility personnel, document delivery to team leader, scoping and scheduling. In the analysis phase, there is an opening meeting, plant walk-through, and team meetings.

During the follow-up and reporting phase, there is resolution of any open or parking lot items from the team meetings, close-out meeting with the site, and production of a report with the findings (recommendations) of the team.

While the follow-up and reporting phases are critical to a successful DHA, the scope of this paper is to streamline the preparation and analysis phases of the study.

The sections below provide generic lists of information needed for successful preparation and analysis activities. Following are more details on the specific information needed and how it is used in the DHA.

Please refer to the CCPS books on PHA and DHA for more details on other phases of the DHA [6], [7].

During preparation, significant time is spent in collecting, sharing, and reviewing documents.

It is typically the role of the site contact to collect and share their plant documentation while the DHA leader reviews the documents and develops the scope and schedule.

The process safety information requested during preparation includes the following:

• Process descriptions
• Combustible dust characteristics and test reports
• Drawings
• Block Flow
• Process Flow
• Process & Instrument Diagrams
• Area Electrical Classification Drawings
• Relevant incidents
• Relevant MOCs (for revalidations)
• Action plans from previous DHAs (for revalidations)

With this process safety information, the team leader can outline the nodes to be evaluated.

Once complete, a node review meeting is held to review the proposed nodes and fill in the design and operating information needed to define each node.

The design and operating information to document includes:

- Process name
- Type of equipment
- Relevant drawing numbers
- Equipment numbers
- Design intent of the equipment
- Dust properties applied in the node
- Safe operating ranges

This information can be populated during the Node Review meeting with a subset of the full DHA team, shortening the time for the full set of team members.

This means less team time is spent explaining the process to the team leader and chasing down design and operating details.

Overall, up-front work by the team leader and site contact will streamline team meeting time.

Analysis

The analysis phase is where the team meets to identify hazards, evaluate existing safeguards, and make recommendations.

It is here where the real work is done. It is critical to have the right process experts in the meeting and supporting documentation at the ready.

The following process experts, at a minimum, should be in the team meetings:

- Design
- Operation
- Maintenance
- Housekeeping

Supporting documentation should also be available, as follows:

- Equipment files
- Operating parameters and procedures
- Control logic
- Explosion protection systems designs

Streamlining Application

In the DHA team meetings, the team will work together to identify and define hazards, evaluate existing safeguards, and write recommendations.

To do this, they will need a basic understanding of the operation of the equipment, what is it designed to do, at what operating parameters does it accomplish this, and what material is it handling.

A risk-ranking matrix will also streamline the team discussion by forcing the team to focus on higher risk hazards.

See Murphy and Borene [5] for details on risk ranking matrices.

To identify hazards, they will need to understand where there is a possibility of incendive ignition sources based on the process design and operation vs. the dust characteristics of the material handled in the equipment.

This will be followed by an evaluation of the existing safeguards, whether they be preventive or mitigative. Where the existing safeguards are not adequate, they will write recommendations for additional safeguards.

To understand the operation of the equipment, they will need to know the relevant operating parameters. The relevant operating parameters vary by type of equipment and are listed in Table 1.

To identify hazards the team will need to understand where there is a possibility of incendive ignition sources. Here, the team will couple the operation of the equipment, including failure modes, with the dust characteristics of the material handled to determine if there is a possibility of ignition in the equipment.

Table 2 presents the relevant characterization tests as a function of equipment type. Note that the characteristics of minimum explosible concentration, minimum ignition energy, minimum ignition temperature of a cloud, and minimum ignition temperature of a layer define the sensitivity to ignition of a given material while the maximum explosion pressure (Pmax) and explosion index (KSt) define the severity of an event.

Ignition Source Evaluation

The majority of team time in a DHA is spent in evaluating ignition hazards.

Ignition hazards can be grouped into types, temperature, mechanical, and electrostatic. Any of these might be present in a piece of equipment or in a building space with fugitive dust.

To identify temperature-based ignition hazards operating parameters (including failure modes) should be compared with dust sensitivity data. This is listed in Figure 3.

For mechanical ignition hazards, a review of design, operating, and maintenance practices is needed. See Figure 4.

A review of design, operating, and maintenance practices can also uncover electrostatic ignition hazards.

Figure 5 lists the practices to review for electrostatic hazards.

When it comes to identifying ignition hazards in building spaces, a review of operating and maintenance practices will provide the input needed, as shown in Figure 6.

Table 1. Relevant Operating Parameters for Equipment

Equipment	Moisture Content	Particle Size	Temp	Press	Solids Rate	Airflow	Level	RPM
Bulk unloading	●	●	●	●	●	● *		
Bulk storage	●	●	●	●	●		●	
Pneumatic conveying	●	●	●	●	●	●		
Air material spearators	●	●	●	●	●	●	●	
Sifters & screens	●	●	●	●	●			● *
Bucket elevators	●	●	●	●	●			●
Mechanical conveyors	●	●	●	●	●			●
Material feeding devices	●	●	●	●	●			●
Size reduction equipment	●	●	●	●	●			●
Blenders & mixers	●	●	●	●	●		●	●
Ovens & dryers	●	●	●	●	●	●	● *	● *
Packaging units	●	●	●	●	●			● *
Big bag unloading	●	●	●	●	●			
Solids charging	●	●	●	●	●			
Buildings housing equipment	●	●	●	●	●			

Table 2. Relevant Characterization Data for Equipment

Equipment	Severity of Ignition		Sensitivity to Ignition			
	P_{max}*	K_{st}*	MEC	MIE	MIT_{cloud}	MIT_{layer}
Bulk unloading	●	●		●		
Bulk storage	●	●				
Pneumatic conveying	●	●		●		
Air material spearators	●	●		●		
Sifters & screens	●	●		●		
Bucket elevators	●	●	●	●		
Mechanical conveyors	●	●	●			
Material feeding devices	●	●	●			
Size reduction equipment	●	●	●		●	
Blenders & mixers	●	●				
Ovens & dryers	●	●	●		●	●
Packaging units	●	●		●		
Big bag unloading	●	●		●		
Solids charging	●	●		●		
Buildings housing equipment	●	●	●	●	●	●

Figure 3. Identification of temperature-based ignition sources requires comparison of worst-case operating parameters with dust characteristics

Self-Heating or Burning

- Highest temperature achievable
- Decomposition temperature
- MIT Layer
- MIT Cloud

Open Flames

- Concentration of dust in contact with the flame
- MEC

Hot Surfaces

- Highest temperature achievable
- MIT Layer
- MIT Cloud
- Note presence of dust layers

Heated Equipment

- Highest temperature achievable
- MIT Layer
- MIT Cloud

Fuel-Fired

- Concentration of dust in contact with the flame
- MEC

Heated Air

- Highest temperature achievable
- MIT Layer
- MIT Cloud

Figure 4. Identification of mechanical ignition hazards requires a review of design, operating, and maintenance practices

Bearings

- RPM of equipment
- Location of bearings
- In contact with dust stream
- Monitored for overheating

Impact Spark

- Materials of construction of equipment
- Presence of foreign material separators

Frictional Spark

- RPM of equipment
- Presence of foreign material separators

Figure 5. Identification of electrostatic ignition hazards requires a review of design, operating, and maintenance practices

Electrostatic Spark

- Conductivity of equipment
- Resistance of flexible connections
- Rate of transport of materials
- Grounding and bonding program
- Personnel discharge potential (materials MIE < 30 mJ)
- Application of FIBSs and RIBCs
- MIE

Figure 6. Identification of building space ignition hazards requires a review of operating and maintenance practices

Electrical Spark

- Area electrical classification
- Proper electrical equipment

Hot Work

- Hot work programme
- Awareness of combustible dust hazard
- Use of portable electrical equipment

Industrial Truck

- Appropriate for area electrical classification
- Comply with NFPA 505

Conclusions

This paper provides actions to take to streamline dust hazard analyses. Actions to take, include:

1. Gathering process safety information ahead of the team meetings and providing to the team leader
2. Conducting a node review with a subset of the full team to review the proposed nodes and fill in the design and operating information
3. Gathering the right process experts and supporting information during the team meetings
4. Gathering the correct process safety information for a targeting ignition source review during the team meetings
5. Applying a risk-ranking matrix

It is important to note that streamlining does not equal shortcutting. Not having the necessary experts present, applying overly conservative dust characteristics, writing prescriptive recommendations without detailed understanding, not understanding safeguard design bases, and not risk ranking recommendations can have negative impacts that derail the success of the DHA.

Proper implementation of these streamlining activities will have many benefits:

- Keep the team engaged, and reduce their burden
- Inform all levels of participants and management
- Lower cost and shorten time
- Reduce risk

The success of a DHA is measured by the risk-reduction it provides.

References

[1] NFPA. Standard on the Fundamentals of Combustible Dust. NFPA 652, National Fire Protection Association, Quincy, MA, 2019 Edition.

[2] ATEX 153 Directive 99/92/EC

[3] ATEX 114 Directive 2014/34/EU

[4] Dangerous Substances and Explosive Atmospheres Regulations 2002

[5] M.R. Murphy and M.J. Borene "How to Conduct a Dust Hazards Analysis," Process Safety Progress, March 2018.

[6] CCPS. Guidelines for Hazard Evaluation Procedures. 3rd Edition. Center for Chemical Process Safety, American Institute of Chemical Engineers, New York, NY, 2008.

[7] CCPS. Guidelines for Combustible Dust Hazard Analysis. Center for Chemical Process Safety, American Institute of Chemical Engineers, New York, NY, 2017.

If you'd like to learn more about how Sigma-HSE can help you streamline your dust hazard analysis, check out sigma-hse.com.

Contact Details
US Office
1060 Osgood Street, North Andover
MA 01845
Tel: +1 (848) 828 3661
Email: info-us@sigma-hse.com

UK Office
Unit 2 Moorside Point, Moorside Road
Winchester, UK
SO23 7RX
Tel: +44 1962 840570
Email: info@sigma-hse.com

India Office
Office No. 1008-1009
10th Floor, Mercantile Building, Kasturba
Gandhi Marg, Connaught Place,
New Delhi
Tel: +91 11 4356 5446
Email: safety-india@sigma-hse.com

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