Combustible Dust Management Screening: Methodology and Tool Development

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Abstract

The requirement to conduct a Dust Hazard Analysis is now in place per NFPA Combustible Dust standards. This affects a wide variety of industries that have various levels of experience with implementing process safety management (PSM) systems. Companies or individual sites that do not have an existing combustible dust hazard management system, or sites with an out-of-date dust hazard analysis benefit from a coarse screening to identify key compliance gaps prior to any detailed gap assessment against applicable NPFA standards. This paper outlines a coarse screening approach that can be used as a first pass to evaluate a specific site's processes for managing combustible dust hazards, and is useful to identify areas of highest priority for managing combustible dust hazards.

1 Introduction

Combustible dust hazards occupy a curious category of process hazards. Unlike other hazardous materials, which are generally recognized for their hazardous potential, combustible dusts are sometimes not fully recognized for potentially hazardous characteristics. For example, a facility that has an accidental and unignited release of a butane into an occupied area would certainly recognize this as a near miss. However, a dispersed release of corn starch may not reach the same levels of attention. OSHA's Combustible Dust poster even addresses those who may not be aware of combustible dust hazards. In this poster, materials such as starches, carrot dust, hops (malted), corn, aluminum, lactose, and poly vinyl chloride, are just a handful of some of the materials listed to indicate hazard potential.[1] Dust Hazards span a variety of industries, and this is further reflected in OSHA's Combustible Dust National Emphasis Program.[2]

To highlight this deficit in hazard recognition, the 2015 Color Play Asia incident provides a useful case study that highlights how the hazard of corn starch was not identified. Colored corn starch was released over the 2015 "Color Play Asia" party in Taiwan while music played for the attendees at the party. The corn starch ignited, creating flash fire that engulfed part of the crowd, and resulted in 15 fatalities, 331 serious burn cases, and 135 less severe burn cases. [3] Videos of this event are readily available online, and ignition of the corn starch can be observed.

Once a company recognizes that onsite combustible dust quantities may be hazardous, the next step is to perform a risk evaluation and create actionable plans to manage combustible dust risk. However, managing combustible dust hazards is not a one-size-fits-all process that can be accomplished by a single technology, and multiple regulations/codes/standards may be applicable.

Regulatory requirements to manage combustible dust hazards is outlined in OHSA's Combustible Dust National Emphasis Program (NEP), which was reissued in 2008 from its original release in 2007. For grain handling facilities, enforcement is based on 29 CFR 1910.272. For facilities not categorized as a grain handling facility, enforcement is conducted through 29 CFR 1910.22 (housekeeping), or 29 CFR 1910.176(c) (housekeeping in storage areas). In addition, enforcement is made through the General Duty Clause OSHA 5(a)(1) for protection against fire and explosion hazards. Where electrical classification is required, 29 CFR 1910.307 is used to regulate electrical equipment. In some cases, overlap with OSHA PSM may exist for combustible dusts that are already be in place, such as the case for ammonium perchlorate.[2]

This means that the grain handling standard (29 CFR 1910.272) remains the only combustible dust-specific regulation, and while OSHA's Combustible Dust NEP is in place, a comprehensive federal standard does not exist for specific safeguards that are used for combustible dust hazards. NFPA standards are referenced within OSHA's Combustible Dust NEP as an industry recognition of combustible dust hazards and are useful as a means by which employers can demonstrate evidence that combustible dust hazards have been recognized. Companies that are seeking relevant industry consensus documents that provide the means to manage combustible dust risk have a variety of sources available, including:

Table 1. Selected Industry Consensus Documents for Combustible Dust Risk Management

Ref	**Title**
NFPA 61	Standard for the Prevention of Fires an Dust Explosions in Agricultural and Food Processing Facilities
NFPA 68	Standard on Explosion Prevention by Deflagration Venting
NFPA 69	Standard on Explosion Prevention Systems
NFPA 70	National Electrical Code
NFPA 77	Recommended Practice on Static Electricity
NFPA 85	Boiler and Combustion Systems Hazards Code
NFPA 86	Standard for Ovens and Furnaces
NFPA 91	Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids
NFPA 484	Standard for Combustible Metals
NFPA 499	Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas
NFPA 652	Standard on the Fundamentals of Combustible Dust
NFPA 654	Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids
NFPA 655	Standard for Prevention of Sulfur Fires and Explosions
NFPA 64	Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities
FM Global Data Sheet No. 7-76	Prevention and Mitigation of Combustible Dust Explosions and Fire
CCPS	Guidelines for Combustible Dust Hazard Analysis

Note: ATEX standards are also applicable to European jurisdictions

Recent structural improvement efforts to the NFPA combustible dust standards made strides to harmonize requirements, improve consistency, and improve clarity of requirements. One outcome of this effort was in the creation of NFPA 652, Standard on the Fundamentals of

Combustible Dust, which provides a comprehensive set of minimum requirements for combustible dust hazards.[4] NFPA 652 is a natural entry point for understanding what measures should be taken to understand and protect against combustible dust hazards.

Included within NFPA 652 is the requirement to conduct a Dust Hazard Analysis (DHA) where combustible dusts are present in order to identify hazards and the necessary safeguards. Various industry-specific NFPA standards, including NFPA 61, 484, 664, and 654 also include DHA requirements.

A DHA can be used as a tool to thoroughly identify, evaluate, and control dust hazards. Levels of detail vary and can increase if utilizing risk-based analysis or if gap assessments against specific safeguard requirements are conducted. One observation is that when performing a DHA, gaps in fundamental safeguards or process can be identified. In these cases, detailed findings can be overshadowed by fundamental observations, and the closure of these fundamental observations gets rightfully prioritized. This kind of scenario would have likely been the case if a DHA was applied at the sites of various well-known incidents that have occurred involving combustible dusts. Selected fundamental observations for the following incidents were made by the CSB:

2008 Imperial Sugar dust explosion: Poor housekeeping / Dangerous levels of combustible sugar dust accumulation throughout the facility

2003 West Pharmaceutical Services dust explosion: Poor recognition of combustible dust hazard, dust accumulation occurred in inaccessible locations.

2003 CTA Acoustics dust explosion and fire: Open furnaces near combustible dust accumulations

Where foundational observations on combustible dust hazard management deficiencies are identified, corrective actions that can be conducted in the near-term should be prioritized. Because of this, companies or individual sites that do not have an existing combustible dust hazard management system, or sites with an out of date dust hazard analysis may benefit from a coarse screening to identify areas of highest risk in the near term.

Intended Use

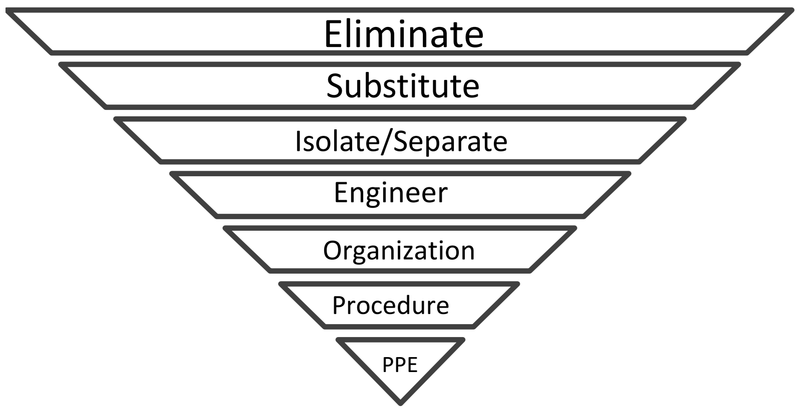
As the name implies, the coarse screening approach is not a replacement for an in-depth evaluation against specific requirements. Rather, the completion of a coarse assessment for combustible dust safety management can accomplish the following:

1) Identify preliminary high-value mitigation efforts that can accelerate safety outcomes of the facility in the near-term
2) Improve the effectiveness of subsequent detailed assessments/improvements once foundational hazard controls are in place
3) Reinforce applicability of relevant regulatory codes/standards or NFPA standards

The next section outlines a coarse screening approach that can be used as a first pass to evaluate a specific site's processes for managing combustible dust risk.

2 Screening Tool Methodology

The overall effect of a combustible dust safety management program is to protect people and business assets, and is accomplished using various types of safety controls. As outlined in the hierarchy of controls in the figure below, the most effective control is the elimination of the hazard, and effectiveness of controls are reduced as controls move away from simply preventing a hazardous scenario occurrence.



In the context of combustible dust hazards, fundamental control measures focus on the more effective areas within the hierarchy of controls by preventing combustible dust fires/explosions, and are covered in NFPA 652, Standard on the Fundamentals of Combustible Dust, and the OSHA Combustible Dust NEP. These same fundamental principles are extended into other industry-specific standards.

In developing a coarse assessment guide, categories of foundational controls were organized into the following areas:

- Combustibility/Explosibility Potential and Parameters
- Housekeeping
- Facility Siting
- Ignition Control
- Equipment Design
- Safety Management Systems

A screening guide's effectiveness depends on its content and usability. A concise 2-page 8½" x 11" paper format was selected so that a printed format would be easy to apply, with a checklist approach adopted due to the well-defined nature of fundamental combustible dust hazard controls. On the first page, simple "yes"/"no" questions are used to prompt the user to explore specific regulatory requirements or industry consensus guidelines. Where a "no" answer is identified, this correlates to a gap that would be identified. Answering "yes" does not necessarily indicate that no gaps would be found in a detailed compliance analysis, but it is intended to show that fundamental measures are at least partially in place. On the second page, selected references to applicable regulations and industry consensus documents are described so that further information can be located.

The screening tool in its entirety is included in Appendix A. Subsequent content in this section describes specific questions used in the screening tool, and what the selected questions are intended to accomplish.

Combustibility/Explosibility Potential and Parameters

Y N

❑ ❑ Has dust/particulates in the process been determined as either combustible or non-combustible?
Awareness of combustibility characteristics is a pre-requisite so correct hazard control measures can be implemented

❑ ❑ Is combustibility/explosibility parameter knowledge up to date based on the current process?
Process changes that change explosibility parameters could mean that legacy deflagration controls may no longer be adequate

An understanding of the combustibility of the hazardous substance involved is a foundational element required for combustible dust hazard management. Recognition of hazard potential is needed to spur the implementation and maintenance of correct control measures. For facilities that have not evaluated particulate materials and dusts for combustibility, these questions are intended to create an awareness of a potential hazard otherwise not identified. For facilities with updated compositions in their process, the recognition that combustible dust characteristics may have changed could impact the sizing of control mechanisms such as deflagration vent sizing, active mitigation systems, and pressure containment capacity of pressure vessels.

Supplementary information for this category points the user towards NFPA 652, Chapter 5, which defines the need to determine combustibility/explosibility parameters. In addition, the OSHA Hazard Communication Standard (29 CFR 1910.1200) is a key resource, since combustible dust is included in the definition of "hazardous chemicals."

Housekeeping

Y N

❑ ❑ Is dust accumulation cleaned before the color of surrounding process areas is obscured?

❑ ❑ Is there a documented housekeeping plan in place for controlling dust accumulation?
Documented plans support regular accumulation removal, & prevents unexpected accumulations from posing a hazard

❑ ❑ Are inaccessible, obscured, or elevated surfaces included in housekeeping or verified to not collect dust?
Inaccessible/elevated areas can collect smaller particles and can present a substantial secondary dust explosion hazard

Secondary dust explosions, which have the potential for increased severity compared to initial/primary dust explosions, can be entirely prevented if fuel sources are removed. NFPA 652 goes into additional details for housekeeping, and covers topics associated with:

- Preventing the accumulation of combustible dusts on interior surfaces
- Addressing the possible impact of a fire/explosion on adjacent building sections

- Fundamental design considerations to contain or collect dust
- Requirements to document housekeeping procedures and for the appropriate cleaning methods to be implemented.

These fundamental measures were summed into screening questions so that the risk of a secondary dust explosion is minimized. The first question regarding dust accumulation and an obscured surface color is used as a simple litmus test for the presence of a secondary dust explosion hazard. The simplicity of this question recognizes that sites which do not adequately manage levels of dust accumulation are best served by a straightforward way to identify potential problems for a screening purpose. As described in NFPA 654, various techniques can be used to determine the correct housekeeping frequencies such that critical quantities of dust accumulation are avoided. Users are directed to these methods in supplementary information.

Next, the processes used to ensure effective housekeeping are tested with the remaining questions. Documentation of a housekeeping process is important since ad-hoc cleaning may not adapt to lapses in housekeeping or periods where increased cleaning frequency is required, such as in the event of equipment failure.

The presence of inaccessible, obscured, or elevated areas is next included as a checklist question since the smallest particles that can accumulate in these areas pose a higher explosive hazard. Hidden accumulations above ceiling tiles were cited as contributing causes to the 2003 West Pharmaceutical Services incident.[5]

Facility Siting

Y	N	
❑	❑	Is deflagration venting provided to building areas with continuous/periodic ignitable combustible dust atmospheres?
❑	❑	If deflagration vents are used to protect buildings or vessels, is the venting routed to a safe area?
❑	❑	Are occupied buildings located to avoid impact from deflagrations?

Facility siting encompasses a process that recognizes the potential impact of fires/explosions on nearby personnel and occupied areas. This is accomplished by evaluating the relative spacing and layout of equipment. Nuanced evaluations are frequently required where potential combustible dust explosions could occur, either internal or external to process equipment. Where these evaluations have taken place, equipment spacing/separation rationale or the design criteria of equipment or building components would be identified. To meet the objective of a coarse screening tool, the facility siting portion utilized two questions that are intended to identify if these key components of facility siting have been sufficiently evaluated.

The first question focuses on operations that create indoor dust hazards. Any deflagrations in these areas should be vented, and fires/explosions isolated to their area of impact. Any potential "no" answer on this question would indicate that fire and explosion hazards could cause structural damage or impact adjacent areas, and would represent a significant weakness in the foundational area of facility siting. NFPA 652 covers this in sections 8.2.3 and 8.2.6, and supplemental information in the coarse assessment guide refers to these sections.

The second question is associated with the safe venting of building compartments and equipment. The energy associated with deflagration venting can vary depending on the initial explosion strength and deflagration vent design. Here, a “safe area” for deflagration venting is used to identify an area that prevents impact on buildings or people during venting events.

Ignition Control

Y N

- ❑ ❑ Are process areas designated, labeled, and maintained as Class 2 Div I or Class 2 Div II?
  Electrical area classification controls ignition sources from electrical equipment
- ❑ ❑ Is a program in place and effective at verifying bonding/grounding on equipment?
  An effective bonding/grounding program needs to prevent static build-up/discharge internally or externally to equipment
- ❑ ❑ Are ignition sources from hot surfaces or mechanical sparks controlled/eliminated?
  Examples of hot surfaces: hot bearings, rotating equipment, heater systems, slipping belts, tramp metal, etc.
- ❑ ❑ If particulates can decompose to create an ignition source, is the process/operation designed to prevent decomposition ignition hazards?
- ❑ ❑ Is a Hot Work program in place?

Ignition control is a central safeguard component against fires and explosions, and is applicable both internally to process equipment and to external areas. Where other processes involving flammable liquids or gasses frequently do not already have an oxidizer present inside process equipment, combustible dust processes must consider that the only missing component of an ignition event is an energy source. Due to this, bonding and grounding of equipment has heightened importance since the development of static charges can occur as a result of particulate transport movement within equipment. External to process equipment, an accidental release of combustible dust could also ignite if energy sources such as static electricity, hot surfaces, open flames, or arcing electrical equipment are present.

29 CFR 1910.307 and NFPA 499 provide clear requirements for electrical classifications, so the first question focuses on electrical classification of process areas as Class 2 Div I or II. Next, the control of static electricity is tested with a question on bonding/grounding, with explanatory text that effective bonding/grounding should prevent static build-up/discharge internally or externally to equipment.

Hot surfaces, with temperatures hot enough to ignite combustible dust, can present itself in a variety of forms, such as rotating equipment or even labeling equipment. This equipment could possibly be hot under normal conditions, and would pose an ignition hazard if at the autoignition temperature of combustible dust. Or as in the case of the Imperial Sugar explosion in 2008, a malfunctioning bearing created a hot surface that ignited the suspended sugar particles. Hot equipment is also attributed to the ignition source for the 2003 CTA Acoutstics, Inc. incident, where an ignition of stirred-up resin particles during cleaning is thought to have been ignited by a nearby curing oven which was left open.[6] In addition, some particles have the potential to decompose exothermally under the right circumstances, and depending on the chemistry involved, various design and operational considerations should be in place to prevent an ignition source from developing.

A final question in this section verifies if a hot work program is in place. A hot work program provides administrative control protections during temporary timeframes where ignition sources such as welding, soldering, torch heating/burning/brazing, grinding, and cutting would be present.[7]

Equipment Design

Y N
- ❑ ❑ Have process vessels been evaluated for protection requirements from internal deflagrations?
- ❑ ❑ Is regular maintenance performed for deflagration control systems and for vessels designed to contain explosions? *(deflagration vents, active isolation for stopping flame-fronts, etc.)*
- ❑ ❑ Does the system prevent unintended accumulation of combustible dust in ductwork and equipment for all operating conditions?

Equipment designed for combustible dust generally fall in one of 3 categories:

- Vessels are below the risk threshold for an explosion hazard
- Vessels/equipment have a maintained pressure rating such that an internal deflagration would not lead to vessel overpressure
- A design safeguard is in place to protect against or prevent internal deflagration events.

The first two questions selected for this portion of the coarse assessment guide were selected to help users recognize whether protection requirements have been evaluated as being necessary. Then, where protection systems have been put into place, the ongoing maintenance of these systems are necessary to ensure their correct function when needed. Like other questions in this assessment guide, “yes” answers for the first two systems would not imply adequate vessel protection per various industry best practices. Rather, the selection of these questions recognizes that identification of risk management gaps in vessel protection is necessary prior to the implementation of control measures.

The unintended accumulation of combustible dust in ductwork was included as a final question, and correlates with the principles included in section 8.3.3 of NFPA 652. Unintended dust accumulation within processes generally indicates incorrect process parameters, and various hazards have the potential to be introduced, including the risk of decomposition risks (where applicable) and an increased amount of fuel that could be combusted in the event of fires/explosions in ductwork.

Safety Management Systems

Y N
- ❑ ❑ Does Training/Procedures communicate the hazards of the process to applicable employees/contractors?
- ❑ ❑ Are incidents investigated (and systemic corrections made) when flammable dust releases occur, or where fires/deflagrations have occurred?

Safety management systems are associated with many controls used to protect people and equipment from combustible dust hazards. Some controls addressed in other portions of the screening tool inherently require some management systems to be in place for continued effectiveness. For example, an MOC process is used to ensure that electrical equipment replacement still maintains electrical classification requirements, and a Maintenance & Integrity program would cover the regular maintenance referred to in the above equipment design section. These inherent management systems were not all included since the screening tool focuses on immediate deficiencies in safety management instead of long term degradation.

This section of the coarse assessment guide focuses on components of a safety management system that if missing could reveal foundational weaknesses in the near term.

Effective training and maintaining adequate employee knowledge on the hazards of combustible dust has been a continuous hurdle in industries that process combustible dust. Challenges exist to educate and spread knowledge on combustible dust hazards, and this condition is not just limited to individual facilities, but even to suppliers of material. This was identified by the CSB in their 2006 Dust Report, where 41% of the 140 combustible powder MSDSs surveyed lacked warnings of explosion hazards, and only 7 of these documents referenced applicable NFPA standards. [6] Since then, the 2012 update of OSHA's Hazard Communication standard includes combustible dust in the definition of a hazardous chemical. Safety data sheets would now include warnings with the hazard statement, "may form combustible dust concentrations in air," if combustible dust hazards are applicable.

Knowledge of combustible dust hazards is crucial to support the various process safety control measures in place to protect people and assets. As deficiencies or gaps in various controls develop, the general workforce is the best source to make observations that become the impetus to make safety improvements. However, this requires that personnel are trained such that they recognize hazard potential. For the coarse assessment, the intent of this question is to prompt the user to question whether workers at their site can recognize what constitutes a hazard. An answer of "no" would indicate fundamental weaknesses, and the user is referred to supplementary information to spur improvement.

Finally, the presence of prior incidents or significant near misses are a clear indication that foundational improvements should be addressed. If prior incidents or significant near misses have not undergone a completed investigation, this constitutes a foundational weakness on the part of a safety management system and could indicate the presence of ongoing unsafe practices. The characteristics of an effective incident investigation program remains a topic of continual improvement for the process industries, so an answer of "yes" would not necessarily imply that a site does not have room for improvement. However, the placement of this question is intended to prompt meaningful reflection on prior incidents and the impact they made on the organization. As in the case for the 2003 aluminum dust explosion at a Hayes facility in Indiana, prior dust fires had not been investigated. Investigation of these incidents may very well have resulted in systemic improvements that could have prevented the single fatality and multiple injuries that occurred in 2003.[6]

3 Conclusion

Since 2006, the CSB has openly called for the development of a comprehensive combustible dust standard to be developed by OSHA.[8] A rulemaking process that would issue a comprehensive standard on combustible dust was initiated in April 2009, but after almost 9 years of efforts, the rulemaking process was stalled indefinitely in March 2017. One contributing factor in the stalling of this rulemaking was due to the lengthy process of completing a small business impact analysis, per the Small Business Regulatory Enforcement Fairness Act (SBREFA)[9]. This means that outside of the grain handling standard (29 CFR 1910.272), OSHA's current combustible dust NEP remains the primary mechanism to regulate safety improvements to protect against combustible dust hazards.

In comparison to the resources provided by the NFPA, OSHA NEPs have a relatively limited set of requirements that bolster preventative safeguards for combustible dust hazard management. However, this should not minimize the importance of making strides in the prevention of combustible dust accidents. Companies or individual sites that do not have an existing combustible dust hazard management system, or sites with an out of date dust hazard analysis may benefit from a coarse screening at the onset of a broader effort to manage combustible dust hazards. Use of the screening tool outlined in this paper provides a way to make this kind of assessment.

Once preliminary assessments are completed, areas of highest risk can be prioritized and addressed. The next step towards improving the management of combustible dust hazards is often aided by completion of a Dust Hazard Analysis to provide this next level of granularity. Foundational concepts used in the development of the screening tool are then used alongside risk management principles and industry-specific requirements to apply a fit-for-purpose analysis. The continuation of this process leads to the safeguarding of lives and the livelihood of people against the hazards of combustible dusts, which is a shared goal between many companies. The completion of a screening assessment may be the first step in this very worthwhile endeavor.

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5 Appendix A – Screening Tool for Combustible Dust Management

Combustibility/Explosibility Potential and Parameters

Y N

- ❑ ❑ Has dust/particulates in the process been determined as either combustible or non-combustible?
  Awareness of combustibility characteristics is a pre-requisite so correct hazard control measures can be implemented
- ❑ ❑ Is combustibility/explosibility parameter knowledge up to date based on the current process?
  Process changes that change explosibility parameters could mean that legacy deflagration controls may no longer be adequate

Housekeeping

- ❑ ❑ Is dust accumulation cleaned before the color of surrounding process areas is obscured?
- ❑ ❑ Is there a documented housekeeping plan in place for controlling dust accumulation?
  Documented plans support regular accumulation removal, & prevents unexpected accumulations from posing a hazard
- ❑ ❑ Are inaccessible, obscured, or elevated surfaces included in housekeeping or verified to not collect dust?
  Inaccessible/elevated areas can collect smaller particles and can present a substantial secondary dust explosion hazard

Facility Siting

- ❑ ❑ Is deflagration venting provided to building areas with continuous/periodic ignitable combustible dust atmospheres?
- ❑ ❑ If deflagration vents are used to protect buildings or vessels, is the venting routed to a safe area?
- ❑ ❑ Are occupied buildings located to avoid impact from deflagrations?

Ignition Control

- ❑ ❑ Are process areas designated, labeled, and maintained as Class 2 Div I or Class 2 Div II?
  Electrical area classification controls ignition sources from electrical equipment
- ❑ ❑ Is a program in place and effective at verifying bonding/grounding on equipment?
  An effective bonding/grounding program needs to prevent static build-up/discharge internally or externally to equipment
- ❑ ❑ Are ignition sources from hot surfaces or mechanical sparks controlled/eliminated?
  Examples of hot surfaces: hot bearings, rotating equipment, heater systems, slipping belts, tramp metal, etc.
- ❑ ❑ If particulates can decompose to create an ignition source, is the process/operation designed to prevent decomposition ignition hazards?
- ❑ ❑ Is a Hot Work program in place?

Equipment Design

- ❑ ❑ Have process vessels been evaluated for protection requirements from internal deflagrations?
- ❑ ❑ Is regular maintenance performed for deflagration control systems and for vessels designed to contain explosions?
  (deflagration vents, active isolation for stopping flame-fronts, etc.)
- ❑ ❑ Does the system prevent unintended accumulation of combustible dust in ductwork and equipment for all operating conditions?

Safety Management Systems

- ❑ ❑ Does Training/Procedures communicate the hazards of the process to applicable employees/contractors?
- ❑ ❑ Are incidents investigated (and systemic corrections made) when flammable dust releases occur, or where fires/deflagrations have occurred?

This checklist can identify areas where a combustible dust hazard management is inadequate and may be for prioritizing combustible dust hazard management activities. Where a "no" answer is identified, a fundamental gap in combustible dust hazard management may be identified. "Yes" responses may indicate that fundamental measures are at least partially in place, but does not necessarily indicate that a detailed analysis would not identify further hazard management improvement needs.

Supplementary information included on this page directs users to resources that can be used as a starting place for identifying published resources for managing combustible dust risk. These references are generally focused on those sources that are applicable to multiple technologies, therefore, additional industry-specific standards are applicable. Resources applicable to all categories include: OSHA's Combustible Dust NEP OSHA NEP CPL 03-00-008, FM Global's Data Sheet 7-76, and the CCPS Book: Guidelines for Combustible Dust Hazard Analysis.

Explosibility Potential and Parameters

NFPA 652 Chapter 5 (Hazard Identification)
Hazard Communication Standard: 29 CFR 1910.1200
NFPA 68 Chapter 6 (Fundamentals of Venting of Deflagrations)
Annex C (Guidelines for measuring Deflagration Parameters of Dusts)
NFPA 69 Chapter 15 (Installation, Inspection, & Maintenance of Explosion Prevention Systems)

Housekeeping

NFPA 652 8.2.5 (Construction Features to Limit Accumulation)
8.4 (Housekeeping)
NFPA 499 Chapter 6 (Classification of Combustible Dust Locations)
NFPA 654 – Chapter 6 (Facility and Systems Design) and 8 (Fugitive Dust Control and Housekeeping)
Housekeeping: 29 CFR 1910.22

Facility Siting

NFPA 652 8.2 (Building Design)
8.3 (Equipment Design)
NFPA 68 - Chapter 4 (General Requirements [for deflagration venting])

Ignition Control

NFPA 499 Chapter 6 (Classification of Combustible Dust Locations)
NFPA 652 8.5 (Ignition Source Control)
Hazardous (classified) locations: 29 CFR 1910.307

Equipment Design

NFPA 68 Standard on Explosion Prevention by Deflagration Venting
NFPA 69 Standard on Explosion Prevention Systems
(Multiple sections may be applicable depending on a process design)
NFPA 652 8.9 (Explosion Prevention/Protection)
9.4 (Inspection, Testing, and Maintenance)

Safety Management Systems

NFPA 652 9.3 (Operating Procedures and Practices)
9.5 (Training and Hazard Awareness)
NFPA 652 9.3 (Operating Procedures and Practices)
Hazard Communication Standard: 29 CFR 1910.1200