FOCUS ARTICLE

NFPA 652: Beyond the DHA – Management Systems

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Facilities that process combustible particulate solids such as agricultural commodities, pharmaceuticals, chemicals, metals, wood, and paper must consider the requirements of the National Fire Protection Association's NFPA 652, Standard on the Fundamentals of Combustible Dusts as a part of good engineering practices.

As described in NFPA 652, appropriate management of combustible dusts hazards begins with an understanding of key material properties of combustible solids that are handled and processed. This knowledge is the basis for a Dust Hazard Analysis (DHA) to identify and evaluate fire, flash fire, and explosion hazards associated with the presence of combustible particulate solid(s) in a process or facility. Once the DHA has been completed it is critical that risk management systems be established, followed, and maintained to ensure that the risks associated with combustible dusts are tolerable. NFPA 652 describes those process safety management systems needed to minimize residual risk of combustible dust handling and processing activities consistent with the findings of the DHA.

Introduction

The National Fire Prevention Association (NFPA), issued a standard, **NFPA 652** Standard on the Fundamentals of Combustible Dust, with the objective of providing general requirements for the management of combustible dust fire and explosion hazards and directing the user to appropriate NFPA industry or commodity-specific standards, ensuring that fundamental requirements are addressed consistently across industries, processes, and dust types. This standard includes background information about combustible dust fire, flash fire, and explosion hazards and describes an action plan to manage the risks. An important requirement of NFPA 652 is that covered sites that handle and process combustible solids shall complete a DHA.

Following NFPA 652 is important to comply with local Building / Fire Code and to conform to OSHA's expectations for employers to follow good engineering practices. NFPA 652 requires the owner/operator of the facility processing powders to determine the pertinent combustibility and explosibility hazards of the materials, and then complete a Dust Hazard Analysis. After the DHA has been completed and documented, those management systems required to control residual risk must be established and maintained to ensure that the fire and explosion risk is tolerable.

The Dust Hazard Analysis (DHA) Process

In order to determine the combustible solid's hazards, the first requirement is to verify if the powders handled are combustible. Determination of combustibility or explosibility is permitted to be based on the following:

- Historical facility data or published data that are deemed to be representative of current materials & process conditions
- Laboratory analysis of representative samples
- Permitted to test a sample sieved to less than 75 microns
- Permitted to test the as-received sample
- Permitted to assume a material is explosible, forgoing the laboratory analysis

It must be noted that the absence of previous incidents shall not be used as a basis for deeming a particulate non-combustible or non-explosible.

The purpose of testing is to answer several important safety questions [1, 2, 3]. Materials that are determined to be combustible also need to be tested to establish their ignition sensitivity and explosion severity in order to support the DHA, associated risk assessments and hazard minimization strategies. Explosibility, ignition sensitivity, and explosion severity of dusts must be determined in accordance with applicable test standards such as American Society for Testing and Materials (ASTM). Typical tests that might be considered include:

- Go / No Go test (ASTM E1226 or E1515)
- Minimum Ignition Energy (ASTM E2019)
- Minimum Ignition Temperature (Cloud and Layer)
- Self-Heating
- Minimum Explosible Concentration (ASTM E1515)
- Limiting Oxygen Concentration (E2931)
- Maximum Explosion Pressure (Pmax) and Kst (ASTM E1226)
- Electrostatic Chargeability and Volume Resistivity

The next step in compliance with the requirements of NFPA 652 is to perform a DHA to identify items of process equipment and rooms or enclosures where materials could form ignitable dust suspensions or dust layers and access ignition sources.

The DHA report provides documentation of the properties of process-materials and the operating conditions and, for each potential hazard zone, establishes what hazard management methods exist or are appropriate. Hazard management methods are those safeguards that prevent or mitigate a combustible dust fire, flash fire, or explosion event. Chapter 8 provides equipment specific prescriptive control recommendations and Chapter 6 provides a management option: Performance-Based Design for some cases where it can be demonstrated that alternate safeguards meet life safety goals.

Management Systems

NFPA 652 includes Chapter 8, Management Systems. This closely follows the Process Safety Management methods applied to highly hazardous chemicals as described in CFR29-1910.119, the OSHA process safety regulation. This chapter applies to both new and existing facilities and operations and covers those systems that support safe risk management of combustible dusts. Sub-sections provide specifics expected for individual systems. Systems include the following:

- **Operating Procedures and Practices** - Written standard operating procedures (SOPs) such that fires and explosions are avoided. Procedures must include startup, normal operation, shutdown, and emergency response. Include all safe work practices required to prevent fires and explosions.
- **Inspection, Testing and Maintenance** - Identify safety- critical equipment and systems required to manage combustible dust fire and explosion risks. Devices such as explosion **relief vents**, dust extraction systems, and classified electrical devices are necessary to maintain a low risk operation and must be identified and managed to ensure reliability. Routine, scheduled inspection and testing is key to safeguard reliability and a program must be in place to manage this issue.
- **Training and Hazard Awareness** - All affected personnel (including contractors) must receive training for combustible dust hazards. The training program should be documented and

include job-specific as well as training about those safeguards required to manage fire and explosion risks. Routine re-training should occur annually.

- **Emergency Planning and Response** - A written emergency action plan must be established that includes:
  - A means to notify personnel in the event of a fire or explosion,
  - A pre-planned evacuation route and assembly location,
  - Designated emergency response personnel assigned to notify appropriate community response personnel and direct coordinate efforts, and
  - Maps, layout drawings and other support information (such as Safety Data Sheets for hazardous materials) necessary for responders use. The Emergency Response Plan should be reviewed periodically to ensure that it is current and should be used in annual personnel training.
- **Incident Investigation** - Incidents that occur can be too easily forgotten and lessons-learned, not learned. A **management program** plan must be in place to investigate fires and explosions that may occur, in a timely fashion, and incorporate recommendations in the sites activities and systems. These learnings must be shared with appropriate personnel.
- **Management of Change** - Without a rigorous Management of Change (MOC) program it is easy for changes to be made to equipment, procedures, systems or personnel that negatively impact the risk of fires and explosions. Changes that could affect the risk of fires and explosions must be assessed to ensure that they can be applied safely and do not introduce un-assessed risk or increase residual risk.
- **Document Retention** - There should be a program to retain documentation of safety related information including:
  - Training records,
  - Equipment and system inspections and maintenance records,
  - Incident investigation reports, recommendations and issue closure reports,
  - Dust Hazard Analysis reports, recommendations and issue closure reports,
  - Management of Change documentation,
  - Contractor records, and
  - Process and material technology.
- **Management Systems Review** - In order to keep management practices current, it is important that all management practices be reviewed on a routine schedule.
- **Employee Participation** - All affected personnel involved in the handling and processing of combustible particulate materials shall be included in the control and mitigation of fire and explosion hazards and in the investigation of combustible dust incidents.

Summary

The handling, storage, and processing of combustible solids such as agricultural commodities, pharmaceuticals, chemicals, metals, and cellulosic materials (wood and paper) requires that appropriate safeguards are in place to prevent damaging **fires, flash fires, or explosions** that could be caused by the ignition of combustible dusts and protect people and facilities against their consequences. The consensus standard, NFPA 652 is intended to provide the accumulated experience of the associated industries on those practices needed to manage fire and explosion risks. Management systems play a key role in the continuing control of dust fire and explosion risks and NFPA 652 requires that written management programs are established and maintained so that residual risk is minimized. Systems that are important and required by NFPA 652 standard include:

- Operating Procedures and Practices
- Inspection, Testing and Maintenance
- Training and Hazard Awareness
- Contractors and Contractor Training
- Emergency Planning and Response
- Incident Investigation
- Management of Change
- Document Retention and
- Employee Participation

Sites and processes covered by the OSHA PSM regulation (CFR 1910.119) will be familiar with these systems but other sites should consult this standard to understand how they support dust hazard management.

How We Can Help You

DEKRA Process Safety helps industry understand and avoid fire, explosion, and loss of containment events and improve performance. We combine specialist process safety management (PSM) and process safety engineering expertise, with the understanding of Building and Fire Codes to help our clients achieve the most effective and practical approaches to safe and efficient operations and processes, globally. We are the trusted advisor for process safety excellence - always keeping our client's needs/wants in focus as we evaluate their process hazards and propose practical solutions. We look forward to assisting you with your Process Safety consulting, including DHA, laboratory testing, and training needs. Please do not hesitate to contact us if we can answer any questions about our services.

References

1. Frank, W. L. & Rogers, S. A. (2012). NFPA Guide to Combustible Dusts. Quincy: National Fire Protection Association.
2. NFPA 654 (2020). "Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids. "Quincy: National Fire Protection Association.
3. NFPA 68 (2018), Standard on Explosion Protection by Deflagration Venting. Quincy: National Fire Protection Association.
4. NFPA 652 (2019), Standard on the Fundamentals of Combustible Dust. Quincy: National Fire Protection Association.

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David E. Kaelin, Sr., B.S.Ch.E. Mr. Kaelin has over 30 years' experience in the specialty chemical manufacturing industry and 20 years specializing as a Process Safety Engineer. He has participated in the design and construction of numerous chemical processing facilities and provided support and training in all areas of PSM. As a Process Safety Engineer, he has led process hazard analysis, risk assessments and facility siting reviews. At the corporate level he has created and taught courses in PSM and hazard recognition methods.

Mr. Kaelin has led or provided technical assistance to many fire, explosion and runaway reaction incident investigations including incidents involving nitrations, chlorinations, hydrogenations, thermal heat transfer fluids, spontaneous combustion, dust explosions and thermal oxidizer and incinerator operations.

Mr. Kaelin is an expert in the application of hazard recognition techniques including: HAZOP, FMEA. What-If, Fault Tree Analysis, Risk Screening and Checklist. He is an active member of AIChE, and NFPA.

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DEKRA Process Safety

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Process Safety Management (PSM) Programs

> Design and creation of relevant PSM programs
> Support the implementation, monitoring, and sustainability of PSM programs
> Audit existing PSM programs, comparing with best practices around the world
> Correct and improve deficient programs

Process Safety Information/Data (Laboratory Testing)

> Flammability/combustibility properties of dusts, gases, vapors, mists, and hybrid atmospheres
> Chemical reaction hazards and chemical process optimization (reaction and adiabatic calorimetry RC1, ARC, VSP, Dewar)
> Thermal instability (DSC, DTA, and powder specific tests)
> Energetic materials, explosives, propellants, pyrotechnics to DOT, UN, etc. protocols
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> Electrostatic testing for powders, liquids, process equipment, liners, shoes, FIBCs

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We have offices throughout North America, Europe, and Asia. For more information, visit **www.dekra.us/process-safety**
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