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INTRODUCTION

1.1 PURPOSE OF BOOK

In a 2006 study, the U.S. Chemical Safety Board (CSB) found that government enforcement officials, plant workers and management were often unaware of the hazard of dust explosions. This has frequently led to the failure to identify dust explosion hazards even though there were consensus standards for preventing and mitigating dust fires and explosions. This was due to a number of factors. For example, 41% of material safety data sheets (now referred to as Safety Data Sheets, SDS) did not warn about dust explosion hazards. Enforcement officials did not receive training on combustible dusts (Chemical Safety Board (CSB) 2006).

The National Fire Protection Association (NFPA) standard 652, *Standard on the Fundamentals of Combustible Dust* (NFPA 2016), released in late 2015, requires that any facility or process that manufactures, processes, re-packages, generates, or handles combustible dusts or combustible particulate solids, performs a Dust Hazard Analysis (DHA) of the facility/process. The focus of this book is to provide practical guidance on how to do a quality DHA, either by following prescriptive standards or by using a risk-based approach. Guidance on how to assess the hazards of a dust, typical prevention and protection methods, and the data needed to do such an assessment is provided.

Although not meant to be a thorough treatment of the science of combustible dusts, this book provides an overview of the basics of combustible dust fires and explosions, and methods to prevent and mitigate them. The main focus of this book is the combustion hazards of dusts. Potential reactivity or decomposition hazards are covered only as they relate to the ignition of a combustible dust. Toxicity hazards of dusts are not covered in this book. A list of standards and books for further study is provided.

The target audience for this book is primarily technical personnel involved in process research and development, and in designing and running solids handling plants and processes. Combustible dust and hazard analysis subject matter experts will find the book useful as a guideline to develop a consistent methodology for risk assessment of processes handling combustible dusts.

1.2 BOOK ROAD MAP

Chapter 2 provides basic background information about dust fires and explosions. Statistics about the frequency of dust explosions are presented along with some selected case histories. An overview of what creates fire and explosion hazards is provided. Key combustibility and explosibility parameters are explained. The concept of secondary explosions is described. Secondary explosions, which take place outside of process equipment but inside a building, are by far the major cause of fatalities and injuries from dust explosions. Finally a comparison of combustible dusts and vapors is made.

Chapter 3 provides guidance on explosion prevention and protection systems for combustible dust hazards inside of process equipment. This chapter also describes the hazards, concerns, and control measures for some selected equipment items or operations commonly involved in dust explosions. Many equipment items handling combustible dusts already have four of the five sides of the explosion pentagon present, and only require an ignition source for a fire or explosion to occur. The equipment items and operations covered are:

- Air/Material Separators
- Size Reduction Equipment
- Dryers
- Silos/Hoppers
- Portable Containers
- Conveyors (e.g. belt, bucket elevators, pneumatic)
- Blenders/Mixers
- Feeding Solids to Vessels Containing Flammable Solvents

Chapter 4 describes the dust hazards outside of equipment, but inside a building. Combustible dust accumulations in buildings have contributed to the severity of some of the worst dust explosions on record. Housekeeping is often the single most important measure a facility can take to reduce the hazard of combustible dust fires and explosions within a building. This chapter discusses how to prevent dust accumulations, housekeeping and damage limiting construction.

Chapter 5 presents the traditional approach to hazard assessment, including a summary of relevant standards, and how to use standards and checklists to determine the needed prevention and mitigation methods to comply with the NFPA 652 requirement to conduct a DHA. The working assumption of the traditional approach is that full compliance with the applicable codes, standards and good practices provides sufficient protection from dust fires and explosions.

For this book the overall approach to the hazard assessment and control process is broken up into seven basic steps. They are discussed in detail.

Chapter 6 describes the risk-based approach to hazard analysis and provides organizations with a method to apply risk tolerance criteria to the decision of what protections are required. The described approach is consistent with the NFPA performance-based design option. It describes a systematic method of demonstrating that a proposed design, in lieu of prescriptive requirements in the NFPA standards, meets the safety and business continuity objectives that underlie the traditional prescriptive option.

A nine step technique for doing a risk-based DHA, adapted from *Design Solutions for Process Equipment Failures* (CCPS 1999), is presented and each step discussed.

Appendix C provides some generic data that can be used in risk-based DHAs.

Chapter 7 describes some special considerations with combustible dusts. One consideration is how to address risk issues in existing facilities, where there are more constraints than when designing new facilities. This chapter also addresses a few other issues that require vigilance when doing hazard assessments of solids handling processes.

To avoid slipping into a state where significant catching up is required, organizations should implement a good Management of Change program, revalidate the DHAs on a regular basis, and conduct audits. When acquiring a new facility, an organization should practice due diligence to avoid surprises.

Chapter 8 is the heart of the book. A traditional and risk-based DHA is presented for three example processes:

1. A process line with a feed hopper, hammer mill, cyclone, dust collector, product hopper and packaging line.
2. Example 1 but with a vessel with a flammable solvent instead of a packaging line.
3. A spray dryer.

Layer of Protection Analysis (LOPA) is the risk-based technique used for this book, due to its widespread use in process industries.

Appendix A provides list of regulations and codes that apply to combustible dusts. Appendix B provides additional books, articles and other items that are useful resources on combustible dusts. Appendix D lists some good practices to employ when handling dusts.

Appendix E provides a “how to” flowchart for doing DHAs and is also a roadmap through the book.

1.3 REFERENCES

CCPS 1999, *Design solutions for process equipment failures*, Center for Chemical Process Safety of the American Institute of Chemical Engineers, New York, NY.

CCPS 2001, *Layer of protection analysis, simplified process risk assessment*, Center for Chemical Process Safety of the American Institute of Chemical Engineers, New York, NY.

CSB 2006, U.S. Chemical Safety and Hazard Investigation Board, Investigation Report, Combustible dust hazard study, Report No. 2006-H-1, November 2006. http://www.csb.gov/combustible-dust-hazard-investigation/

NFPA 2016, NFPA 652, Standard on the fundamentals of combustible dust, National Fire Protection Association, Quincy, MA., 2016.