

NFPA®

654

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

2020



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NFPA® 654

Standard for the

Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids

2020 Edition

This edition of NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, was prepared by the Technical Committee on Handling and Conveying of Dusts, Vapors, and Gases, released by the Correlating Committee on Combustible Dusts, and acted on by NFPA at its June Association Technical Meeting held June 17–20, 2019, in San Antonio, TX. It was issued by the Standards Council on August 5, 2019, with an effective date of August 25, 2019, and supersedes all previous editions.

This edition of NFPA 654 was approved as an American National Standard on August 25, 2019.

Origin and Development of NFPA 654

NFPA 654 was initiated by the Committee on Dust Explosion Hazards in 1943 and originally applied only to the prevention of dust explosions in the plastics industry. As such, it was tentatively adopted in 1944 and officially adopted in 1945. Amendments were adopted in 1946, 1959, 1963, and 1970. The 1970 edition was reconfirmed in 1975.

In 1976, responsibility for NFPA 654 was transferred to the Technical Committee on Fundamentals of Dust Explosion Prevention and Control. The committee prepared a complete revision for the 1982 edition, the scope of which was expanded to include chemical, dye, and pharmaceutical dusts, since the fire and explosion hazards of those dusts are generally the same as for plastic dusts.

In 1988, the committee voted to reconfirm the text as it appeared in the 1982 edition, with minor editorial corrections and changes in accordance with the *NFPA Manual of Style*.

In 1994, the standard was revised to improve its usability, adoptability, and enforceability; to update outdated terminology; and to add the NFPA language for equivalency and retroactivity. In addition, the Technical Committee on Fundamentals of Dust Explosion Prevention and Control added new technologies for explosion prevention to NFPA 69, *Standard on Explosion Prevention Systems*. The committee also clarified the requirements relating to controlling hazardous accumulations of process dust.

The 1997 edition was a complete revision that incorporated new processing and explosion protection technologies. The title of the document was revised to reflect that the standard encompassed all industries not otherwise included in previous editions of the standard, including the fibers industry. The complete revision incorporated new requirements for design basis of systems and design details for management of change.

A complete revision for the 2000 edition incorporated portions of NFPA 650, *Standard for Pneumatic Conveying Systems for Handling Combustible Particulate Solids*, which was withdrawn in 2000. NFPA 654 retained its title and provided a unified approach for protecting facilities that handled most combustible particulate solids. The combination of documents eliminated the redundancy that previously had existed between the two, similar standards. The 2000 edition of NFPA 654 included specific requirements related to fire protection in addition to the existing explosion protection requirements.

The 2006 edition incorporated a complete revision, which introduced a performance-based approach for protecting combustible particulate solids processing facilities. This approach enabled users of the standard to follow the traditional prescriptive method or, for unique situations, allowed the option of a performance-based design. Other changes included updating the standard to the current *Manual of Style for NFPA Technical Committee Documents* format.

The 2013 edition incorporated updates to definitions to coordinate with extracted text from the source documents in accordance with the *Manual of Style for NFPA Technical Committee Documents*. The most important change was the inclusion of four methods to determine whether a dust fire or explosion hazardous condition exists in a facility. The methods include those based on mass accumulation and risk evaluation as well as the layer depth criterion, which was described in the 2006 edition. Each of the methods was viewed as equivalent in establishing that a hazardous condition exists for either fires or explosions, so the change offered options for users of the standard when determining this fundamental condition.

The standard included changes to the housekeeping requirements in two aspects. One involved the determination of a dust hazardous condition and prompts a cleaning frequency based on the nature of the dust layer or dust mass. The second change established a hierarchy for cleaning methods: vacuuming first, followed by sweeping or water wash and then, if still necessary, blowing with compressed air, but only under controlled conditions. It is clearly recognized from the incidents reported over the past decade or more that housekeeping has not been adequate in all instances, so establishing a strategy for cleaning frequency based on accumulated dust will improve the practice. In some instances, improper housekeeping has contributed to incidents, so creating a preferred sequence for cleaning methods will increase safety as well.

Safety management elements also were strengthened in the standard, including hazard analysis, management of change, training, emergency procedures, incident investigations, and contractor/subcontractor safety. Incident investigations indicated that one or more of these elements were reported as contributing factors to various incidents, so including them in the standard stressed their importance in the overall safety culture at a facility.

The 2017 edition included changes designed to begin the alignment of the standard with the newly issued NFPA 652, *Standard on the Fundamentals of Combustible Dust*. Definitions used in NFPA 654 were aligned with those in NFPA 652, and the objectives in Chapter 4 were updated. Although the requirement to perform a hazard analysis had been part of the standard since the 2006 edition, requirements to perform a dust hazard analysis (DHA) retroactively were added for those facilities constructed prior to the 2006 edition. The work to align NFPA 654 with NFPA 652 will continue in the next revision cycle.

The 2020 edition is a complete reorganization of the document. Many of the existing requirements were moved to align the document with NFPA 652, *Standard on the Fundamentals of Combustible Dust*, and any material previously extracted into NFPA 652 from NFPA 654 is now hosted in NFPA 652. Where requirements in the code are retroactive, statements were made to clearly indicate this to the user. New requirements for ultrafine particles (including nanopowders and nanoparticles) and additive manufacturing have been added to recognize unique hazards and developing technology, and requirements covering static, conductivity, and portable vacuum cleaners have been extracted from NFPA 652. The deadline for performing a dust hazard analysis (DHA) on existing processes and facility compartments is now specified to align with NFPA 652.

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Contents

Chapter 1 Administration	654– 6	8.5 Open Flames and Sparks (Hot Work).	654– 15
1.1 Scope.	654– 6	8.6 Personal Protective Equipment (PPE).	654– 16
1.2 Purpose.	654– 6	8.7 Inspection and Maintenance.	654– 16
1.3 Goal.	654– 6	8.8 Employee Training and Procedures.	654– 16
1.4 Application.	654– 6	8.9 Contractors and Subcontractors.	654– 17
1.5 Conflicts.	654– 6	8.10 Emergency Planning and Response.	654– 17
1.6 Retroactivity.	654– 6	8.11 Incident Investigation.	654– 17
1.7 Equivalency.	654– 7	8.12 Management of Change.	654– 17
1.8 Units and Formulas.	654– 7	8.13 Document Retention. (Reserved)	654– 17
Chapter 2 Referenced Publications	654– 7	8.14 Management Systems Review. (Reserved)	654– 17
2.1 General.	654– 7	8.15 Employee Participation. (Reserved)	654– 17
2.2 NFPA Publications.	654– 7	Chapter 9 Hazard Management: Mitigation and Prevention	654– 17
2.3 Other Publications.	654– 7	9.1 Process and Facility Design.	654– 17
2.4 References for Extracts in Mandatory Sections.	654– 8	9.2 Building Design.	654– 17
Chapter 3 Definitions	654– 8	9.3 Equipment Design.	654– 18
3.1 General.	654– 8	9.4 Ignition Source Control.	654– 25
3.2 NFPA Official Definitions.	654– 8	9.5 Pyrophoric Dusts. (Reserved)	654– 27
3.3 General Definitions.	654– 8	9.6 Dust Control.	654– 27
Chapter 4 General Requirements	654– 11	9.7 Explosion Prevention and Protection.	654– 28
4.1 Owner's Obligation.	654– 11	9.8 Fire Protection.	654– 28
4.2 Objectives.	654– 11	Annex A Explanatory Material	654– 29
4.3 Compliance Options.	654– 11	Annex B Explosion Protection	654– 52
Chapter 5 Hazard Identification	654– 11	Annex C Informational Primer on Spark Detection and Extinguishing Systems	654– 56
5.1 Hazard Identification.	654– 11	Annex D Dust Layer Characterization and Precautions	654– 59
Chapter 6 Performance-Based Design Option	654– 11	Annex E Deflagration Propagation Isolation Methods	654– 64
6.1 General Requirements.	654– 11	Annex F Use of Water as Extinguishing Agent for Combustible Particulate Solids	654– 64
6.2 Performance Criteria.	654– 12	Annex G Informational References	654– 65
6.3 Design Scenarios.	654– 12	Index	654– 68
6.4 Evaluation of Proposed Design.	654– 13		
Chapter 7 Dust Hazards Analysis (DHA)	654– 13		
7.1 General Requirements.	654– 13		
7.2 Hazard Assessment.	654– 13		
Chapter 8 Management Systems	654– 14		
8.1 Retroactivity.	654– 14		
8.2 General. (Reserved)	654– 14		
8.3 Operating Procedures.	654– 14		
8.4 Housekeeping Procedures and Portable Vacuum Cleaners.	654– 15		

NFPA 654

Standard for the

Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids

2020 Edition

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Information on referenced and extracted publications can be found in Chapter 2 and Annex G.

Chapter 1 Administration

1.1* Scope.

1.1.1* This standard provides requirements for all phases of the manufacturing, processing, blending, conveying, repackaging, and handling of combustible **dusts and particulate solids** or hybrid mixtures, regardless of concentration or particle size, where the materials present a fire, a flash fire, or an explosion hazard.

N 1.1.2 This standard includes specific requirements for additive manufacturing.

1.1.3 The owner/operator shall be responsible for implementing the requirements in this standard.

1.2 Purpose. The purpose of this standard is to prescribe technical requirements necessary to manage safety to life and property from fire, flash fire, and explosion hazards involving combustible particulate solids, including hybrid mixtures, and to minimize the resulting damage from a fire or an explosion.

1.3 Goal. The goal of this standard is to provide safety measures to prevent and mitigate fires and dust explosions in facilities that handle combustible particulate solids.

1.4 Application.

1.4.1 This standard shall be used to supplement the requirements established by NFPA 652.

1.4.2 This standard shall not apply to the following:

- (1) Storage or use of consumer quantities of such materials on the premises of residential or office occupancies
- (2) Storage or use of commercially packaged materials at retail facilities
- (3) Such materials displayed in original packaging in mercantile occupancies and intended for personal or household use or as building materials
- (4) Warehousing of sealed containers of such materials when not associated with an operation that handles or generates combustible dust
- (5) Such materials stored or used in farm buildings or similar occupancies for on-premises agricultural purposes

Δ 1.4.3 This standard shall not be required to apply to materials covered by the following documents, unless specifically referenced by the applicable document:

- (1) NFPA 30B
- (2) NFPA 33
- (3) NFPA 61
- (4) NFPA 85
- (5) NFPA 120
- (6) NFPA 400
- (7) NFPA 484
- (8) NFPA 495
- (9) NFPA 655
- (10) NFPA 664
- (11) NFPA 1125

1.5 Conflicts.

1.5.1 Where a requirement specified in this industry-specific standard differs from a requirement specified in NFPA 652, the requirement in this standard shall be permitted to be used.

1.5.2 Where a requirement specified in this standard specifically prohibits a requirement specified in NFPA 652, the prohibition in this standard shall apply.

1.6* Retroactivity. The provisions of this standard reflect a consensus of what is necessary to provide an acceptable degree of protection from the hazards addressed in this standard at the time the standard was issued.

1.6.1 Unless otherwise specified, the provisions of this standard shall not apply to facilities, equipment, structures, or installations that existed or were approved for construction or installation prior to the effective date of the standard. Where specified, the provisions of this standard shall be retroactive.

1.6.2 In those cases where the authority having jurisdiction determines that the existing situation presents an unacceptable degree of risk, the authority having jurisdiction shall be permitted to apply retroactively any portions of this standard deemed appropriate.

1.6.3 The retroactive requirements of this standard shall be permitted to be modified if their application clearly would be impractical in the judgment of the authority having jurisdiction, and only where it is clearly evident that a reasonable degree of safety is provided.

1.6.4 When major replacement or renovation of existing facilities is planned, provisions of this standard shall apply.

1.7 Equivalency. Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard.

1.7.1 Technical documentation shall be made available to the authority having jurisdiction to demonstrate equivalency.

1.7.2 The authority having jurisdiction shall be permitted to require that the system, method, or device shall be approved for the intended purpose.

1.8 Units and Formulas. Where extracted text contains values expressed in only one system of units, the values in the extracted text have been retained without conversion to preserve the values established by the responsible technical committee in the source document.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 10, *Standard for Portable Fire Extinguishers*, 2018 edition.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, 2016 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 2018 edition.

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*, 2018 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 2019 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 2017 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, 2019 edition.

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, 2017 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2020 edition.

NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products*, 2019 edition.

NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials*, 2018 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 2019 edition.

NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities*, 2017 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2018 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2019 edition.

NFPA 70®, *National Electrical Code®*, 2020 edition.

NFPA 72®, *National Fire Alarm and Signaling Code®*, 2019 edition.

NFPA 80, *Standard for Fire Doors and Other Opening Protectives*, 2019 edition.

NFPA 85, *Boiler and Combustion Systems Hazards Code*, 2019 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 2019 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids*, 2015 edition.

NFPA 101®, *Life Safety Code®*, 2018 edition.

NFPA 120, *Standard for Fire Prevention and Control in Coal Mines*, 2015 edition.

NFPA 220, *Standard on Types of Building Construction*, 2018 edition.

NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls*, 2018 edition.

NFPA 252, *Standard Methods of Fire Tests of Door Assemblies*, 2017 edition.

NFPA 400, *Hazardous Materials Code*, 2019 edition.

NFPA 484, *Standard for Combustible Metals*, 2019 edition.

NFPA 495, *Explosive Materials Code*, 2018 edition.

NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations*, 2018 edition.

NFPA 652, *Standard on the Fundamentals of Combustible Dust*, 2019 edition.

NFPA 655, *Standard for Prevention of Sulfur Fires and Explosions*, 2017 edition.

NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*, 2017 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems*, 2019 edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2020 edition.

NFPA 1125, *Code for the Manufacture of Model Rocket and High-Power Rocket Motors*, 2017 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, 2018 edition.

NFPA 2113, *Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire*, 2020 edition.

2.3 Other Publications.

2.3.1 AMCA Publications. Air Movement and Control Association International, Inc., 30 West University Drive, Arlington Heights, IL 60004-1893.

AMCA 99, *Standards Handbook*, 2016.

2.3.2 ASME Publications. American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990.

ASME B31.3, *Process Piping*, 2016.

Boiler and Pressure Vessel Code, 2017.

2.3.3 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM E1226, *Standard Test Method for Explosibility of Dust Clouds*, 2012a.

ASTM E2019, *Standard Test Method for Minimum Ignition Energy of a Dust Cloud in Air*, 2003, reapproved 2013.

2.3.4 IEC Publications. International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, CH-1211 Geneva 20, Switzerland.

IEC 61340-4-4, *Electrostatics — Part 4-4: Standard Test Methods for Specific Applications — Electrostatic Classification of Flexible Intermediate Bulk Containers (FIBC)*, 2012.

2.3.5 ISA Publications. International Society of Automation, 67 T.W. Alexander Drive, P.O. Box 12277, Research Triangle Park, NC 27709.

ISA 84.00.01, *Functional Safety: Application of Safety Instrumented Systems for the Process Industry Sector — Part 1: Framework, Definitions, System, Hardware and Software Requirements*, 2004.

2.3.6 NEMA Publications. National Electrical Manufacturers Association, 1300 North 17th Street, Suite 900, Arlington, VA 22209.

NEMA 250, *Enclosures for Electrical Equipment*, 2014.

2.3.7 U.S. Government Publications. U.S. Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401-0001.

Title 29, Code of Federal Regulations, Part 1910.242(b), “Hand and Portable Powered Tools and Equipment, General.”

2.3.8 Other Publications.

Merriam-Webster’s Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

▲ 2.4 References for Extracts in Mandatory Sections.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 2019 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2018 edition.

NFPA 77, *Recommended Practice on Static Electricity*, 2019 edition.

NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls*, 2018 edition.

NFPA 484, *Standard for Combustible Metals*, 2019 edition.

NFPA 652, *Standard on the Fundamentals of Combustible Dust*, 2019 edition.

NFPA 921, *Guide for Fire and Explosion Investigations*, 2017 edition.

NFPA 1250, *Recommended Practice in Fire and Emergency Service Organization Risk Management*, 2015 edition.

NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program*, 2018 edition.

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster’s Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.3 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

3.2.4* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

3.2.5 Shall. Indicates a mandatory requirement.

3.2.6 Should. Indicates a recommendation or that which is advised but not required.

3.2.7 Standard. An NFPA Standard, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase “standards development process” or “standards development activities,” the term “standards” includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

▲ 3.3 General Definitions.

3.3.1 Abort Gate/Abort Damper. A device for the quick diversion of material or air to the exterior of a building or other safe location in the event of a fire.

■ 3.3.2* Additive Manufacturing. A process of joining materials to make objects from 3D model data, usually layer upon layer.

3.3.3* Air-Material Separator (AMS). A device designed to separate the conveying air from the material being conveyed. [652, 2019]

3.3.4* Air-Moving Device (AMD). A power-driven fan, blower, or other device that establishes an airflow by moving a given volume of air per unit time. [652, 2019]

3.3.5 Bonding. For the purpose of controlling static electric hazards, the process of connecting two or more conductive objects by means of a conductor so that they are at the same electrical potential but not necessarily at the same potential as the earth. [652, 2019]

3.3.6* Centralized Vacuum Cleaning System. A fixed-pipe system utilizing variable-volume negative-pressure (i.e., vacuum) air flows from remotely located hose connection stations to allow the removal of dust accumulations from surfaces and conveying those dusts to an air-material separator (AMS). [652, 2019]

3.3.7* Combustible Dust. A finely divided combustible particulate solid that presents a flash-fire hazard or explosion hazard when suspended in air or the process-specific oxidizing medium over a range of concentrations. [652, 2019]

3.3.8* Combustible Particulate Solid. Any solid material composed of distinct particles or pieces, regardless of size, shape, or chemical composition that, when processed, stored, or handled in the facility, has the potential to produce a combustible dust. [652, 2019]

3.3.9 Compartmentation. The interposing of a physical barrier that is not required to be fire or explosion resistant in order to limit combustible particulate solid migration and hence to control the size of a hazard area.

N 3.3.10* Conductive. Possessing the ability to allow the flow of an electric charge. [652, 2019]

N 3.3.10.1 Conductive Particulate Solids. Particulate solids with a volume resistivity of less than 10^6 ohm-m.

3.3.11* Deflagration. Propagation of a combustion zone at a velocity that is less than the speed of sound in the unreacted medium. [68, 2018]

3.3.12 Deflagration Hazard Area.

3.3.12.1* Dust Explosion Hazard Area. A room or building volume where an unvented deflagration of the entrainable dust mass can result in a pressure exceeding the strength of the weakest structural element not intended to fail.

3.3.12.2* Dust Flash-Fire Hazard Area. An area where combustible dust accumulation on exposed or concealed surfaces, external to equipment or containers, can result in personnel injury from thermal dose during a dust deflagration, as well as any areas where a dust cloud of a hazardous concentration exists.

3.3.13 Detachment. A hazard management strategy in which the hazard is located in a separate building or an outside area, removed from other structures to be protected by a distance as required by this standard.

N 3.3.14* Dissipative. A material or a construction that will reduce static charge to acceptable levels. [77, 2019]

3.3.15 Dryer. A piece of processing equipment using temperature or pressure change to reduce the moisture or volatile content of the material being handled.

3.3.16 Duct. Pipes, tubes, or other enclosures used to convey materials pneumatically or by gravity. [652, 2019]

3.3.17* Dust Collection System. A combination of equipment designed to capture, contain, and pneumatically convey fugitive dust to an air-material separator (AMS) in order to remove the dust from the process equipment or surrounding area. [652, 2019]

3.3.18 Dust Deflagration Hazard. A condition that presents the potential for harm or damage to people, property, or the environment due to the combustion of a sufficient quantity of combustible dust suspended in air or another oxidizing medium. [652, 2019]

3.3.19 Dust Explosion Hazard. A dust deflagration hazard in an enclosure that is capable of bursting or rupturing the enclosure due to the development of internal pressure from the deflagration. [652, 2019]

3.3.20* Dust Hazards Analysis (DHA). A systematic review to identify and evaluate the potential fire, flash-fire, and explosion hazards associated with the presence of one or more combustible particulate solids in a process or facility. [652, 2019]

3.3.21 Enclosureless Dust Collector. An air-material separator designed and used to remove dust from the transport air where the filter medium is not enclosed or in a container.

3.3.22 Explosion. The bursting or rupture of an enclosure or a container due to the development of internal pressure from a deflagration.

Δ 3.3.23 Fire Hazard. Any situation, process, material, or condition that can cause a fire or provide a ready fuel supply to augment the spread or intensity of a fire and poses a threat to life or property. [652, 2019]

3.3.24* Flash Fire. A fire that spreads by means of a flame front rapidly through a diffuse fuel, such as dust, gas, or the vapors of an ignitable liquid, without the production of damaging pressure. [921, 2017]

3.3.25 Fuel Object. A combustible object or mass of particulate that can serve as a source of fuel for a fire or deflagration; sometimes referred to as a *fuel package*. [652, 2019]

3.3.26 Grounding. The process of bonding one or more conductive objects to the ground so that all objects are at zero electrical potential; also referred to as earthing. [652, 2019]

3.3.27 Hot Work. Work involving burning, welding, or a similar operation that is capable of initiating fires or explosions. [51B, 2019]

3.3.28* Hybrid Mixture. An explosible heterogeneous mixture, comprising gas with suspended solid or liquid particulates, in which the total flammable gas concentration is ≥ 10 percent of the lower flammable limit (LFL) and the total suspended particulate concentration is ≥ 10 percent of the minimum explosible concentration (MEC). [68, 2018]

3.3.29 Intermediate Bulk Containers.

3.3.29.1* Flexible Intermediate Bulk Container (FIBC). Large bags typically made from nonconductive woven fabric that are used for storage and handling of bulk solids. [652, 2019]

3.3.29.1.1 Type A FIBC. An FIBC made from nonconductive fabric with no special design features for control of electrostatic discharge hazards. [652, 2019]

3.3.29.1.2 Type B FIBC. An FIBC made from nonconductive fabric where the fabric or the combination of the fabric shell, coating, and any loose liner has a breakdown voltage of less than 6000 volts. [652, 2019]

3.3.29.1.3 Type C FIBC. An FIBC made from conductive material or nonconductive woven fabric incorporating interconnected conductive threads of specified spacing with all conductive components connected to a grounding tab. [652, 2019]

3.3.29.1.4 Type D FIBC. An FIBC made from fabric and/or threads with special static properties designed to control electrostatic discharge energy without a requirement for grounding the FIBC. [652, 2019]

3.3.29.2* Rigid Intermediate Bulk Container (RIBC). An intermediate bulk container (IBC) that can be enclosed in or encased by an outer structure consisting of a steel cage, a single-wall metal or plastic enclosure, or a double wall of foamed or solid plastic. [652, 2019]

3.3.29.2.1 Insulating RIBC. An RIBC constructed entirely of solid plastic or solid plastic and foam composite that cannot be electrically grounded. [652, 2019]

3.3.30* Lower Flammable Limit (LFL). The lowest concentration of material that will propagate a flame from an ignition source through a mixture of flammable gas or combustible dust dispersion with a gaseous oxidizer.

3.3.31* Minimum Explosible Concentration (MEC). The minimum concentration of a combustible dust suspended in air, measured in mass per unit volume, that will support a deflagration. [652, 2019]

3.3.32* Minimum Ignition Energy (MIE). The lowest capacitive spark energy capable of igniting the most ignition-sensitive concentration of a flammable vapor-air mixture or a combustible dust-air mixture as determined by a standard test procedure. [652, 2019]

N 3.3.33 Nanopowder. See 3.3.48, Ultrafine Particle.

3.3.34* Noncombustible Material. A material that, in the form in which it is used and under the conditions anticipated, will not ignite, support combustion, burn, or release flammable vapors when subjected to fire or heat.

N 3.3.35* Nonconductive. A material or a construction that has the ability to accumulate charge, even when in contact with ground. [652, 2019]

3.3.36 Owner/Operator. The organization with fiscal responsibility for the operation, maintenance, and profitability of the facility.

3.3.37* Pneumatic Conveying System. An equipment system that transfers a controlled flow of solid particulate material from one location to another using air or other gases as the conveying medium, and that is comprised of the following components: a material feeding device; an enclosed ductwork, piping, or tubing network; an air-material separator; and an air-moving device. [652, 2019]

3.3.37.1 Negative-Pressure Pneumatic Conveying System. A pneumatic conveying system that transports material by utilizing gas at less than atmospheric pressure.

3.3.37.2 Positive-Pressure Pneumatic Conveying System. A pneumatic conveying system that transports material by utilizing gas at greater than atmospheric pressure.

N 3.3.38 Portable Vacuum Cleaner. A movable assembly consisting basically of a vacuum source air-moving device (AMD), an air-material separator (AMS) using either liquid or filter media within an enclosure, and vacuum hose, used to remove dusts and particles from surfaces. [652, 2019]

Δ 3.3.39 Pyrophoric Material. A material that ignites upon exposure to air at or below 130°F (54.4°C). [484, 2019]

3.3.40 Qualified Person. A person who, by possession of a recognized degree, certificate, professional standing, or skill, and who, by knowledge, training, and experience, has demonstrated the ability to deal with problems related to the subject matter, the work, or the project. [1451, 2018]

3.3.41 Replacement-in-Kind. A replacement that satisfies the design specifications of the replaced item. [652, 2019]

3.3.42* Risk Assessment. An assessment of the likelihood, vulnerability, and magnitude of the incidents that could result from exposure to hazards. [1250, 2015]

3.3.43 Segregation. A hazard management strategy in which a physical barrier is established between the hazard area and an area to be protected. [652, 2019]

3.3.44 Separation. A hazard management strategy achieved by the establishment of a distance as required by the standard between the combustible particulate solid process and other operations that are in the same room. [652, 2019]

3.3.45 Spark. A moving particle of solid material that emits radiant energy due to either its temperature or the process of combustion on its surface.

3.3.46 Threshold Housekeeping Dust Accumulations. The maximum quantity of dust permitted to be present before cleanup is required. [652, 2019]

3.3.47 Ullage Space. The open space above the surface of the stored solids in a storage vessel. [652, 2019]

N 3.3.48* Ultrafine Particle. Individual particles that have a median size, in two or three dimensions, less than 0.5 μm (500 nm).

3.3.49 Vent Closure. A pressure-relieving cover that is placed over a vent. [68, 2018]

3.3.50 Vented Explosion Pressure (P_{red}). The maximum pressure developed in a vented enclosure during a vented deflagration.

3.3.51 Wall.

3.3.51.1 Fire Barrier Wall. A wall, other than a fire wall, having a fire resistance rating. [221, 2018]

3.3.51.2 Fire Wall. A wall separating buildings or subdividing a building to prevent the spread of fire and having a fire resistance rating and structural stability. [221, 2018]

3.3.52* Water-Compatible. A material that is neither reactive with water nor incompatible with water and that, consequently, can be extinguished with a water-based extinguishing system.

3.3.53* Water-Incompatible. A material that does not chemically react with water, but which undergoes a change of phase or state upon mixture with water that renders it permanently changed or incompatible with the remainder of the process.

3.3.54* Water-Reactive. A material that chemically reacts with water, producing another compound that can represent a different set of fire protection concerns.

Chapter 4 General Requirements

4.1 Owner's Obligation. The facility owner/operator shall be responsible for ensuring that the facility and the systems handling combustible particulate solids are designed, installed, and maintained in accordance with the requirements of this standard and NFPA 652.

4.2 Objectives. The objectives stated in this section shall be interpreted as intended outcomes of this standard and not as prescriptive requirements. [652:4.2]

4.2.1 Life Safety.

4.2.1.1* The facility, processes, and equipment shall be designed, constructed, equipped, and maintained and management systems shall be implemented to reasonably protect occupants not in the immediate proximity of the ignition from the effects of fire for the time needed to evacuate, relocate, or take refuge. [652:4.2.1.1]

4.2.1.1.1 The facility, processes, and equipment shall be designed, constructed, equipped, and maintained and management systems shall be implemented to reasonably prevent serious injury from flash fires. [652:4.2.1.2]

4.2.1.1.2 The facility, processes, and equipment shall be designed, constructed, equipped, and maintained and management systems shall be implemented to reasonably prevent serious injury from explosions. [652:4.2.1.3]

4.2.1.2 The structure shall be located, designed, constructed, and maintained to reasonably protect adjacent properties and the public from the effects of fire, flash fire, or explosion. [652:4.2.1.4]

4.2.2 Structural Integrity. The facility shall be designed, constructed, and equipped to maintain its structural integrity in spite of the effects of fire or explosion for the time necessary to evacuate, relocate, or defend in place occupants not in the immediate proximity of the ignition.

4.2.3* Mission Continuity. The facility, processes, and equipment, shall be designed, constructed, equipped, and maintained and management systems shall be implemented to limit damage to levels that ensure the ongoing mission, production, or operating capability of the facility to a degree acceptable to the owner/operator. [652:4.2.2]

4.2.4 Mitigation of Fire Spread and Explosions. The facility and processes shall be designed to prevent fires and explosions that can cause failure of adjacent buildings or building compartments or other enclosures, emergency life safety systems, adjacent properties, adjacent storage, or the facility's structural elements.

4.2.4.1* The structure shall be designed, constructed, and maintained to prevent fire or explosions from causing failure of load-bearing structural members, from propagating into adjacent interior compartments, and from incapacitating fire protective and emergency life safety systems in adjacent compartments.

4.2.4.2 The structure shall be located, designed, constructed, equipped, and maintained to prevent the propagation of fire or explosion to or from adjacent storage or structures.

Δ 4.3* Compliance Options. The goal in Section 1.3 and the objectives in Section 4.2 shall be achieved by either of the following means:

- (1) The prescriptive provisions in accordance with Chapters 5, 7, 8, and 9 of this standard
- (2) The performance-based approach in accordance with Chapter 6

N Chapter 5 Hazard Identification

N 5.1 Hazard Identification. The materials handled in the facility shall be evaluated for their hazard in accordance with Chapter 5 of NFPA 652.

Chapter 6 Performance-Based Design Option

6.1 General Requirements.

N 6.1.1 Retained Prescriptive Requirements. Portions of a facility designed in accordance with this chapter as an alternative for particular prescriptive requirements shall meet all other relevant prescriptive requirements in this standard. [652:6.1.1]

N 6.1.2* It shall be permitted to use performance-based alternative designs for a process or part of a process, specific material, or piece of equipment in lieu of the prescriptive requirements found in Chapter 9. [652:6.1.2]

6.1.3 Approved Qualifications. The performance-based design shall be prepared by a person knowledgeable about the affected systems and their associated hazards and with qualifications acceptable to the owner/operator.

6.1.4* Independent Review. The AHJ shall be permitted to obtain an independent third party review of the proposed design.

6.1.5* Performance-based designs shall be documented with all calculations, references, assumptions, and sources from which material characteristics and other data have been obtained or on which the designer has relied for some material aspect of the design in accordance with Section 5.8 of NFPA 101. The documentation requirements of 5.8.6 shall be supplemented to include documentation of flash fire and explosion scenarios.

6.1.5.1 A sensitivity analysis shall be performed for each assumption that is not provided in an authoritative reference acceptable to the AHJ to show that variation of said assumption does not result in a failure to meet design criteria.

6.1.5.2 The source of all calculation methods and models shall be documented with their limits of applicability.

6.1.6* Performance-based designs and documentation shall be updated and subject to re-approval if any of the assumptions on which the original design was based are changed.

6.1.7* Sources of Data.

6.1.7.1 Data sources shall be identified and documented for each input data requirement that must be met using a source other than a design fire scenario, an assumption, or a building design specification.

6.1.7.2 The degree of conservatism reflected in such data shall be specified, and a justification for the sources shall be provided.

6.2 Performance Criteria. A system and facility design shall be deemed to meet the objectives specified in Section 4.2 if its performance meets the criteria in 6.2.1 through 6.2.5.

Δ 6.2.1 Occupant Life Safety.

6.2.1.1 The life safety objectives of 4.2.1 with respect to a fire hazard shall be achieved if either of the following criteria is met:

- (1) Ignition has been prevented.
- (2) Under all fire scenarios, no person, other than those in the immediate proximity of the ignition, is exposed to untenable conditions due to the fire, and no critical structural element of the building is damaged to the extent that it can no longer support its design load during the period of time necessary to effect complete evacuation of the occupants.

6.2.1.2 The life safety objectives of 4.2.1 with respect to an explosion hazard shall be achieved if either of the following criteria is met:

- (1) Ignition has been prevented.
- (2) Under all explosion scenarios, no person, other than those in the immediate proximity of the ignition, is exposed to untenable conditions, including missile impact or overpressure, due to the occurrence of an explosion, and no critical structural element of the building is damaged to the extent that it can no longer support its design load during the period of time necessary to effect complete evacuation of the occupants.

6.2.2* Structural Integrity. The structural integrity objective of 4.2.2 with respect to fire and explosion shall be achieved when no critical structural element of the building is damaged to the extent that it can no longer support its design load under all fire and explosion scenarios.

6.2.3 Mission Continuity. The mission continuity objectives of 4.2.3 shall be achieved when damage to equipment and the facility has been limited to a level of damage acceptable to the owner/operator.

6.2.4 Mitigation of Fire Spread and Explosions. When limitation of fire spread is to be achieved, all of the following criteria shall be demonstrated:

- (1) Adjacent combustibles shall not attain their ignition temperature.
- (2) Building design and housekeeping shall prevent combustibles from accumulating exterior to the enclosed process system to a concentration that is capable of supporting propagation.

- (3) Particulate processing systems shall prevent fire or explosion from propagating from one process system to an adjacent process system or to the building interior.

6.2.5 Effects of Explosions. Where the prevention of damage due to explosion is to be achieved, deflagrations shall not produce any of the following conditions:

- (1) Internal pressures in the room or equipment sufficient to threaten its structural integrity
- (2) Extension of the flame front outside the compartment or equipment of origin except where intentionally vented to a safe location
- (3)* Rupture of the compartment or equipment of origin and the ejection of fragments that can constitute missile hazards

Δ 6.3* Design Scenarios.

6.3.1 Fire Scenarios.

6.3.1.1 Each fuel object in the compartment shall be considered for inclusion as a fire scenario.

6.3.1.2 The fuel object that produces the most rapidly developing fire during startup, normal operating conditions, or shutdown shall be included as a fire scenario.

6.3.1.3 The fuel object that produces the most rapidly developing fire under conditions of a production upset or single equipment failure shall be included as a fire scenario.

6.3.1.4 The fuel object that produces the greatest total heat release during startup, normal operating conditions, or shutdown shall be included as a fire scenario.

6.3.1.5 The fuel object that produces the greatest total heat release under conditions of a production upset or single equipment failure shall be included as a fire scenario.

6.3.1.6 The fuel object that can produce a deep-seated fire during startup, normal operating conditions, or shutdown shall be included as a fire scenario.

6.3.1.7 The fuel object that can produce a deep-seated fire under conditions of a production upset or single equipment failure shall be included as a fire scenario.

6.3.2 Explosion Scenarios.

6.3.2.1 Each duct, enclosed conveyor, silo, bunker, AMS, or other vessel containing a combustible dust in sufficient quantity or conditions to support the propagation of a flame front during startup, normal operating conditions, or shutdown shall be included as an explosion scenario.

6.3.2.2 Each duct, enclosed conveyor, silo, bunker, AMS, or other vessel containing a combustible dust in sufficient quantity or conditions to support the propagation of a flame front under conditions of production upset or single equipment failure shall be included as an explosion scenario.

6.3.2.3 Each building or building compartment containing a combustible dust in sufficient quantity or conditions to support the propagation of a flame front during startup, normal operating conditions, or shutdown shall be included as an explosion scenario.

6.3.2.4 Each building or building compartment containing a combustible dust in sufficient quantity or conditions to support the propagation of a flame front under conditions of production upset or single equipment failure shall be included as an explosion scenario.

6.4 Evaluation of Proposed Design.

6.4.1* A proposed design's performance shall be assessed relative to each performance objective in Section 4.2 and each applicable scenario in Section 6.3, with the assessment conducted through the use of appropriate calculation methods acceptable to the AHJ.

6.4.2 The design professional shall establish numerical performance criteria for each of the objectives in Section 4.2.

6.4.3 The design professional shall use the assessment methods to demonstrate that the proposed design will achieve the goals and objectives, as measured by the performance criteria in light of the safety margins and uncertainty analysis, for each scenario, given the assumptions.

N Chapter 7 Dust Hazards Analysis (DHA)

N 7.1 General Requirements.

7.1.1 The requirements of this chapter shall be applied retroactively in accordance with 7.1.1.1 through 7.1.1.3. [652:7.1.1]

7.1.1.1* A DHA shall be completed for all new processes and facility compartments. [652:7.1.1.1]

7.1.1.2 For existing processes and facility compartments a DHA shall be completed by September 7, 2020. [652:7.1.1.2]

7.1.1.3 The owner/operator shall demonstrate reasonable progress each year in completing DHAs prior to the deadline set in 7.1.1.2. [652:7.1.1.3]

7.1.2 The owner/operator of a facility where materials determined to be combustible or explosible in accordance with Chapter 5 of NFPA 652 are present in an enclosure shall be responsible to ensure a DHA is completed in accordance with the requirements of Chapter 7 of NFPA 652. [652:7.1.2]

7.1.3 The absence of previous incidents shall not be used as the basis for not performing a DHA. [652:7.1.3]

7.1.4 The DHA shall be reviewed and updated at least every 5 years. [652:7.1.4]

N 7.2 Hazard Assessment.

7.2.1 The facility and process equipment shall be evaluated for dust flash-fire and dust explosion hazards in accordance with this chapter. The hazard assessment shall be conducted in accordance with the retroactivity provisions in Section 7.1.

7.2.1.1 Those portions of the process and facility interior where dust accumulations exist external to equipment in sufficient depth to prevent discerning the underlying contrasting surface color shall be evaluated to determine if a dust explosion hazard or flash-fire hazard exists.

7.2.1.2 Areas where dust clouds of a hazardous concentration exist shall be deemed to be dust flash-fire and dust explosion hazard areas.

7.2.1.3* Dust flash-fire or dust explosion hazard areas shall additionally be determined in accordance with any one of the following four methods:

- (1) Layer depth criterion method in 7.2.3
- (2) Mass method A in 7.2.4
- (3) Mass method B in 7.2.5
- (4) Risk assessment method in 7.2.6

7.2.1.4 Each of the methods in 7.2.3, 7.2.4, 7.2.5, and 7.2.6 shall be deemed to provide equivalent levels of safety.

7.2.1.5* It shall be permitted to determine the accumulated mass and bulk density on a dry weight basis by drying the sample to less than or equal to 5 percent moisture by weight.

7.2.1.6 Dust accumulations are deemed nonseparated unless segregation, separation, or detachment is used to limit the hazard area in accordance with 9.2.1.

7.2.1.7 All dust accumulated on structures above the lowest footprint shall be evaluated as if accumulated on the lowest footprint.

7.2.1.8 Dust accumulation amounts shall reflect the conditions that exist just prior to routinely scheduled cleaning and shall not include short-term accumulations cleaned in accordance with Chapter 8.

7.2.1.9 The process equipment shall be assessed in accordance with 7.2.7.

7.2.1.10 Personnel exposed to a dust flash-fire hazard shall be protected in accordance with 8.8.1.2.

7.2.2 Those portions of the facility and process where a dust explosion hazard or flash-fire hazard exists shall be protected from the effects of those hazards in accordance with this section as well as 9.2.1, 9.2.2, and 9.2.3 and Chapter 7.

7.2.3* Layer Depth Criterion Method. A dust flash-fire or dust explosion hazard area exists when the average dust layer thickness measured external to process equipment over the compartment area exceeds the quantity determined in 7.2.3.1 and 7.2.3.2.

7.2.3.1 The layer depth criterion, which is $\frac{1}{32}$ in. (0.8 mm), shall be permitted to be increased according to the following equation for materials with bulk density less than 75 lb/ft³ (1200 kg/m³):

N [7.2.3.1]

$$LD \text{ (in.)} = \frac{\left(\frac{1}{32} \text{ in.}\right) \left(75 \frac{\text{lb}}{\text{ft}^3}\right)}{BD}$$

where:

LD = layer depth (in.)

BD = bulk density (lb/ft³)

7.2.3.2* A dust explosion hazard and dust flash-fire hazard shall be deemed to exist in any building or room where any of the following conditions exists:

- (1) The total area of nonseparated dust accumulations exceeding the layer depth criterion is greater than 5 percent of the footprint area

- (2) The area of any single nonseparated dust accumulation exceeding the layer depth criterion is greater than 1000 ft² (92.9 m²)
- (3) The total volume of nonseparated dust accumulations is greater than the layer depth criterion multiplied by 5 percent of the footprint area
- (4) The total volume of any single nonseparated dust accumulation is greater than the layer depth criterion multiplied by 1000 ft² (92.9 m²)

N 7.2.4* Mass Method A. A dust flash-fire or dust explosion hazard area exists when the total accumulated dust external to process equipment exceeds the quantities determined from the equations in 7.2.4.1 and 7.2.4.2.

N 7.2.4.1 The threshold dust mass establishing a building or room as a dust explosion hazard area, $M_{basic-exp}$, shall be determined by the following equation:

$$M_{basic-exp} = 0.004 \cdot A_{floor} \cdot H \quad [7.2.4.1]$$

where:

$M_{basic-exp}$ = threshold dust mass (kg) based on building damage criterion

A_{floor} = lesser of enclosure floor area (m²) or 2000 m²

H = lesser of enclosure ceiling height (m) or 12 m

N 7.2.4.2 The threshold dust mass establishing a building or room as a dust flash-fire hazard area, $M_{basic-fire}$, shall be determined by the following equation:

$$M_{basic-fire} = 0.02 \cdot A_{floor} \quad [7.2.4.2]$$

where:

$M_{basic-fire}$ = threshold dust mass (kg) based on personnel fire exposure criterion

A_{floor} = lesser of enclosure floor area (m²) or 2000 m²

N 7.2.5* Mass Method B. A dust flash-fire or dust explosion hazard area exists when the total accumulated dust external to process equipment exceeds the quantities determined from the equations in 7.2.5.1 and 7.2.5.2.

N 7.2.5.1* The threshold dust mass establishing a building or room as a dust explosion hazard area, M_{exp} , shall be determined by the following equation:

$$M_{exp} = \left[\frac{P_{es}}{DLF} \right] \cdot \left[\frac{C_w}{P_{max}} \right] \cdot \frac{A_{floor} \cdot H}{\eta_D} \quad [7.2.5.1]$$

where:

M_{exp} = threshold dust mass (kg) based on building damage criterion

P_{es} = enclosure strength evaluated based on static pressure calculations for the weakest building structural element not intended to vent or fail (bar g) per NFPA 68

DLF = dynamic load factor, the ratio of maximum dynamic deflection to static deflection per NFPA 68

C_w = worst-case dust concentration (kg/m³) at which the maximum rate-of-pressure-rise results in tests conducted per ASTM E1226

P_{max} = maximum pressure (bar g) developed in ASTM E1226 tests with the accumulated dust sample

A_{floor} = enclosure floor area (m²)

H = enclosure ceiling height (m)

η_D = entrainment fraction = 0.25

N 7.2.5.1.1 In the absence of detailed structural response analysis, it shall be permitted to assume a worst-case value of $DLF = 1.5$ and design based on the weakest structural element of the enclosure.

N 7.2.5.1.2* It shall be permitted to use an alternative value of η_D based on a risk assessment that is acceptable to the AHJ.

N 7.2.5.2* The threshold dust mass establishing a building or room as a dust flash-fire hazard area, M_{fire} , shall be determined by the following equation:

$$M_{fire} = \rho \cdot C_w \cdot \left[\frac{P_{initial}}{P_{initial} + P_{max}} \right] \cdot \frac{A_{floor} \cdot D}{\eta_D} \quad [7.2.5.2]$$

where:

M_{fire} = threshold dust mass (kg) based on personnel fire exposure criterion

ρ = probability of flame impingement on a person, not to exceed 0.05 (5 percent probability)

C_w = worst-case dust concentration (kg/m³) at which the maximum rate-of-pressure-rise results in tests conducted per ASTM E1226

$P_{initial}$ = 1 bar absolute

P_{max} = maximum pressure (bar g) developed in ASTM E1226 tests with the accumulated dust sample

A_{floor} = enclosure floor area (m²)

D = nominal height of a person (2 m)

η_D = entrainment fraction = 0.25

N 7.2.5.2.1* It shall be permitted to use an alternative value of η_D , based on a risk assessment that is acceptable to the AHJ.

N 7.2.6* Risk Assessment Method. A documented risk assessment acceptable to the AHJ shall be permitted to be conducted to determine whether or where a dust explosion hazard or dust flash-fire hazard area exists.

N 7.2.7 An explosion hazard shall be deemed to exist in enclosed process equipment where both of the following conditions are possible:

- (1) Combustible dust is present in sufficient quantity to cause enclosure rupture if suspended and ignited.
- (2) A means of suspending the dust is present.



Chapter 8 Management Systems

N 8.1 Retroactivity. This chapter shall be applied retroactively to new and existing facilities and processes.

N 8.2 General. (Reserved)

N 8.3 Operating Procedures. See 8.8.1.

△ 8.4 Housekeeping Procedures and Portable Vacuum Cleaners.

8.4.1 Cleaning Frequency.

8.4.1.1* Where the facility is intended to be operated with less than the dust accumulation defined by the owner/operator's chosen criterion in Section 7.2, the housekeeping frequency shall be established to ensure that the accumulated dust levels on walls, floors, and horizontal surfaces such as equipment, ducts, pipes, hoods, ledges, beams, and above suspended ceilings and other concealed surfaces, such as the interior of electrical enclosures, does not exceed the threshold dust mass/accumulation.

8.4.1.2 Where the facility is intended to be operated with less than the dust accumulation defined by the owner/operator's chosen criterion in Section 7.2, a planned inspection process shall be implemented to evaluate dust accumulation rates and the housekeeping frequency required to maintain dust accumulations below the threshold dust mass/accumulation.

8.4.1.3* Where the facility is intended to be operated with less than the dust accumulation defined by the owner/operator's chosen criterion in Section 7.2, the housekeeping procedure shall include specific requirements establishing time to clean local spills or short-term accumulation to allow the elimination of the spilled mass or accumulation from the calculations in Section 7.2.

△ **8.4.1.4*** Where the facility is intended to be operated with more than the dust accumulation defined by the owner/operator's chosen criterion in Section 7.2, a documented risk assessment acceptable to the AHJ shall be permitted to be conducted to determine the level of housekeeping consistent with any dust explosion and dust flash-fire protection measures provided in accordance with 9.2.3 and 8.8.1.2.

8.4.2 Cleaning Methods.

8.4.2.1 Surfaces shall be cleaned in a manner that minimizes the risk of generating a fire or explosion hazard.

8.4.2.2 Vacuuming shall be the preferred method of cleaning.

8.4.2.3 Where vacuuming is impractical, permitted cleaning methods shall include sweeping and water washdown.

8.4.2.4* Blowdowns using compressed air or steam shall be permitted to be used for cleaning inaccessible surfaces or surfaces where other methods of cleaning result in greater personal safety risk. Where blowdown using compressed air is used, the following precautions shall be followed:

- (1) Vacuuming, sweeping, or water washdown methods are first used to clean surfaces that can be safely accessed prior to using compressed air.
- (2) Dust accumulations in the area after vacuuming, sweeping, or water washdown do not exceed the threshold dust accumulation.
- (3) Compressed air hoses are equipped with pressure relief nozzles limiting the discharge gauge pressure to 30 psi (207 kPa) in accordance with the OSHA requirements in 29 CFR 1910.242(b), "Hand and Portable Powered Tools and Equipment, General."
- (4) All electrical equipment potentially exposed to airborne dust in the area meets, as a minimum, the requirements of NFPA 70; NEMA 12 as defined by NEMA 250, *Enclosures for Electrical Equipment*; or the equivalent.

- (5) All ignition sources and hot surfaces capable of igniting a dust cloud or dust layer are shut down or removed from the area.

8.4.2.5* Housekeeping procedures shall be documented in accordance with the requirements of Sections 7.1 and 8.12.

△ 8.4.3* Portable Vacuum Cleaners.

N 8.4.3.1 Portable vacuum cleaners with a dirty side volume greater than 8 ft³ shall comply with 9.7.1 and 9.7.2. [652:8.4.2.2.1.1]

N 8.4.3.2* When metal particles, dusts, or powders are being cleaned NFPA 484 shall be the reference source for proper use and limitations of both dry and wet portable vacuum cleaners. [652:8.4.2.2.1.2]

N 8.4.3.3* The operation of portable vacuum cleaning devices shall be subject to a dust hazard analysis to ensure that the risk to personnel and facility operations from deflagrations is minimized. [652:8.4.2.2.1.3]

N 8.4.3.4 Hoses and vacuum tools shall be appropriate for use and be static dissipative or conductive. [652:8.4.2.2.1.4]

N 8.4.3.5 Portable vacuum cleaners shall not be used on processes generating hot embers or sparks. [652:8.4.2.2.1.5]

N 8.4.3.6* For portable vacuum cleaners used with combustible dusts having a minimum ignition energy less than 30 mJ, the path to ground shall be verified prior to use after each movement or new connection, or both. [652:8.4.2.2.1.6]

8.4.3.7* Portable vacuum cleaners that meet the following minimum requirements shall be permitted to be used to collect combustible particulate solids in unclassified (general purpose) areas:

- (1) Materials of construction shall comply with 9.3.13.2 and 9.4.3.2.
- (2) Hoses shall be conductive or static dissipative.
- (3) All conductive components, including wands and attachments, shall be bonded and grounded.
- (4) Dust-laden air shall not pass through the fan or blower.
- (5) Electrical motors shall not be in the dust-laden air stream unless listed for Class II, Division 1, locations.
- (6)* When liquids or wet material are picked up by the vacuum cleaner, paper filter elements shall not be used.
- (7) Vacuum cleaners used for metal dusts shall meet the requirements of NFPA 484.

△ **8.4.3.8*** In Class II electrically classified (hazardous) locations, vacuum cleaners shall be listed for the purpose and location or shall be a fixed-pipe suction system with remotely located exhausters and AMS installed in conformance with 9.3.13 and shall be suitable for the dust being collected.

8.4.3.9 Where flammable vapors or gases are present, vacuum cleaners shall be listed for Class I and Class II hazardous locations.

N 8.5 Open Flames and Sparks (Hot Work).

N 8.5.1 Cutting and welding shall comply with the applicable requirements of NFPA 51B.

N 8.5.2 Grinding, chipping, and other operations that produce either sparks or open-flame ignition sources shall be controlled by a hot work permit system in accordance with NFPA 51B.

N 8.5.3 Smoking shall be permitted only in designated areas.

N 8.6 Personal Protective Equipment (PPE). See 8.8.1.

N 8.7 Inspection and Maintenance.

N 8.7.1 General Requirements.

N 8.7.1.1 An inspection, testing, and maintenance program shall be developed and implemented to ensure that the fire and explosion protection systems and related process controls and equipment perform as designed.

N 8.7.1.2 The inspection, testing, and maintenance program shall include the following:

- (1) Fire and explosion protection and prevention equipment in accordance with the applicable NFPA standards
- (2) Dust control equipment
- (3) Housekeeping
- (4) Potential ignition sources
- (5)* Electrical, process, and mechanical equipment, including process interlocks
- (6) Process changes
- (7) Lubrication of bearings

N 8.7.1.3 Records shall be kept of maintenance and repairs performed.

N 8.7.2 Specific Requirements.

N 8.7.2.1 Maintenance of Material Feeding Devices.

N 8.7.2.1.1 Bearings shall be lubricated and checked for excessive wear on a periodic basis.

N 8.7.2.1.2 If the material has a tendency to adhere to the feeder or housing, the components shall be cleaned periodically to maintain good balance and minimize the probability of ignition.

N 8.7.2.2 Maintenance of Air-Moving Devices.

N 8.7.2.2.1 Fans and blowers shall be checked periodically for excessive heat and vibration.

N 8.7.2.2.2 Maintenance, other than the lubrication of external bearings, shall not be performed on fans or blowers while the unit is operating.

N 8.7.2.2.3 Bearings shall be lubricated and checked periodically for excessive wear.

N 8.7.2.2.4* If the material has a tendency to adhere to the rotor or housing, the components shall be cleaned periodically to maintain good balance and minimize the probability of ignition.

N 8.7.2.2.5* The surfaces of fan housings and other interior components shall be maintained free of rust.

N 8.7.2.2.6 Aluminum paint shall not be used on interior steel surfaces.

N 8.7.2.3 Maintenance of Air-Material Separators.

N 8.7.2.3.1 Means to Dislodge.

N 8.7.2.3.1.1 Air-material separation devices that are equipped with a means to dislodge particulates from the surface of filter media shall be inspected periodically as recommended in the manufacturers' instructions for signs of wear, friction, or clogging.

N 8.7.2.3.1.2 These devices shall be adjusted and lubricated as recommended in the manufacturers' instructions.

N 8.7.2.3.2 AMSs that recycle air (i.e., cyclones and filter media dust collectors) shall be maintained to comply with 9.3.13.1.6.3.

N 8.7.2.3.3 Filter media shall not be replaced with an alternative type unless a thorough evaluation of the fire hazards has been performed, documented, and reviewed by management.

N 8.7.2.4 Maintenance of Abort Gates and Abort Dampers. Abort gates and abort dampers shall be adjusted and lubricated as recommended in the manufacturers' instructions.

N 8.7.2.5 Maintenance of Fire and Explosion Protection Systems.

N 8.7.2.5.1 All fire detection equipment monitoring systems shall be maintained in accordance with the requirements of NFPA 72.

N 8.7.2.5.2 All fire-extinguishing systems shall be maintained pursuant to the requirements established in the standard that governs the design and installation of the system.

N 8.7.2.5.3* All vents for the relief of pressure caused by deflagrations shall be maintained.

N 8.7.2.5.4 All explosion prevention systems and inerting systems shall be maintained pursuant to the requirements of NFPA 69.

N 8.7.3 Impairments of Fire Protection and Explosion Prevention Systems.

N 8.7.3.1* Impairments shall include anything that interrupts the normal intended operation of the fire protection or explosion prevention system.

N 8.7.3.2* A written impairment procedure shall be followed for every impairment to the fire protection or explosion prevention system.

N 8.7.3.3* Impairments shall be limited in size and scope to the system or portion thereof being repaired, maintained, or modified.

N 8.7.3.4* Impairment notification procedures shall be implemented by management to notify plant personnel and the AHJ of existing impairments and their restoration.

N 8.8 Employee Training and Procedures.

N 8.8.1 Plan.

N 8.8.1.1 Operating and maintenance procedures shall be developed.

N 8.8.1.2* Operating and maintenance procedures shall address personal protective equipment (PPE), including flame-resistant garments, in accordance with the workplace hazard assessment required by NFPA 2113.

N 8.8.1.3 The plans and procedures shall be reviewed annually and as required by process changes.

N 8.8.2 Initial and Refresher Training.

N 8.8.2.1 Initial and refresher training shall be provided to employees who are involved in operating, maintaining, and supervising facilities that handle combustible particulate solids.

N 8.8.2.2 Initial and refresher training shall ensure that all employees are knowledgeable about the following:

- (1) Hazards of their workplace
- (2) General orientation, including plant safety rules
- (3) Process description
- (4) Equipment operation, safe startup and shutdown, and response to upset conditions
- (5) The necessity for proper functioning of related fire and explosion protection systems
- (6) Equipment maintenance requirements and practices
- (7) Housekeeping requirements
- (8)* Emergency response plans

N 8.8.3 Certification. The employer shall certify annually that the training and review required by 8.8.1 and 8.8.2 have been completed.

N 8.9 Contractors and Subcontractors.

N 8.9.1 General. Owner/operators shall ensure that the requirements of 8.9.1.1 through 8.9.2.5 are met.

N 8.9.1.1* Only qualified contractors possessing the requisite craft skills shall be employed for work involving the installation, repair, or modification of buildings (interior and exterior), machinery, and fire protection equipment.

N 8.9.1.2 Contractors involved in the commissioning, repair, or modification of explosion protection equipment shall be qualified as specified in Chapter 15 of NFPA 69.

N 8.9.2 Contractor Training.

N 8.9.2.1 Contractors operating owner/operator equipment shall be trained and qualified to operate the equipment and perform the work.

N 8.9.2.2 Written documentation shall be maintained detailing the training that was provided and who received it.

N 8.9.2.3 Contractors working on or near a given process shall be made aware of the potential hazards from and exposures to fire, explosion, or toxic releases.

N 8.9.2.4* Contractors shall be trained and required to comply with the facility's safe work practices and policies, including but not limited to equipment lockout/tagout permitting, hot work permitting, fire system impairment handling, smoking, housekeeping, and use of PPE.

N 8.9.2.5 Contractors shall be trained on the facility's emergency response and evacuation plan, including but not limited to emergency reporting procedures, safe egress points, and evacuation areas.

N 8.10 Emergency Planning and Response.

N 8.10.1 A written emergency response plan shall be developed for preventing, preparing for, and responding to work-related emergencies including but not limited to fire and explosion.

N 8.10.2 The plans and procedures shall be reviewed annually and as required by process changes.

N 8.11 Incident Investigation.

N 8.11.1* Incidents that result in a fire or explosion of a magnitude that causes property damage, production shutdown time, or injury shall be investigated.

N 8.11.2 Once the scene has been released by the AHJ, incident investigations shall be promptly initiated by management personnel or by a designee who has a working knowledge of the facility and processes.

N 8.11.3* A written report of the investigation shall be prepared that describes the incident, lists what has been learned from the investigation, and makes recommendations to prevent recurrence of that or similar incidents.

N 8.11.4* A summary of the incident investigation report shall be shared with affected personnel operating, maintaining, and supervising the facility.

N 8.12* Management of Change. Written procedures shall be established and implemented to manage proposed changes to process materials, staffing, job tasks, technology, equipment, procedures, and facilities. [652:8.12.1]

N 8.12.1 The management of change procedure shall ensure that the following issues are addressed prior to any change:

- (1)* The technical basis for the proposed change
- (2)* The safety and health implications
- (3) Whether the change is permanent or temporary, including the authorized duration of the temporary change
- (4) Modifications to operating and maintenance procedures
- (5) Employee training requirements
- (6) Authorization requirements for the proposed change
- (7) Results of characterization tests used to assess the hazard, if conducted

N 8.12.2 Implementation of the management of change procedure shall not be required for replacements-in-kind. [652:8.12.3]

N 8.12.3 Design documentation, as required by 9.1.2 and procedures shall be updated to incorporate the change.

N 8.13 Document Retention. (Reserved)

N 8.14 Management Systems Review. (Reserved)

N 8.15 Employee Participation. (Reserved)

N Chapter 9 Hazard Management: Mitigation and Prevention

N 9.1 Process and Facility Design.

N 9.1.1 The design of processes and facilities that handle combustible particulate solids shall consider the physical and chemical properties that establish the hazardous characteristics of the materials.

N 9.1.2* The design and its basis shall be documented and maintained for the life of the process.

N 9.2 Building Design.

N 9.2.1 Segregation, Separation, or Detachment of Combustible Dust Handling and Processing Areas.

N 9.2.1.1 General. Areas in which combustible dusts are produced, processed, handled, or collected such that combustible dust accumulation on exposed or concealed surfaces, external to equipment or containers, exceeds the threshold as determined in Section 7.2, shall be detached, segregated, or separated from other occupancies to minimize damage from a fire or explosion.

N 9.2.1.2 Use of Segregation.

N 9.2.1.2.1* Physical barriers that are erected to segregate dust flash-fire hazards areas, including seals at all penetrations of floors, walls, ceilings, or partitions, shall have a minimum 1-hour fire resistance rating.

N 9.2.1.2.2 Physical barriers that are erected to segregate dust explosion hazard areas shall be designed to preclude failure of those barriers during a dust explosion per NFPA 68.

N 9.2.1.2.3 Doors and openings shall not be permitted in physical barriers unless they are normally are closed and have at least the strength and fire resistance rating required of the physical barrier. These doors shall be installed according to NFPA 80.

N 9.2.1.3 Use of Separation.

N 9.2.1.3.1* Separation shall be permitted to be used to limit the dust explosion hazard or dust flash-fire hazard area where supported by a documented engineering evaluation acceptable to the AHJ.

N 9.2.1.3.1.1 The required separation distance between the dust explosion hazard or flash-fire hazard area identified in Section 7.2 and surrounding exposures shall be determined by an engineering evaluation that addresses the following:

- (1) Properties of the materials
- (2) Type of operation
- (3) Amount of material likely to be present external to process equipment
- (4) Building and equipment design
- (5) Nature of surrounding exposures

N 9.2.1.3.1.2 The separation area either shall be free of dust or, where dust accumulations exist on any surface, the surface colors below shall be readily discernible.

N 9.2.1.3.1.3 Where separation is used to limit the dust flash-fire or dust explosion hazard area determined in Section 7.2, the minimum separation distance shall not be less than 35 ft (11 m), consistent with NFPA 51B.

N 9.2.1.3.2* Where separation is used, housekeeping, fixed dust collection systems employed at points of release, and compartmentation shall be permitted to be used to limit the extent of the dust explosion hazard or flash-fire hazard area.

N 9.2.1.3.3 Where separation is used to limit a dust explosion hazard or dust flash-fire hazard area, dust thresholds in Section 7.2 shall be determined for this limited area such that the parameter A_{floor} in the equations in Section 7.2 is consistent with the limited area under consideration.

N 9.2.2 Building Construction.

N 9.2.2.1 All buildings shall be of Type I or Type II construction, as defined in NFPA 220.

N 9.2.2.2 Where local, state, or national building codes are more restrictive, modifications shall be permitted for conformance to those codes.

N 9.2.2.3* Interior surfaces where dust accumulations can occur shall be designed and constructed so as to facilitate cleaning and to minimize combustible dust accumulations.

N 9.2.2.4 Spaces inaccessible to housekeeping shall be sealed to prevent dust accumulation.

N 9.2.2.5 Interior walls erected for the purpose of limiting fire spread shall be designed in accordance with NFPA 221 and have a minimum 1-hour fire resistance rating.

N 9.2.2.6 Fire Doors.

N 9.2.2.6.1 Openings in fire walls and in fire barrier walls shall be protected by self-closing fire doors that have a fire protection rating, when tested in accordance with NFPA 252, equivalent to the wall design.

N 9.2.2.6.2 Fire doors shall be installed according to NFPA 80 and shall normally be in the closed position.

N 9.2.2.7 Egress. Means of egress shall comply with NFPA 101.

N 9.2.2.7.1* Means of egress for buildings or building compartments that contain a deflagration hazard area shall be designed in accordance with Section 7.11 of NFPA 101.

N 9.2.2.8 Penetrations. Where floors, walls, ceilings, and other partitions have been erected to control the spread of fire or deflagrations, penetrations in these structures shall be sealed to maintain their fire resistance rating and their physical integrity in a deflagration. (See 9.3.6.5.)

N 9.2.2.9 Fire Resistance Rating.

N 9.2.2.9.1* Interior stairs and elevators shall be enclosed in shafts designed to prevent the migration of dust and that have a minimum fire resistance rating of in accordance with Section 8.6 of NFPA 101.

N 9.2.2.9.2* Doors that are the automatic-closing or self-closing type and that have a minimum fire protection rating of 1 hour shall be provided at each landing.

N 9.2.2.9.3 Stairs, elevators, and manlifts that serve only open-deck floors, mezzanines, and platforms shall not be required to be enclosed.

N 9.2.2.10* Floors and load-bearing walls that are exposed to dust explosion hazards shall be designed to preclude failure during an explosion.

N 9.2.3* Deflagration Venting of Buildings or Building Compartments.

N 9.2.3.1* If a building or building compartment contains a dust explosion hazard area external to protected equipment as specified in 7.2.1.2 or 7.2.1.3, the building or building compartment shall be provided with deflagration venting in accordance with NFPA 68.

N 9.2.3.2* Vent Closures.

N 9.2.3.2.1 Vent closures shall be directed toward a restricted area.

N 9.2.3.2.2 The vent closure shall not be a missile hazard.

N 9.2.3.2.3 The fireball and the blast pressure that are created by the venting process shall not impinge on unrestricted personnel pathways.

N 9.3 Equipment Design.**N 9.3.1* General.**

N 9.3.1.1 Equipment shall be maintained and operated in a manner that minimizes the escape of dust.

N 9.3.1.2 Methods of fire and explosion protection for specific equipment shall be in accordance with this section.

N 9.3.1.3* Risk Assessment. A documented risk assessment acceptable to the AHJ shall be permitted to be conducted to determine the level of protection to be provided per this chapter.

N 9.3.1.4* Systems for the pre-deflagration detection and control of ignition sources, installed in accordance with NFPA 69 shall be permitted to be used to reduce the probability of occurrence of a deflagration in the following:

- (1) In ductwork supplying AMS
- (2) In recycled air from AMS to a building
- (3) In ductwork between process equipment

N 9.3.2 Bulk Storage Enclosures.

N 9.3.2.1 General.

N 9.3.2.1.1 For the purposes of this section, bulk storage shall include items such as bins, tanks, hoppers, and silos.

N 9.3.2.1.2* The requirements of this section shall not apply to containers that are used for transportation of the material.

N 9.3.2.2* Construction. Bulk storage containers, whether located inside or outside of buildings, shall be constructed so as not to represent an increase in the fire load beyond the capabilities of the existing fire protection.

N 9.3.2.3 Explosion Hazards.

N 9.3.2.3.1 Where an explosion hazard exists, intertank or inter-bin venting shall not be permitted.

N 9.3.2.3.2 Fixed Bulk Storage Location.

N 9.3.2.3.2.1 Where an explosion hazard exists, fixed bulk storage containers shall be located outside of buildings.

N 9.3.2.3.2.2 Fixed bulk storage containers shall be permitted to be located inside buildings where one of the following applies:

- (1) Fixed bulk storage containers are protected in accordance with 9.7.1.
- (2)* Fixed bulk storage containers are less than 8 ft³ (0.2 m³).

N 9.3.2.3.3 Fixed Bulk Storage Protection.

N 9.3.2.3.3.1 Where an explosion hazard exists, fixed bulk storage containers shall be protected in accordance with 9.7.1.

N 9.3.2.3.3.2* The explosion protection requirements of 9.7.1 shall not be required provided that the volume of the fixed bulk storage container is less than 8 ft³ (0.2 m³).

N 9.3.2.3.3.3 The requirements of 9.3.2.3.3 shall not apply to storage and receiving containers that are used for transportation of the material.

N 9.3.2.4* Interior Surfaces. Interior surfaces shall be designed and constructed to facilitate cleaning and to minimize combustible dust accumulation.

N 9.3.2.5* Access Doors and Openings.

N 9.3.2.5.1 Access doors or openings shall be provided to allow inspection, cleaning, and maintenance.

N 9.3.2.5.2 Access doors or openings shall be designed to prevent dust leaks.

N 9.3.2.5.3 Access doors or openings that are not specifically designed for deflagration venting shall not be considered as providing that function.

N 9.3.2.5.4 Access doors shall be bonded and grounded.

N 9.3.2.5.5 Access doors not designed to be used as deflagration vents shall be designed to withstand the vented explosion pressure (P_{rel}).

N 9.3.3 Material Transfer System.

N 9.3.3.1 General.

N 9.3.3.1.1* Where more than one material is to be handled by a system, compatibility tests shall be run.

N 9.3.3.1.2 Where incompatibility is found, provisions shall be made for cleaning the system prior to transporting a new material.

N 9.3.3.1.3 Where the materials being conveyed are corrosive, the system shall be constructed of corrosion-resistant materials.

N 9.3.3.1.4 Where the atmosphere surrounding the conveying system is corrosive, the conveying system shall be constructed of corrosion-resistant materials.

N 9.3.3.1.5* Systems that handle combustible particulate solids shall be designed by and installed under the supervision of qualified engineers who are knowledgeable about these systems and their associated hazards.

N 9.3.3.2* Pneumatic Conveying, Dust Collection, and Centralized Vacuum Cleaning Systems.

N 9.3.3.2.1 The design of the system shall be documented, and the documentation shall include the following information:

- (1) Data on the range of particulate size
- (2) Concentration of combustible dust in the conveyance air stream
- (3) Potential for reaction between the transported particulates and the extinguishing media used to protect process equipment
- (4) Conductivity of the particulates
- (5) Other physical and chemical properties that could affect the fire protection of the process

N 9.3.3.2.2* Existing systems shall not be modified without considering the effects of those changes on the system performance, including the redesign of the system to incorporate the proposed changes.

N 9.3.3.2.3 All system components that handle combustible particulate solids shall be designed to be dusttight, except for openings designed for intake and discharge of air and material.

N 9.3.3.2.4* The system shall be designed and maintained to ensure that the air/gas velocity during operation shall at all times meet or exceed the minimum required to keep the interior surfaces of all piping free of particulate accumulations.

N 9.3.3.2.5* Pneumatic Conveying Systems. Where a pneumatic conveying system operates at a gauge pressure of 15 psi (103 kPa) or greater, the components exposed to that pressure under normal or upset conditions shall be designed in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code or ASME B31.3, *Process Piping*.

N 9.3.3.2.5.1* Where a pneumatic conveying system or any part of such a system operates as a positive pressure-type system and

the AMD's gauge discharge pressure is 15 psi (103 kPa) or greater, the system shall be designed in accordance with Section VIII of the ASME *Boiler and Pressure Vessel Code*, ASME B31.3, *Process Piping* or an international equivalent.

N 9.3.3.2.6 Dust Collection Systems.

N 9.3.3.2.6.1* At each collection point, the system shall be designed to achieve the minimum required face velocity for dust capture over the entire opening of the hood or pickup point.

N 9.3.3.2.6.2* The volumetric flow rate for each collection point shall be included in the system design documentation.

N 9.3.3.2.6.3* The rate of airflow at each hood or pickup point for each dust source shall be designed so as to convey and control the collected dust.

N 9.3.3.2.6.4* Branch lines shall not be disconnected and unused portions of the system shall not be blanked off without providing a means to maintain required and balanced airflow.

N 9.3.3.2.6.5* Branch lines shall not be added to an existing system without reviewing the design of the entire system.

N 9.3.3.2.6.6* All ductwork shall be sized to provide the air volume and air velocity necessary to keep the duct interior clean and free of residual material.

N 9.3.3.2.6.7 Dust collection systems that remove material from operations that generate flames, sparks, or hot material shall not be interconnected with dust collection systems that transport combustible particulate solids or hybrid mixtures.

N 9.3.3.2.6.8* Heating, ventilation, and air conditioning (HVAC) systems shall not be used as the means to collect dusts from localized sources.

N 9.3.3.2.7* Centralized Vacuum Cleaning Systems.

N 9.3.3.2.7.1* The system shall be designed to ensure minimum transport velocities at all times.

N 9.3.3.2.7.2* The system shall be operated only with the hoses and tools that have been designated in the design documentation for the specific hose connection station.

N 9.3.3.2.7.3* Vacuum hose, couplings, and tools shall be made of conductive or static-dissipative materials that are bonded and grounded in accordance with 9.4.3.2.3.

N 9.3.3.2.7.4* Controls shall be provided to prevent overfilling the AMS, which could disable the system.

N 9.3.3.2.7.5 The maximum number of hose connection stations that can be simultaneously used shall be included in the system documentation.

N 9.3.3.3* Operations.

N 9.3.3.3.1 Sequence of Operation. Pneumatic conveying, dust collection, and centralized vacuum cleaning systems shall be designed with the operating logic, sequencing, and timing outlined in 9.3.3.3.2 and 9.3.3.3.3.

N 9.3.3.3.2* Startup. Pneumatic conveying, dust collection, and centralized vacuum cleaning systems shall be designed such that, on startup, the system achieves and maintains design air velocity prior to the admission of material to the system.

N 9.3.3.3.3 Shutdown.

N 9.3.3.3.3.1 Pneumatic conveying, dust collection, and centralized vacuum cleaning systems shall be designed such that, on normal shutdown of the process, the system maintains design air velocity until material is purged from the system.

N 9.3.3.3.3.2 The requirements of 9.3.3.3.3.1 shall not apply during emergency shutdown of the process, such as by activation of an emergency stop button or by activation of an automatic safety interlocking device.

N 9.3.3.3.3.3 Dilute phase pneumatic conveying systems shall be designed such that, upon restart after an emergency shutdown, residual materials can be cleared and design air velocity can be achieved prior to admission of new material to the system.

N 9.3.4 Specific Requirements for Systems that Convey Metal Particulates.

N 9.3.4.1 General. This section shall apply to facilities that operate pneumatic conveying, dust collection, and centralized vacuum cleaning systems for metal particulates.

N 9.3.4.2 Systems handling metal particulates shall be designed in accordance with NFPA 484 in addition to the requirements of this section.

N 9.3.4.3* Water Reactivity.

N 9.3.4.3.1 Unless otherwise determined, metal particulates shall be deemed water-reactive, and water-based extinguishing agents shall not be used.

N 9.3.4.3.2 Specially engineered high-density water spray systems approved by the AHJ shall be permitted to be used.

N 9.3.4.3.3 The requirement of 9.3.4.3.1 shall not apply to the collection of iron dusts from shot blasting.

N 9.3.4.4 Systems that convey alloys that exhibit fire or explosion characteristics similar to those of the base metal shall be provided with the same protection as systems that convey the base metal.

N 9.3.4.5 Iron, Nickel, Copper, and Other Transition Metal Particulates. Transition metal combustible particulates shall be classified as water-compatible, water-incompatible, or water-reactive based on the available chemical and physical data and in conjunction with the AHJ.

N 9.3.5 Systems That Convey Hybrid Mixtures. The percentage of the lower flammable limit (LFL) of flammable vapors and the percentage of the minimum explosible concentration (MEC) of combustible dusts, when combined, shall not exceed 25 percent within the airstream, except for systems protected in accordance with 9.7.1.1(1) through 9.7.1.1(4).

N 9.3.6 Duct Systems.

N 9.3.6.1 Ducts that handle combustible particulate solids shall conform to the requirements of NFPA 91 except as amended by the requirements of this chapter.

N 9.3.6.2 Ductwork shall be constructed of metal or noncombustible, conductive material in accordance with 9.4.3.2.

N 9.3.6.3* Flexible hose and connections shall be permitted in the minimum length necessary to achieve functions such as but not limited to material pickup, material transfer, vibration isola-

tion, weigh bin isolation, or equipment movement in accordance with 9.4.3.

N 9.3.6.4* Changes in duct sizes shall be designed to prevent the accumulation of material by utilizing a tapered transformation piece with the included angle of the taper not more than 30 degrees.

N 9.3.6.5* When ducts pass through a physical barrier that is erected to segregate dust deflagration hazards, physical isolation protection shall be provided to prevent propagation of deflagrations between segregated spaces.

N 9.3.7 Sight Glasses.

N 9.3.7.1 Sight glasses shall be of a material that is impact and erosion resistant.

N 9.3.7.2 Sight glass assemblies shall have a pressure rating equal to or greater than that of the ductwork.

N 9.3.7.3 Ductwork shall be supported on each side of the sight glass so that the sight glass does not carry any of the system weight and is not subject to stress or strain.

N 9.3.7.4 The mechanical strength of the sight glass-mounting mechanism shall be equal to the adjoining ductwork.

N 9.3.7.5 The inside diameter of a sight glass shall not cause a restriction of flow.

N 9.3.7.6 The connections between the sight glass and the ductwork shall be squarely butted and sealed so as to be both airtight and dusttight.

N 9.3.7.7 The electrical bonding across the length of the sight glass shall be continuous and have a resistance of no more than 1 ohm.

N 9.3.8 Pressure Protection Systems.

N 9.3.8.1 Vacuum Breakers. Vacuum breakers shall be installed on negative-pressure systems if the pressure system is not designed for the maximum vacuum attainable.

N 9.3.8.2* Pressure Relief Devices.

N 9.3.8.2.1 Pressure relief devices for relief of pneumatic overpressure shall be installed on positive-pressure systems.

N 9.3.8.2.2 The requirement of 9.3.8.2.1 shall not apply to systems that are designed for a gauge pressure of less than 15 psi (103 kPa) and are provided with safety interlocks designed to prevent overpressure in accordance with ISA 84.00.01, *Functional Safety: Application of Safety Instrumented Systems for the Process Industry Sector*.

N 9.3.8.2.3 The requirement of 9.3.8.2.1 shall not apply to systems that are designed for a gauge pressure of less than 15 psi (103 kPa) and are capable of containing the maximum pressure attainable.

N 9.3.8.2.4* Pressure relief devices shall not be vented to an area where a dust explosion hazard or dust flash-fire hazard exists, as specified by Section 7.2.

N 9.3.8.3 Airflow Control Valves.

N 9.3.8.3.1 Airflow control valves that are installed in pneumatic conveying, dust collection, or centralized vacuum cleaning systems shall be of both airtight and dusttight construction.

N 9.3.8.3.2 Airflow control valves shall be sized to allow passage of the total airflow of the system when the damper is fully open.

N 9.3.8.3.3 The position of airflow control valves shall be visually indicated.

N 9.3.8.3.4 Manually adjusted airflow control valves, dampers, gates, or orifice plates shall have a means of securing them to prevent subsequent adjustment or manipulation once the system is balanced.

N 9.3.8.3.5 Diverter valves shall effect a positive diversion of the material and shall mechanically seal all other directions from air or material leakage.

N 9.3.9 Material Feeding Devices.

N 9.3.9.1 Mechanical Feeding Devices.

N 9.3.9.1.1 Mechanical feeding devices shall be equipped with a shear pin or overload detection device and alarm.

N 9.3.9.1.2 The alarm shall sound at the operator control station.

N 9.3.9.2 Drives.

N 9.3.9.2.1 All drives used in conjunction with feeders, air locks, and other material feeding devices shall be directly connected.

N 9.3.9.2.2 Belt, chain and sprocket, or other indirect drives that are designed to stall the driving forces without slipping and to provide for the removal of static electric charges shall be permitted to be used.

N 9.3.10* Bucket Elevators.

N 9.3.10.1 Deflagration Protection.

N 9.3.10.1.1 Where an explosion hazard exists, bucket elevators shall be protected in accordance with 9.7.1.

N 9.3.10.2 Elevator casings, head and boot sections, and connecting ducts shall be dusttight and shall be constructed of noncombustible materials.

N 9.3.10.3 Where provided, inlet and discharge hoppers shall be designed to be accessible for cleaning and inspection.

N 9.3.10.4 Power Cutoff.

N 9.3.10.4.1* Belt-driven bucket elevators shall be provided with a detector that cuts off the power to the drive motor if the motor speed drops below 80 percent of normal operating speed.

N 9.3.10.4.2 Feed to the elevator leg shall be stopped or diverted when the power to the motor is stopped.

N 9.3.10.5 Belts.

N 9.3.10.5.1 Belt-driven bucket elevators shall have a nonslip material (lagging) installed on the head pulley to minimize slippage.

N 9.3.10.5.2* Belts and lagging shall be fire and oil resistant.

N 9.3.10.6 No bearings shall be located in the bucket elevator casing.

N 9.3.10.7* Head and boot sections shall be provided with openings to allow for cleanout, inspection, and alignment of the pulley and belt.