

NFPA 654

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

2006 Edition



NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471
An International Codes and Standards Organization

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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

2006 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 and acted on by NFPA at its June Association Technical Meeting held June 6–10, 2005, in Las Vegas, NV. It was issued by the Standards Council on July 29, 2005, with an effective date of August 18, 2005, and supersedes all previous editions.

This edition of NFPA 654 was approved as an American National Standard on August 18, 2005.

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 version, 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In 1994, the standard was revised to improve its usability, adoptability, and enforceability; to update outdated terminology; and to add the NFPA language for equivalency and retroactivity.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 is another complete revision, which introduces a performance-based approach for protecting combustible particulate solids processing facilities. This new approach enables users of the standard to follow the traditional prescriptive method or, for unique situations, gives them the option of a performance-based design. Other changes include updating the standard to the current *Manual of Style for NFPA Technical Committee Documents* format.

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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on the prevention, control, and extinguishment of fires and explosions in the design, construction, installation, operation, and maintenance of facilities and systems processing or conveying flammable or combustible dusts, gases, vapors, and mists.

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

A reference in brackets [] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in mandatory sections of the document are given in Chapter 2 and those for extracts in informational sections are given in Annex G. Editorial changes to extracted material consist of revising references to an appropriate division in this document or the inclusion of the document number with the division number when the reference is to the original document. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

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

Chapter 1 Administration**1.1* Scope.**

1.1.1 This standard shall apply to all phases of the manufacturing, processing, blending, pneumatic conveying, repackaging, and handling of combustible particulate solids or hybrid mixtures, regardless of concentration or particle size, where the materials present a fire or explosion hazard.

1.1.2 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 for safety to life and property from fire and explosion and to minimize the resulting damage from a fire or 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 not apply to materials covered by the following documents, unless specifically referenced by the applicable document:

- (1) NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products*
- (2) NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities*
- (3) NFPA 85, *Boiler and Combustion Systems Hazards Code*
- (4) NFPA 120, *Standard for Fire Prevention and Control in Coal Mines*
- (5) NFPA 432, *Code for the Storage of Organic Peroxide Formulations*
- (6) NFPA 484, *Standard for Combustible Metals*
- (7) NFPA 495, *Explosive Materials Code*
- (8) NFPA 655, *Standard for Prevention of Sulfur Fires and Explosions*
- (9) NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*
- (10) NFPA 1124, *Code for the Manufacture, Transportation, Storage, and Retail Sales of Fireworks and Pyrotechnic Articles*
- (11) NFPA 1125, *Code for the Manufacture of Model Rocket and High Power Rocket Motors*

1.4.2 In the event of a conflict between this standard and a specific occupancy standard, the specific occupancy standard requirements shall apply.

1.5 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.

1.5.1 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.

1.5.2 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.

1.5.3 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.

1.5.4 This standard shall apply to facilities on which construction is begun subsequent to the date of publication of the standard.

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

1.6 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.

1.6.1 Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

1.6.2 The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

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*, 2002 edition.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, 2005 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 2005 edition.

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*, 2004 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2002 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 2003 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 2001 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, 2003 edition.

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, 2002 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2002 edition.

NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products*, 2002 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 2003 edition.

NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities*, 2002 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2002 edition.

NFPA 70, *National Electrical Code*[®], 2005 edition.

NFPA 72[®], *National Fire Alarm Code*[®], 2002 edition.

NFPA 80, *Standard for Fire Doors and Fire Windows*, 1999 edition.

NFPA 85, *Boiler and Combustion Systems Hazards Code*, 2004 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 2003 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids*, 2004 edition.

NFPA 101[®], *Life Safety Code*[®], 2006 edition.

NFPA 120, *Standard for Fire Prevention and Control in Coal Mines*, 2004 edition.

NFPA 220, *Standard on Types of Building Construction*, 2006 edition.

NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls*, 2006 edition.

NFPA 432, *Code for the Storage of Organic Peroxide Formulations*, 2002 edition.

NFPA 484, *Standard for Combustible Metals*, 2006 edition.

NFPA 495, *Explosive Materials Code*, 2006 edition.

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*, 2003 edition.

NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations*, 2006 edition.

NFPA 655, *Standard for Prevention of Sulfur Fires and Explosions*, 2001 edition.

NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*, 2002 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems*, 2003 edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2004 edition.

NFPA 1124, *Code for the Manufacture, Transportation, Storage, and Retail Sales of Fireworks and Pyrotechnic Articles*, 2006 edition.

NFPA 1125, *Code for the Manufacture of Model Rocket and High Power Rocket Motors*, 2001 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, 2004 edition.

2.3 Other Publications.

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

ASME B31.3, *Process Piping*, 2002.

ASME Boiler and Pressure Vessel Code, 2001.

2.3.2 ISA Publication. Instrumentation, Systems, and Automation Society, 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*, 2004.

2.3.3 Other Publication. Merriam-Webster's *Collegiate Dictionary*, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Mandatory Sections.

NFPA 68, *Guide for Venting of Deflagrations*, 2002 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids*, 2004 edition.

NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls*, 2006 edition.

NFPA 484, *Standard for Combustible Metals*, 2006 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. A document, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix or annex, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

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* Air-Material Separator (AMS). A collector designed to separate the conveying air from the material being conveyed.

3.3.2.1 Primary Air-Material Separator. A collector that separates the bulk of the product or material from the conveying airstream.

3.3.2.2 Secondary Air-Material Separator. A collector that separates the residual dust or product remaining in the airstream after the airstream has been processed by the primary air-material separator.

3.3.3* 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.

3.3.4* Combustible Dust. A combustible particulate solid that presents a fire or deflagration hazard when suspended in air or some other oxidizing medium over a range of concentrations, regardless of particle size or shape.

3.3.5* Combustible Particulate Solid. Any combustible solid material, composed of distinct particles or pieces, regardless of size, shape, or chemical composition.

3.3.6 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.

3.3.7* Deflagration. Propagation of a combustion zone at a velocity that is less than the speed of sound in the unreacted medium. [68, 2002]

3.3.8 Detachment. Locating a combustible particulate solid process in the open air or in a separate building.

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

3.3.10 Duct. Pipes, tubes, or other enclosures used for the purpose of pneumatically conveying materials. [91, 2004]

3.3.11 Dust Collector. See 3.3.2, Air-Material Separator (AMS).

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

3.3.13* Hybrid Mixture. A mixture of a flammable gas with either a combustible dust or a combustible mist. [68, 2002]

3.3.14 Intermediate Bulk Containers.

3.3.14.1 Flexible Intermediate Bulk Container (FIBC).

3.3.14.1.1 Type A FIBC. A standard insulating flexible intermediate bulk container (FIBC).

3.3.14.1.2 Type B FIBC. A flexible intermediate bulk container (FIBC) where the fabric or the combination of the fabric shell, coating, and any loose liner has a breakdown voltage of less than 6000 volts.

3.3.14.1.3 Type C FIBC. A flexible intermediate bulk container (FIBC) where the fabric is interwoven with an electrically interconnected conductive fiber and provided with a tab for connection to grounding systems.

3.3.14.1.4 Type D FIBC. A flexible intermediate bulk container (FIBC) constructed from fabric and/or threads with special static properties designed to control electrostatic discharge incendivity, without grounding.

3.3.14.2* 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.

3.3.14.2.1 Insulating RIBC. An RIBC constructed entirely of solid plastic or solid plastic and foam composite that cannot be electrically grounded.

3.3.15* 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.

3.3.16* 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.

3.3.17* 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.

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

3.3.19* Pneumatic Conveying System. A material feeder, an air-material separator, an enclosed ductwork system, or an air-moving device in which a combustible particulate solid is conveyed from one point to another with a stream of air or other gases.

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

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

3.3.20 Replacement-in-Kind. A replacement that satisfies the design specifications. [484, 2006]

3.3.21 Segregation. The interposing of a fire- and explosion-resistant barrier between the combustible particulate solid process and other operations.

3.3.22 Separation. The interposing of distance between the combustible particulate solid process and other operations that are in the same room.

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

3.3.24 Vent Closure. A pressure-relieving cover that is placed over a vent. [68, 2002]

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

3.3.26 Wall.

3.3.26.1 Fire Barrier Wall. A wall, other than a fire wall, having a fire resistance rating. [221, 2006]

3.3.26.2 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, 2006]

3.3.27* 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.

3.3.28* 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.

3.3.29* 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 Process and Facility Design.

4.1.1 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.

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

4.2 Process Hazard Analysis.

4.2.1* The design of the fire and explosion safety provisions shall be based on a process hazard analysis of the facility, the process, and the associated fire or explosion hazards.

4.2.2 The results of the process hazard analysis shall be documented and maintained for the life of the process.

4.2.3 The process hazard analysis shall be reviewed and updated at least every 5 years.

4.3 Management of Change. Written procedures to manage change to process materials, technology, equipment, procedures, and facilities shall be established and implemented.

4.3.1 The requirements of 4.3.1.1 through 4.3.1.3 shall be applied retroactively.

4.3.1.1 The management-of-change procedures 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

(4) Modifications to operating and maintenance procedures

(5) Employee training requirements

(6) Authorization requirements for the proposed change

4.3.1.2 Implementation of the management-of-change procedures shall not be required for replacements-in-kind.

4.3.1.3 Design documentation, as required by 4.1.2, shall be updated to incorporate the change.

4.4* Pneumatic Conveying System Design. 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.

4.5 Objectives.

4.5.1 Life Safety.

4.5.1.1 The facility, combustible particulate processes, and human element programs shall be designed, constructed, equipped, and maintained to protect occupants not in the immediate proximity of the ignition from the effects of fire, deflagration, and explosion for the time needed to evacuate, relocate, or take refuge.

4.5.1.2 The structure shall be located, designed, constructed, and maintained to minimize the propagation of fire or explosion to adjacent properties and to avoid injury to the public.

4.5.2 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.

4.5.3* Mission Continuity. The facility, processes and equipment, and human element program shall be designed, constructed, equipped, and maintained 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.

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

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

4.5.4.2 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.

4.6* Compliance Options. The goal in Section 1.3 and the objectives in Section 4.5 shall be achieved by either of the following means:

- (1) The prescriptive provisions in accordance with Chapters 6 through 12 of this standard
- (2) The performance-based provisions in accordance with Chapters 5, 8, 9, 11, and 12 of this standard

Chapter 5 Performance-Based Design Option

5.1 General Requirements.

5.1.1 Approved Qualifications. The performance-based design shall be prepared by a person with qualifications acceptable to the owner/operator.

5.1.2 Independent Review. The authority having jurisdiction shall be permitted to obtain an independent third party review of the proposed design.

5.1.3* 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 per Chapter 5 of NFPA 101, *Life Safety Code*.

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

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

5.1.4* 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.

5.1.5 Sources of Data.

5.1.5.1 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.

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

5.2 Performance Criteria. A system and facility design shall be deemed to meet the objectives specified in Section 4.5 if its performance meets the criteria in 5.2.1 through 5.2.5.

5.2.1 Occupant Life Safety.

5.2.1.1 The life safety objectives of 4.5.1 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.

5.2.1.2 The life safety objectives of 4.5.1 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.

5.2.2 Structural Integrity. The structural integrity objective of 4.5.2 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.

5.2.3 Mission Continuity. The mission continuity objectives of 4.5.3 shall be achieved when damage to equipment and the facility has been limited to a level of damage acceptable to the owner/operator.

5.2.4 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.

5.2.5 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

5.3* Design Scenarios.

5.3.1 Fire Scenarios.

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

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

5.3.1.3 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.

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

5.3.1.5 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.

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

5.3.1.7 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.

5.3.2 Explosion Scenarios.

5.3.2.1 Each duct, enclosed conveyor, silo, bunker, cyclone, dust collector, 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.

5.3.2.2 Each duct, enclosed conveyor, silo, bunker, cyclone, dust collector, 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.

5.3.2.3 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.

5.3.2.4 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.

5.4 Evaluation of Proposed Design.

5.4.1* General. A proposed design's performance shall be assessed relative to each performance objective in Section 4.5 and each applicable scenario in Section 5.3, with the assessment conducted through the use of appropriate calculation methods acceptable to the authority having jurisdiction.

5.4.2 The design professional shall establish numerical performance criteria for each of the objectives in Section 4.5.

5.4.3 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.

Chapter 6 Facility and Systems Design

6.1 General. The provisions of this section shall apply to the overall design of systems that handle combustible particulate solids.

6.1.1* Those portions of the process and facility where a dust deflagration hazard exists shall be protected from the effects of dust deflagrations in accordance with Sections 6.2, 6.3, and 6.4 and Chapter 7.

6.1.2 Those portions of the process and facility where a combustible particulate solid presents a fire hazard shall be protected in accordance with Chapter 10.

6.1.3 Recycling of Air–Material Separator Exhaust. Recycling of air–material separator exhaust to buildings shall be permitted if the system is designed to prevent both return of dust with an efficiency of 99.9 percent at 10 µm and transmission of energy from a fire or explosion to the building.

6.1.3.1 Recycling of air–material separator exhaust to the building shall not be permitted under any circumstances when combustible gases or vapors or hybrid mixtures are involved.

6.1.3.2* Recycling of air–material separator exhaust to the building shall not be permitted when the recycled stream reduces the concentration of oxygen below 19.5 percent by volume in the work area.

6.1.4 Extinguishing agents shall be compatible with the construction and process materials with which they could come into contact.

6.1.5* Where a pneumatic conveying system or any part of such systems operates as a positive-pressure-type system and the air-moving device'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* or ASME B31.3, *Process Piping*.

6.1.6 All components of pneumatic conveying systems that handle combustible particulate solids shall be designed to be dusttight, except for openings designed for intake and discharge of air and material.

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

6.2.1 General. Areas in which combustible dusts are produced, processed, handled, or collected shall be detached, segregated, or separated from other occupancies to minimize damage from a fire or explosion.

6.2.2 Use of Segregation.

6.2.2.1 Physical barriers that are erected to segregate dust hazards shall have all penetrations of floors, walls, ceilings, or partitions sealed dusttight, and, where structural assemblies have a fire endurance rating, the seal shall maintain that rating.

6.2.2.2 Physical barriers that are erected to segregate dust deflagration hazards shall be designed to preclude failure of those barriers before the deflagration pressure can be safely vented to the outside. (*For deflagration venting, see Section 6.4.*)

6.2.2.3 Doors and openings shall not be permitted in physical barriers unless they are normally closed and have the same strength as the physical barrier.

6.2.3 Use of Separation.

6.2.3.1* When separation is used to limit the fire or dust explosion hazardous area, the hazardous area shall include areas where dust accumulations exceed 1/32 in. (0.8 mm) or areas where dust clouds of a hazardous concentration exist, unless otherwise permitted by 6.2.3.3.

6.2.3.2 The requirements of 6.2.3.1 shall not apply to dust accumulations with a bulk density less than 75 lb/ft³ (1200 kg/m³), where the allowable thickness can be prorated upward by the following equation:

$$\text{Allowable thickness (in.)} = \frac{(1/32)(75)}{\text{bulk density (lb/ft}^3\text{)}}$$

6.2.3.3 Distance.

6.2.3.3.1 The required separation distance between the hazardous area identified in 6.2.3.1 and surrounding exposures shall be determined by the following:

- (1) Engineering evaluation that addresses the properties of the materials
- (2) Type of operation
- (3) Amount of material likely to be present outside the process equipment
- (4) Building design
- (5) Nature of surrounding exposures

6.2.3.3.2 In no case shall the distance be less than 30 ft (9 m).

6.2.3.4 When 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 hazardous area.

6.3 Building Construction.

6.3.1 All buildings shall be of Type I or Type II construction, as defined in NFPA 220, *Standard on Types of Building Construction*.

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

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

6.3.4 Spaces inaccessible to housekeeping shall be sealed to prevent dust accumulation.

6.3.5 Interior walls erected for the purpose of limiting fire spread shall have a minimum 1-hour fire resistance rating and shall be designed in accordance with NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls*.

6.3.6 Fire Doors.

6.3.6.1 Openings in fire walls and in fire barrier walls shall be protected by self-closing fire doors that have a fire resistance rating equivalent to the wall design.

6.3.6.2 Fire doors shall be installed according to NFPA 80, *Standard for Fire Doors and Fire Windows*, and shall normally be in the closed position.

6.3.7 Egress. Means of egress shall comply with NFPA 101, *Life Safety Code*.

6.3.8 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 endurance rating and maintain physical integrity in a deflagration. (See 7.6.5.)

6.3.9 Fire Resistance Rating.

6.3.9.1 Interior stairs, elevators, and manlifts shall be enclosed in dusttight shafts that have a minimum fire resistance rating of 1 hour.

6.3.9.2 Doors that are the automatic-closing or self-closing type and have a fire resistance rating of 1 hour shall be provided at each landing.

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

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

6.4* Deflagration Venting.

6.4.1* If a room or building contains a dust explosion hazard as specified in 6.2.3.1 that is external to protected equipment, such areas shall be provided with deflagration venting to a safe outside location.

6.4.2* Vent Closures.

6.4.2.1 Vent closures shall be directed toward a restricted area.

6.4.2.2 The vent closure shall not be a missile hazard.

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

6.5* Relief Valves. Relief valves shall not be vented to a dust hazard area, as specified by 6.2.3.1.

6.6 Electrical Equipment.

6.6.1 All electrical equipment and installations shall comply with the requirements of NFPA 70, *National Electrical Code*, or NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*.

6.6.2* In local areas of a plant where a hazardous quantity of dust accumulates or is suspended in air, the area shall be classified and all electrical equipment and installations in those local areas shall comply with Article 502 or Article 503 of NFPA 70, *National Electrical Code*, as applicable.

6.6.3 Hazardous (classified) areas that are identified in accordance with 6.6.2 shall be documented, and such documentation shall be permanently maintained on file for the life of the facility.

Chapter 7 Process Equipment

7.1* General. Methods of fire and explosion protection for specific equipment shall be in accordance with this section.

7.1.1* Risk Evaluation. A documented risk evaluation acceptable to the authority having jurisdiction shall be permitted to be conducted to determine the level of protection to be provided.

7.1.2 Explosion Protection for Equipment.

7.1.2.1 The design of explosion protection for equipment shall incorporate one or more of the following methods of protection:

- (1) Oxidant concentration reduction in accordance with NFPA 69, *Standard on Explosion Prevention Systems*
 - (a) Where oxygen monitoring is used, it shall be installed in accordance with ISA 84.00.01, *Functional Safety: Application of Safety Instrumented Systems for the Process Industry Sector*.
 - (b)*Where the chemical properties of the material being conveyed require a minimum concentration of oxygen to control pyrophoricity, that level of concentration shall be maintained.
- (2)*Deflagration venting
- (3) Deflagration pressure containment in accordance with NFPA 69, *Standard on Explosion Prevention Systems*
- (4) Deflagration suppression systems in accordance with NFPA 69, *Standard on Explosion Prevention Systems*
- (5)*Dilution with a noncombustible dust to render the mixture noncombustible (See 7.1.2.2.)
- (6)*Deflagration venting through a listed dust retention and flame-arresting device

7.1.2.2 If the method in 7.1.2.1(5) is used, test data for specific dust and diluent combinations shall be provided and shall be acceptable to the authority having jurisdiction.

7.1.3 Fire Protection for Equipment. Equipment fire protection shall be designed in accordance with Chapter 10.

7.1.4* Isolation of Equipment.

7.1.4.1 Where an explosion hazard exists, isolation devices shall be provided to prevent deflagration propagation between pieces of equipment connected by ductwork.

7.1.4.2 Isolation devices shall include, but shall not be limited to, the following:

- (1)*Chokes
- (2)*Rotary valves
- (3)*Automatic fast-acting valve systems in accordance with NFPA 69, *Standard on Explosion Prevention Systems*
- (4)*Flame front diverters in accordance with NFPA 69, *Standard on Explosion Prevention Systems*
- (5)*Chemical isolation systems in accordance with NFPA 69, *Standard on Explosion Prevention Systems*

7.1.4.3 Isolation devices shall not be required when oxidant concentration has been reduced or when the dust has been rendered noncombustible in accordance with 7.1.2.1(1) or 7.1.2.1(5).

7.1.4.4* Isolation devices shall not be required if a documented risk evaluation that is acceptable to the authority having jurisdiction determines that deflagration propagation will not occur.

7.1.5* Deflagration Isolation.

7.1.5.1 Where an explosion hazard exists, isolation devices shall be provided to prevent deflagration propagation from air-material separators upstream to the work areas.

7.1.5.2 Isolation devices shall include, but shall not be limited to, those listed in 7.1.4.2(1) through 7.1.4.2(5).

7.1.5.3 Isolation devices shall not be required if a documented risk evaluation that is acceptable to the authority having jurisdiction determines that deflagration propagation will not occur.

7.1.6 Fire Protection for Facility. Where a fire propagation hazard exists, the requirements of Chapter 10 shall apply.

7.2 Bulk Storage Enclosures.

7.2.1 General.

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

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

7.2.2 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.

7.2.3 Explosion Hazards.

7.2.3.1 Where an explosion hazard exists, intertank or interbin venting shall not be permitted.

7.2.3.2 Fixed Bulk Storage Location.

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

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

- (1) Fixed bulk storage containers are protected in accordance with 7.1.2.1(1), 7.1.2.1(3), 7.1.2.1(4), 7.1.2.1(5), or 7.1.2.1(6).
- (2)*Fixed bulk storage containers meet all of the following criteria:

- (a) They are equipped with deflagration vents that are vented through ducts to the outside.
- (b) The reduced venting efficiency due to the duct has been taken into account.
- (c) The ducts are designed to withstand the effects of the deflagration.

(3)*Fixed bulk storage containers are 8 ft³ (0.2 m³) or less.

7.2.3.3 Fixed Bulk Storage Protection.

7.2.3.3.1 Where an explosion hazard exists, fixed bulk storage containers shall be protected in accordance with 7.1.2.

7.2.3.3.2 For fixed bulk storage containers that are located outside of buildings, a risk evaluation shall be permitted to be conducted to determine the level of explosion protection to be provided.

7.2.3.3.3* The explosion protection requirements of 7.1.2 shall not be required provided that the volume of the fixed bulk storage container is less than 8 ft³ (0.2 m³).

7.2.3.3.4 The requirements of 7.2.3.3 shall not apply to storage and receiving containers that are used for transportation of the material.

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

7.2.5* Access Doors and Openings.

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

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

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

7.2.5.4 Access doors shall be bonded and grounded.

7.3 Material Transfer System.

7.3.1 General.

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

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

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

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

7.3.2 Pneumatic Conveying Systems.

7.3.2.1 The addition of branch lines shall not be made to an existing system without redesigning the entire system.

7.3.2.2 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.

7.3.2.3 The rate of airflow at each hood or other pickup point shall be designed so as to convey and control the material.

7.3.2.4* 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.

7.3.2.5 The design of the pneumatic conveyance system shall be documented, including the following information:

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

7.3.2.6 Pneumatic conveying systems that remove material from operations that generate flames, sparks, or hot material shall not be interconnected with pneumatic conveying systems that transport combustible particulate solids or hybrid mixtures.

7.3.3 Operations.

7.3.3.1 Sequence of Operation. Pneumatic conveying systems shall be designed with the operating logic, sequencing, and timing outlined in 7.3.3.2 and 7.3.3.3.

7.3.3.2* Startup. Pneumatic conveying 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.

7.3.3.3 Shutdown. Pneumatic conveying systems shall be designed such that, on shutdown of the process, the system maintains design air velocity until material is purged from the system.

7.4 Specific Requirements for Systems that Convey Metal Particulates.

7.4.1 General. This section shall apply to facilities that operate pneumatic conveying systems for metal particulates.

7.4.1.1* Water Reactivity.

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

7.4.1.1.2 Specially engineered high-density water spray systems approved by the authority having jurisdiction shall be permitted to be used.

7.4.1.1.3 The requirement of 7.4.1.1.1 shall not apply to the collection of iron dusts from shot blasting.

7.4.1.2 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.

7.4.2 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 authority having jurisdiction.

7.5 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 7.1.2.1(1) through 7.1.2.1(4).

7.6 Duct Systems.

7.6.1 Ducts that handle combustible particulate solids shall conform to the requirements of NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids*, except as amended by the requirements of this chapter.

7.6.2 Flexible hose and connections shall be permitted to be used for material pickup and isolation.

7.6.3 Bellows shall be permitted to be used for the free movement of weigh bins if the bellows are conductive and the equipment is bonded and grounded.

7.6.4* 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.

7.6.5* 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.

7.7 Sight Glasses.

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

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

7.7.3 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.

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

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

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

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

7.8 Pressure Protection Systems.

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

7.8.2* Pressure Relief Devices.

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

7.8.2.2 The requirement of 7.8.2.1 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*.

7.8.2.3 The requirement of 7.8.2.1 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.

7.8.3 Airflow Control Valves.

7.8.3.1 Airflow control valves that are installed in pneumatic systems shall be of both airtight and dusttight construction.

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

7.8.3.3 The position of airflow control valves shall be visually indicated.

7.8.3.4 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.

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

7.9 Material Feeding Devices.

7.9.1 Mechanical Feeding Devices.

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

7.9.1.2 The alarm shall sound at the operator control station.

7.9.2 Drives.

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

7.9.2.2 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.

7.10* Bucket Elevators.

7.10.1* Deflagration Venting.

7.10.1.1 Where an explosion hazard exists, bucket elevators shall be provided with deflagration venting.

7.10.1.2 When bucket elevators are located inside the building, deflagration vents shall be ducted to the outside.

7.10.1.3 As an alternative to deflagration venting, bucket elevators shall be permitted to be protected in accordance with 7.1.2.1(1), 7.1.2.1(3), 7.1.2.1(4), 7.1.2.1(5), 7.1.2.1(6), or 7.1.4.2(5).

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

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

7.10.4 Power Cutoff.

7.10.4.1* 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.

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

7.10.5 Belts.

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

7.10.5.2* Belts and lagging shall be fire and oil resistant.

7.10.6 No bearings shall be located in the bucket elevator casing.

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

7.10.8 Drive.

7.10.8.1* The bucket elevator shall be driven by a motor and drive train that is capable of handling the full-rated capacity of the elevator without overloading.

7.10.8.2 The drive shall be capable of starting the unchoked elevator under full (100 percent) load.

7.10.9 Monitors.

7.10.9.1 Elevators shall have monitors at head and tail pulleys that indicate high bearing temperature, vibration detection, head pulley alignment, and belt alignment.

7.10.9.2 Abnormal conditions shall actuate an alarm requiring corrective action.

7.10.9.3 The alarm shall sound at the operator control station.

7.10.9.4 The requirement of 7.10.9.1 shall not apply to elevators that have belt speeds below 500 ft/min (150 m/min) or capacities less than 3750 ft³/hr (106 m³/hr).

7.10.10 Emergency Controls.

7.10.10.1 All bins into which material is directly discharged from the bucket elevator and that are not designed with automatic overflow systems shall be equipped with devices to shut down equipment or with high-level indicating devices with visual or audible alarms.

7.10.10.2 The audible alarm specified in 7.10.10.1 shall sound at the operator control station.

7.11* Enclosed Conveyors.

7.11.1 Housing and Coverings.

7.11.1.1 Where an explosion hazard exists within enclosed conveyors, they shall be protected in accordance with 7.1.2.

7.11.1.2 Housings for enclosed conveyors (e.g., screw conveyors and drag conveyors) shall be of metal construction and shall be designed so as to prevent escape of combustible dusts.

7.11.1.3 Coverings on cleanout, inspection, and other openings shall be fastened to prevent the escape of combustible dusts.

7.11.2 Power Shutoff.

7.11.2.1* All conveyors shall be equipped with a device that shuts off the power to the drive motor and sounds an alarm in the event the conveyor plugs.

7.11.2.2 The alarm shall sound at the operator control station, and feed to the conveyor shall be stopped or diverted.

7.12 Air-Moving Devices (Fans and Blowers).

7.12.1 Air-moving devices shall conform to the requirements of NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids*, except as amended by the requirements of this chapter.

7.12.2 Combustible Particulate Solids.

7.12.2.1 Where an explosion hazard exists, systems shall be designed in such a manner that combustible particulate solids do not pass through an air-moving device.