NFPA®

61

Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities

2020

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NFPA® 61

Standard for the

Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities

2020 Edition

This edition of NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities*, was prepared by the Technical Committee on Agricultural Dusts and released by the Correlating Committee on Combustible Dusts. It was issued by the Standards Council on November 4, 2019, with an effective date of November 24, 2019, and supersedes all previous editions.

This edition of NFPA 61 was approved as an American National Standard on November 24, 2019.

Origin and Development of NFPA 61

The NFPA 61 standard originated in 1923, when standards were first being developed to prevent dust explosions in grain terminals and flour mills. There were four standards associated with agricultural dusts. In 1969, NFPA 61B was adopted by the Association as a tentative standard to replace three former standards: NFPA 61B, *Code for the Prevention of Dust Explosions in Terminal Grain Elevators*; NFPA 64, *Code for the Prevention of Dust Ignitions in Country Grain Elevators*; and NFPA 661, *Suction and Venting in Grain Elevators*. In addition, NFPA 93, *Standard for Dehydrators and Dryers for Agricultural Products*, was withdrawn in 1968 and its text was incorporated as a chapter in NFPA 61B. The 1969 tentative edition of NFPA 61B was officially adopted at the 1970 NFPA Annual Meeting.

In 1995, the following four agricultural dust standards were combined into a single standard: NFPA 61A, Standard for the Prevention of Fire and Dust Explosions in Facilities Manufacturing and Handling Starch; NFPA 61B, *Standard for the Prevention of Fires and Explosions in Grain Elevators and Facilities Handling Bulk Raw Agricultural Commodities*; NFPA 61C, *Standard for the Prevention of Fire and Dust Explosions in Feed Mills*; and NFPA 61D, *Standard for the Prevention of Fire and Dust Explosions in the Milling of Agricultural Commodities for Human Consumption*. The Technical Committee on Agricultural Dusts determined that the four standards were largely duplicative, and it therefore created one comprehensive standard, NFPA 61, Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities, covering the full range of requirements for good design, operating practice, and protective features.

In the 2002 edition, the second revised edition after the combination of the four documents, requirements were clarified and additional advisory material was added. The document was also modified to comply with the updated NFPA *Manual of Style* for technical committee documents.

In the 2008 edition, requirements for life safety and construction were clarified. A requirement for safety devices on belt conveyors was added. Requirements for proper head section venting were added, as well as a requirement for all filters to be located outdoors. Clarification on training requirements were provided.

In the 2013 edition, the Committee updated definitions related to agricultural products handling, conveying, and dust collection. The requirements in Chapter 7 affecting bucket elevators were revised to reflect current industry practice. The requirements in Chapter 10 affecting dust control systems were revised to include a written housekeeping program. Requirements for pneumatic conveying system design were added into Chapter 11. In Chapter 12, the requirement related to standpipes was revised.

The 2017 edition underwent substantial revision to better align with the newly issued NFPA 652, *Standard on the Fundamentals of Combustible Dust*. The document was reorganized to match, where possible, the organization of NFPA 652. New requirements for dust hazards analysis (Chapter 7) were added, as well as a new Chapter 6 on performance-based design. Objectives were added to the general requirements in Chapter 4. A new Chapter 5 on hazard identification also was added to the document. In addition, the table on agricultural dust test data was reviewed and updated.

In the 2020 edition, additional changes have been made to align the organization of NFPA 61 with NFPA 652 where possible, and the deadline for completing a dust hazard analysis (DHA) for existing processes and facility compartments has been specified as January 1, 2022. Surface resistivity requirements for conveyor belts, lag belts, and lagging have been revised, and a new statement has been added to exclude air-material separators with a dirty side volume of less than 0.2 m^3 (8 ft^3) from explosion protection requirements. This edition contains new sections on spray dryer systems, mixers and blenders, and work activities that present an ignition source. The section on management of change has been revised to clarify what is required to be addressed versus what is recommended. Annex material has been added to provide information about the methods that can be used to complete a DHA; determining filtering efficiency of dust collectors; and protection methods for bins, silos, and tunnels where explosion venting is not practical. The table on agricultural dust test data has been updated and expanded to include additional dusts, and the example checklist for completing a DHA has been replaced with a more detailed, comprehensive example.

Correlating Committee on Combustible Dusts

Kevin Kreitman, *Chair*
Albany Fire Department, OR [E]

Chris Aiken, Cargill, Inc., MN [U]

Matthew J. Bujewski, MJB Risk Consulting, MO [SE]

John M. Cholin, J. M. Cholin Consultants Inc., NJ [SE]

Gregory F. Creswell, Cambridge-Lee Industries, PA [M]

Scott G. Davis, GexCon US, MD [SE]

Walter L. Frank, Frank Risk Solutions, Inc., DE [SE]

Robert C. Gombar, Baker Engineering & Risk Consultants, Inc., MD [U]
Rep. US Beet Sugar Association

John A. LeBlanc, FM Global, MA [I]
Rep. FM Global

Arthur P. Mattos, Jr., TUV SUD America Inc./Global Risk Consultants, NC [SE]

Jack E. Osborn, Airdusco, Inc., TN [M]

Jeffrey R. Roberts, AXA XL/Global Asset Protection Services, LLC, MS [I]

Bill Stevenson, CV Technology, Inc., FL [M]

Alternates

Christopher D. Headen, Cargill, Inc., MN [U]
(Alt. to Chris Aiken)

Jason Krbec, CV Technology, Inc., FL [M]
(Alt. to Bill Stevenson)

Adam Morrison, Fike Corporation, MO [M]
(Voting Alt.)

Nonvoting

Brad D. Burridge, Novelis, Inc., KY [U]
Rep. TC on Fundamentals of Combustible Dusts

Mark W. Drake, Liberty Mutual, KS [I]
Rep. TC on Combustible Metals and Metal Dusts

William R. Hamilton, US Department of Labor, DC [E]

Timothy J. Myers, Exponent, Inc., MA [SE]
Rep. TC on Agricultural Dusts

Jason P. Reason, Seam Group/Lewellyn Technology, IN [SE]
Rep. TC on Wood and Cellulosic Materials Processing

Mark L. Runyon, Marsh Risk Consulting, OR [I]
Rep. TC on Handling and Conveying of Dusts, Vapors, and Gases

Laura E. Moreno, NFPA Staff Liaison

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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 hazard identification, prevention, control, and extinguishment of fires and explosions in the design, construction, installation, operation, and maintenance of facilities and systems used in manufacturing, processing, recycling, handling, conveying, or storing combustible particulate solids, combustible metals, or hybrid mixtures.

Technical Committee on Agricultural Dusts

Timothy J. Myers, *Chair*
Exponent, Inc., MA [SE]

Kevin Baumhover, Todd & Sargent Inc., IA [SE]
Matthew J. Bujewski, MJB Risk Consulting, MO [SE]
Ashok Ghose Dastidar, Fauske & Associates, LLC, IL [SE]
David Depuydt, Hays Companies, MN [I]
Brian Edwards, Conversion Technology, Inc., GA [SE]
Craig Froehling, Cargill, Inc., MN [U]
Matthew S. Gibbons, Archer Daniels Midland Company, IL [U]
Rep. National Oilseed Processors Association
Dan A. Guaricci, ATEX Explosion Protection, L.P., FL [M]
Gary Huddleston, American Feed Industry Association, KY [U]
William E. Janz, Global Asset Protection Services, LLC, IL [I]
William F. Kearns, Fred D. Pfening Company, OH [M]
William F. Kinslow, Jr., Mondelez International, NJ [U]
James E. Maness, JEM Safety Consulting, DE [U]
Rep. Grain Elevator and Processing Society
Nancy J. Marks, Kelloggs, MI [U]
Jess P. McCluer, National Grain and Feed Association, VA [U]
Steven A. McCoy, Ingredion, IN [U]
Bruce McLelland, Fike Corporation, MO [M]
Jack E. Osborn, Airdusco, Inc., TN [M]
Michael Peters, Nebraska State Fire Marshal, NE [E]
Kent C. Quinney, The Amalgamated Sugar Company LLC, ID [U]
Rep. US Beet Sugar Association
Mark L. Runyon, Marsh Risk Consulting, OR [I]
Andrew Ryerson, FM Global, MA [I]
Rep. FM Global
Nicholas P. Schlentz, Boss Products LLC, WA [M]
Robert D. Shafto, Zurich Insurance, MI [I]
Jeffery W. Sutton, TUV SUD America Inc./Global Risk Consultants Corporation, MN [SE]
P. D. (Nick) Thielen, General Mills, Inc., MN [U]
Courtney L. Turner, Process Risk Solutions, AL [SE]
Erdem A. Ural, Loss Prevention Science & Technologies, Inc., MA [SE]
Clyde Waller, Powder Process Solutions, MN [IM]
J. Anthony Yount, Ardent Mills, LLC, CO [U]

Alternates

Darren Adams, The Fred D Pfening Company, OH [M]
(Alt. to William F. Kearns)
Venkateswara Sarma Bhamidipati, Powder Process Solutions, MN [IM]
(Alt. to Clyde Waller)
Eric Douglas Colvin, CHS Inc., MN [U]
(Alt. to Matthew S. Gibbons)
Brian G. Deutsch, Michigan Sugar Company, MI [U]
(Alt. to Kent C. Quinney)
Christopher D. Headen, Cargill, Inc., MN [U]
(Alt. to Craig Froehling)
James Karnesky, Exponent, Inc., CA [SE]
(Alt. to Timothy J. Myers)
Kevin Kimbell, Ardent Mills, LLC, NE [U]
(Alt. to J. Anthony Yount)
Glen R. Mortensen, Zurich Services Corporation, IL [I]
(Alt. to Robert D. Shafto)
James Peters, Boss Products LLC, KS [M]
(Alt. to Nicholas P. Schlentz)
Ronald A. Stein, Aon Global Risk Consultants, MO [I]
(Voting Alt.)

Nonvoting

William R. Hamilton, US Department of Labor, DC [E]
Robert W. Nelson, Pocasset, MA [SE]
(Member Emeritus)

Laura E. Moreno, NFPA Staff Liaison

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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 fire and explosions resulting from dusts produced by the processing, handling, and storage of grain, starch, food, animal feed, flour, and other agricultural products. The Technical Committee shall also be responsible for requirements relating to the protection of life and property from fire and explosion hazards at agricultural and food products facilities.

Contents

NFPA 61

Standard for the

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2020 Edition

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. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

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

Chapter 1 Administration

1.1 Scope. This standard provides requirements applicable to agricultural and/or food processing facilities for managing or mitigating fire and explosion hazards of combustible agricultural or food processing dusts or related particulate solids.

1.2* Purpose. This standard shall provide the minimum requirements necessary for safety to life and property from fire, flash fire, and explosion posed by agricultural and food processing combustible dust and represents the industry and commodity-specific requirements for agricultural and food processing.

1.3 Application.

1.3.1* This standard shall apply to all of the following:

(1) All facilities that receive, handle, process, dry, blend, use, mill, package, store, or ship dry agricultural bulk materials, their by-products, or dusts that include grains, oilseeds, agricultural seeds, legumes, sugar, flour, spices, feeds, dry dairy/food powders, and other related materials
(2) All facilities designed for manufacturing and handling starch, including drying, grinding, conveying, processing, packaging, and storing dry or modified starch, and dry products and dusts generated from these processes
(3) Those seed preparation and meal-handling systems of oilseed processing plants not covered by NFPA 36

1.3.2 This standard shall not apply to oilseed extraction processes that are covered by NFPA 36.

1.4* Conflicts.

1.4.1 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 instead.

1.4.2 Where a requirement specified in this standard specifically prohibits a requirement specified in NFPA 652, the prohibition in this standard shall be permitted.

1.4.3 The requirements of this standard shall be applied or construed so as not to create an unreasonable risk to public food safety.

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 When renovating an existing facility, equipment, or process, the provisions of this standard shall apply to that portion of the facility, equipment, or process.

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. Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency. The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

1.7 Units and Formulas.

1.7.1 SI Units. Metric units of measurement in this standard shall be in accordance with the modernized metric system known as the International System of Units (SI). [**652:**1.7.1]

1.7.2* Primary and Equivalent Values. If a value for a measurement as given in this standard is followed by an equivalent value in other units, the first stated value shall be regarded as the requirement. [**652:**1.7.2]

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

NFPA 30, *Flammable and Combustible Liquids Code,* 2018 edition.

NFPA 31, *Standard for the Installation of Oil-Burning Equipment,* 2020 edition.

NFPA 36, *Standard for Solvent Extraction Plants,* 2017 edition.

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

NFPA 54/ANSI Z223.1, *National Fuel Gas Code,* 2018 edition.

NFPA 58, *Liquefied Petroleum Gas Code,* 2020 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 86, *Standard for Ovens and Furnaces,* 2018 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids,* 2020 edition.

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

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment,* 2017 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 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids,* 2020 edition.

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

NFPA 2112, *Standard on Flame-Resistant Clothing for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire,* 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.

NFPA 5000®, *Building Construction and Safety Code®*, 2018 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.

ANSI/AMCA Standard 99, Standards Handbook, *Classifications for Spark Resistant Construction*, 2010.

2.3.2 ASME Publications. ASME Technical Publishing Office, Two Park Avenue, New York, NY 10016-5990.

Boiler and Pressure Vessel Code, Section VIII, Division I, "Rules for Construction of Pressure Vessels," 2015.

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

ASTM D378, *Standard Test Methods for Rubber (Elastomeric) Conveyor Belting, Flat Type*, 2010, reapproved 2016.

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

ASTM E1515, *Standard Test Method for Minimum Explosible Concentration of Combustible Dusts*, 2014.

2.3.4 ISA Publications. International Society of Automation, 67 T.W. Alexander Drive, Research Triangle Park, NC 27709.

ANSI/ISA 84.00.01, *Functional Safety: Safety Instrumented Systems for the Process Industry Sector*, 2004.

2.3.5 MSHA Publications. Mine Safety and Health Administration (MSHA), 201 12th Street South, Suite 401, Arlington VA 22202-5450.

MSHA Title 30, Code of Federal Regulations, Part 18, Section 18.65, "2G Test."

2.3.6 UN Publications. United Nations Publications, Customer Service, P.O. Box 960, Herndon, VA 20172.

UN Recommendations on the Transport of Dangerous Goods: Model Regulations — Manual of Tests and Criteria, 13th edition.

2.3.7 Other Publications.

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

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

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

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids,* 2020 edition.

NFPA 1250, *Recommended Practice in Fire and Emergency Service Organization Risk Management,* 2020 edition.

NFPA 1451, *Standard for a Fire and Emergency Services 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* Agricultural Combustible Dust. Any finely divided solid agricultural material that presents a flash fire hazard or explosion hazard when suspended and ignited in air.

Δ **3.3.2* Air-Material Separator (AMS).** A device designed to separate the conveying air from the material being conveyed. [**652,** 2019]

Δ **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. [**652,** 2019]

3.3.4 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]

3.3.5 Bucket Elevator. An enclosed vertical conveyor using a belt with buckets or cups attached, with a head pulley, a tail pulley, and a knee pulley.

3.3.6* Bulk Raw Grain. Grain materials, such as cereal grains, oilseeds, and legumes, that have not undergone processing or size reduction.

3.3.7* Centralized Vacuum Cleaning System. A fixed-pipe pneumatic conveying system using remotely located hose connection stations to allow the vacuuming of combustible dust accumulations from surfaces and conveying those dusts to an air-material separator (AMS).

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

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

3.3.11* 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]

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

3.3.13* Enclosure. A confined or partially confined volume. [**68,** 2018]

3.3.14* Explosion. The bursting or rupture of an enclosure or container due to the development of internal pressure from a deflagration. [**654,** 2020]

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

Δ **3.3.16 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]

Δ **3.3.17* 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]

3.3.18 Food. According to the United States FDA, (1) articles used for food or drink for man or other animals, (2) chewing gum, and (3) articles used for components of any such article.

3.3.19 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]

3.3.20 Headhouse. The building or enclosure where grain-handling equipment (e.g., conveyors, legs, scales, cleaners) is located and where grain is lifted by one or more elevator legs and discharged into a bin or grain-handling equipment.

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

3.3.22 Ingredient Transport System. A pneumatic system and AMS dedicated to the transport of clean food ingredients or mixtures from one storage location inside a facility to another location in the facility.

3.3.23 Marine Tower. Stationary or movable tower used for supporting equipment to load or unload grain.

Δ **3.3.24* 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]

Δ **3.3.25* 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]

3.3.26 Ohms per Square. The term used to define electrical surface resistivity of a material.

3.3.27 Outside Bucket Elevator (Leg). A bucket elevator that has less than 20 percent of the abovegrade leg height inside any enclosed structure.

3.3.28* 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 location to another with a stream of air or other gases. Pneumatic conveying for product transfer is distinguished from dust collection systems that are designed to handle dust.

3.3.29 Point-of-Use Dust Collector. A bin vent–type of dust collector with an integral AMD used to create negative pressure on enclosed conveying equipment.

3.3.30 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]

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

Δ **3.3.32* Risk Assessment.** An assessment of the likelihood, vulnerability, and magnitude of incidents that could result from exposure to hazards. [**1250,** 2020]

Δ **3.3.33 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]

Chapter 4 General Requirements

4.1* General. The owner/operator shall be permitted to consider dust generated from bulk raw grain and other organically-derived materials as agricultural combustible dusts unless available data and/or specific testing shows that the dust is not combustible.

4.1.1 Where necessary, testing protocols in Chapter 5 shall be used to identify noncombustible dusts or provide specific information on a given uncharacterized dust.

4.1.2 The owner/operator of a facility with agricultural combustible dust shall be responsible for the following activities:

(1) Identify credible fire, flash fire, and explosion hazards associated with their facility
(2) Assess consequences of credible fire, flash fire, and explosion hazards
(3) Manage credible fire, flash fire, and explosion hazards
(4) Communicate the hazards to affected personnel

4.1.3* 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.

4.2 Objectives.

4.2.1 The design of the facility, processes, and equipment shall be based upon the goal of providing a reasonable level of safety and protection of property by meeting the following objectives:

(1) Life safety
(2) Mission continuity
(3) Mitigation of fire spread and explosions

4.2.1.1 The objectives stated in Section 4.2 shall be interpreted as intended outcomes of this standard and not as prescriptive requirements.

4.2.1.2 The objectives stated in Section 4.2 shall be deemed to be met when, consistent with the goal in 4.2.1 and the provisions in Sections 1.4 and 1.5, the following has been achieved:

(1) The facility, processes, and equipment are designed, constructed, and maintained in accordance with the prescriptive criteria set forth in this standard.
(2) The management systems set forth in this standard are implemented.

4.2.1.3 Where a performance-based alternative design is used, it shall be documented to meet the same objectives as the prescriptive design it replaces, in accordance with Chapter 6 of this standard.

4.2.1.4* Nothing in these objectives shall allow the AHJ to require changes to Good Manufacturing Practices (GMP), sanitation, or Hazard Analysis Critical Control Points (HACCP).

4.2.2 Life Safety. The life safety objective shall be deemed to have been met when, consistent with the goal in 4.2.1 and the provisions in Sections 1.4 and 1.5, the occupants not in the immediate proximity of the ignition are protected from the effects of fires, flash fires, and explosions for the time needed to evacuate, relocate, or take refuge in order to prevent serious injury.

4.2.3* Mission Continuity. The mission continuity objective shall be deemed to have been met when, consistent with the goal in 4.2.1 and the provisions in Sections 1.4 and 1.5, the protection features for the facility, processes, and equipment limit damage to levels that ensure the ongoing mission, production, or operating capability of the facility to a degree acceptable to the owner/operator.

4.2.4* Mitigation of Fire Spread and Explosions. The mitigation of fire spread and explosions shall be deemed to have been met when, consistent with the goal in 4.2.1 and the provisions in Sections 1.4 and 1.5, the prescribed or performance-based alternative design features are incorporated into the facility and processes to prevent or mitigate fires and explosions that can cause failure of adjacent buildings, emergency life safety systems, adjacent properties, or the facility's structural elements.

4.2.5* Compliance Options. The objectives in Section 4.2 shall be achieved by either of the following means:

(1) A prescriptive approach in accordance with Chapters 5, 7, 9, and 8.
(2) A performance-based approach in accordance with Chapter 6.

Chapter 5 Hazard Identification

5.1 Responsibility. The owner/operator of a facility with potentially combustible dusts shall be responsible for determining whether the materials are combustible or explosible, and, if so, for characterizing their properties as required to support the DHA. [**652:**5.1]

5.1.1 Where dusts are determined to be combustible or explosible, the hazards associated with the dusts shall be assessed in accordance with Chapter 7. [**652:**5.1.1]

5.1.1.1 The owner/operator shall be permitted to either assume the dust is combustible or determine its combustibility or noncombustibility in accordance with Sections 5.2 through 5.5.

5.1.2 Where dusts are determined to be combustible or explosible, controls to address the hazards associated with the dusts shall be identified and implemented in accordance with 4.2.5. [**652:**5.1.2]

5.2* Screening for Combustibility or Explosibility.

5.2.1 The determination of combustibility or explosibility shall be permitted to be based upon either of the following:

(1) Historical facility data or published data that are deemed to be representative of current materials and process conditions
(2) Analysis of representative samples in accordance with the requirements of 5.4.1 and 5.4.3

[**652:**5.2.1]

5.2.2* Test results, historical data, and published data shall be documented and, when requested, provided to the authority having jurisdiction (AHJ). [**652:**5.2.2]

5.2.3 The absence of previous incidents shall not be used as the basis for deeming a particulate to not be combustible or explosible. [**652:**5.2.3]

5.2.4 Where dusts are determined to not be combustible or explosible, the owner/operator shall maintain documentation to demonstrate that the dusts are not combustible or explosible. [**652:**5.2.4]

5.3* Self-Heating and Reactivity Hazards. (Reserved)

5.4 Combustibility and Explosibility Tests. Where combustibility or explosibility screening tests are required, they shall be conducted on representative samples obtained in accordance with Section 5.5. [**652:**5.4]

5.4.1 Determination of Combustibility.

5.4.1.1 Where the combustibility is not known, determination of combustibility shall be determined by one of the following tests:

(1) A screening test based on the *UN Recommendations on the Transport of Dangerous Goods: Model Regulations — Manual of Tests and Criteria*, Part III, Subsection 33.2.1, Test N.1, "Test Method for Readily Combustible Solids"
(2) Other equivalent fire exposure test methods

[**652:**5.4.1.1]

5.4.1.2* For the purposes of determining combustibility, if the dust in the form tested ignites and propagates combustion or ejects sparks from the heated zone after the heat source is removed, the material shall be considered combustible. [**652:**5.4.1.2]

5.4.1.3 If the dust is known to be explosible, it shall be permitted to assume that the dust is combustible and the requirements of 5.4.1.1 shall not apply. [**652:**5.4.1.3]

5.4.2 Determination of Flash-Fire Potential. (Reserved)

5.4.3 Determination of Explosibility.

5.4.3.1 It shall be permitted to assume a material is explosible, forgoing the requirements of 5.4.3.2. [**652:**5.4.3.4]

5.4.3.2 Where the explosibility is not known, determination of explosibility of dusts shall be determined according to one of the following tests:

(1) The "Go/No-Go" screening test methodology described in ASTM E1226, *Standard Test Method for Explosibility of Dust Clouds*
(2) ASTM E1515, *Standard Test Method for Minimum Explosible Concentration of Combustible Dusts*
(3) An equivalent test methodology

[**652:**5.4.3.1]

5.4.3.3* When determining explosibility, it shall be permitted to test a sample sieved to less than 200 mesh (75 μm). [**652:**5.4.3.2]

5.4.3.4* When determining explosibility, it shall be permitted to test the as-received sample. [**652:**5.4.3.3]

5.4.3.5 When the representative sample has a characteristic particle size smaller than 0.5 μm, the explosibility screening test method shall account for possible ignitions in the sample injection apparatus. [**652:**5.4.3.5]

5.4.4 Quantification of Combustibility and Explosibility Characteristics.

5.4.4.1* Where dusts are determined to be combustible or explosible, additional testing shall be performed, as required, to acquire the data necessary to support the performance-based design method described in Chapter 6; the DHA described in Chapter 7; the risk assessments described in Chapter 9; or specification of the hazard mitigation and prevention described in Chapter 9. [**652:**5.4.4.1]

5.4.4.2 The owner/operator shall be permitted to use the worst-case characteristics of the various materials being handled as a basis for design. [**652:**5.4.4.2]

N **5.4.4.3** When quantifying combustibility and explosibility characteristics, it shall be permitted to test the as-received sample only for those locations where the particulate remains homogeneously mixed. [**652:**5.4.4.3]

N **5.4.4.4*** Where there is a potential for fines to segregate from the sample, a representative fine fraction shall be tested.

5.5* Sampling.

5.5.1 Sampling Plan.

5.5.1.1 A sampling plan shall be developed and documented to provide data as needed to comply with the requirements of this chapter. [**652:**5.5.1.1]

5.5.1.2* Representative samples of dusts shall be identified and collected for testing according to the sampling plan. [**652:**5.5.1.2]

5.5.2* Mixtures. If the combustible particulate solid sample is a mixture, the approximate proportions of each general category of particulate solid shall be determined and documented on the basis of available information and shall be used to assist in determining representative samples. [**652:**5.5.2]

Chapter 6 Performance-Based Design Option

6.1 General Requirements.

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]

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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 with qualifications acceptable to the owner/operator. [**652:**6.1.3]

6.1.3.1* General. All applicable aspects of the design, including those described in 6.1.4.1 through 6.1.4.13, shall be documented in a format and content acceptable to the AHJ. [**652:**6.1.3.1]

Δ **6.1.4* Document Requirements.** Performance-based designs shall be documented to include 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 6.1.4. [**652:**6.1.4]

6.1.4.1* Technical References and Resources. When requested by the AHJ, the AHJ shall be provided with sufficient documentation to support the validity, accuracy, relevance, and precision of the proposed methods. The engineering standards, calculation methods, and other forms of scientific information provided shall be appropriate for the particular application and methodologies used. [**652:**6.1.4.1]

6.1.4.2 Building Design Specifications. All details of the proposed building, facilities, equipment, and process designs that affect the ability of the facility to meet the stated goals and objectives shall be documented. [**652:**6.1.4.2]

6.1.4.3 Performance Criteria. Performance criteria, with sources, shall be documented. [**652:**6.1.4.3]

6.1.4.4 Occupant Characteristics. Assumptions about occupant characteristics shall be documented. [**652:**6.1.4.4]

6.1.4.5 Design Fire and Explosion Scenarios. Descriptions of combustible dust fire and explosion design scenarios shall be documented. [**652:**6.1.4.5]

6.1.4.6 Input Data. Input data to models and assessment methods, including sensitivity analyses, shall be documented. [**652:**6.1.4.6]

6.1.4.7 Output Data. Output data from models and assessment methods, including sensitivity analyses, shall be documented. [**652:**6.1.4.7]

6.1.4.8 Safety Factors. The safety factors utilized shall be documented. [**652:**6.1.4.8]

6.1.4.9 Prescriptive Requirements. Retained prescriptive requirements shall be documented. [**652:**6.1.4.9]

6.1.4.10 Modeling Features.

6.1.4.10.1 Assumptions made by the model user and descriptions of models and methods used, including known limitations, shall be documented. [**652:**6.1.4.10.1]

6.1.4.10.2 Documentation shall be provided to verify that the assessment methods have been used validly and appropriately to address the design specifications, assumptions, and scenarios. [**652:**6.1.4.10.2]

6.1.4.11 Evidence of Modeler Capability. The design team's relevant experience with the models, test methods, databases, and other assessment methods used in the performance-based design proposal shall be documented. [**652:**6.1.4.11]

6.1.4.12 Performance Evaluation. The performance evaluation summary shall be documented. [**652:**6.1.4.12]

6.1.4.13 Use of Performance-Based Design Option. Design proposals shall include documentation that provides anyone involved in the ownership or management of the building with notification of the following:

(1) Approval of the building, facilities, equipment, or processes, in whole or in part, as a performance-based design with certain specified design criteria and assumptions
(2) Need for required re-evaluation and re-approval in cases of remodeling, modification, renovation, change in use, or change in established assumptions

[**652:**6.1.4.13]

6.1.5* 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. [**652:**6.1.5]

Δ **6.1.6 Sources of Data.**

6.1.6.1 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. [**652:**6.1.6.1]

6.1.6.2 The degree of conservatism reflected in such data shall be specified, and a justification for the sources shall be provided. [**652:**6.1.6.2]

6.1.7* Maintenance of the Design Features. To continue meeting the performance goals and objectives of this standard, the design features required for each hazard area shall be maintained for the life of the facility subject to the management of change provisions of Section 8.12. [**652:**6.1.7]

6.1.7.1* This shall include complying with originally documented design assumptions and specifications. [**652:**6.1.7.1]

N **6.1.7.2*** Any variation from the design shall be acceptable to the AHJ. [**652:**6.1.7.2]

6.2 Risk Component and Acceptability. The specified performance criteria of Section 6.3 and the specified fire and explosion scenarios of Section 6.4 shall be permitted to be modified by a documented risk assessment acceptable to the AHJ. The final performance criteria, fire scenarios, and explosion scenarios established for the performance-based design shall be documented. [**652:**6.2]

6.3 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 6.3.1 through 6.3.5. [**652:**6.3]

6.3.1 Life Safety.

6.3.1.1* The life safety objectives of 4.2.2 with respect to a fire hazard shall be achieved if either of the following conditions 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 time necessary to effect complete evacuation.

[**652:**6.3.1.1]

6.3.1.2 The life safety objectives of 4.2.2 with respect to an explosion hazard shall be achieved if either of the following conditions 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 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 time necessary to effect complete evacuation.

[**652:**6.3.1.2]

6.3.2 Structural Integrity. The structural integrity objectives embodied in 4.2.2 and 4.2.3 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. [**652:**6.3.2]

6.3.3 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. [**652:**6.3.3]

6.3.4 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.

[**652:**6.3.4]

6.3.5 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 building or building compartment or equipment sufficient to threaten its structural integrity.
(2) Extension of the flame front outside the building or building compartment or equipment of origin except where intentionally vented to a safe location.
(3) Rupture of the building or building compartment or equipment of origin and the ejection of fragments that can constitute missile hazards.

[**652:**6.3.5]

6.4* Design Scenarios.

6.4.1 Fire Scenarios.

6.4.1.1* Each fuel object in the building or building compartment or equipment of origin shall be considered for inclusion as a fire scenario. [**652:**6.4.1.1]

6.4.1.2 The fuel object that produces the most rapidly developing fire during startup, normal operating conditions, or shutdown shall be included as a fire scenario. [**652:**6.4.1.2]

6.4.1.3 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. [**652:**6.4.1.3]

6.4.1.4 The fuel object that produces the greatest total heat release during startup, normal operating conditions, or shutdown shall be included as a fire scenario. [**652:**6.4.1.4]

6.4.1.5 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. [**652:**6.4.1.5]

6.4.1.6 Each fuel object that can produce a deep-seated fire during startup, normal operating conditions, or shutdown shall be included as a fire scenario. [**652:**6.4.1.6]

6.4.1.7 Each 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. [**652:**6.4.1.7]

6.4.2 Explosion Scenarios.

6.4.2.1 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. [**652:**6.4.2.1]

6.4.2.2 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. [**652:**6.4.2.2]

6.4.2.3 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. [**652:**6.4.2.3]

6.4.2.4 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. [**652:**6.4.2.4]

6.4.2.5* Where combustible dust can cause other explosion hazards, such as generation of hydrogen or other flammable gases, those hazards shall be included as explosion scenarios. [**652:**6.4.2.5]

6.5 Evaluation of Proposed Design.

6.5.1* A proposed design's performance shall be assessed relative to each documented performance criterion as established in Section 6.2 or in Section 6.3 and in each documented fire and explosion scenario established for the design, with the assessment conducted through the use of appropriate calculation methods acceptable to the AHJ. [**652:**6.5.1]

6.5.2 The designer shall establish numerical performance criteria for each of the documented performance objectives established for the design. [**652:**6.5.2]

6.5.3 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. [**652:**6.5.3]

Chapter 7 Dust Hazard Analysis (DHA)

7.1* General Requirements.

Δ **7.1.1 Retroactivity.** The requirements of Chapter 7 shall apply retroactively in accordance with 7.1.2.1 through 7.1.2.3.

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

7.1.2.1 For new processes that will be constructed and facility processes that are undergoing significant modification, the owner/operator shall complete DHAs as part of the project.

7.1.2.2* For existing processes and facility compartments that are not undergoing significant modification, the owner/operator shall schedule and complete DHAs of bucket elevators, conveyors, grinding equipment, spray dryer systems, and dust collection systems by January 1, 2022.

7.1.2.3 For the purposes of applying the provisions of 7.1.2, significant modification shall include modifications that exceed 25 percent of the replacement cost of the equipment system.

7.2 Criteria.

7.2.1* Overview. The DHA shall evaluate the fire, deflagration, and explosion hazards and provide recommendations to manage the hazards in accordance with Section 4.2. [**652:**7.2.1]

7.2.2* Qualifications. The DHA shall be performed or led by a qualified person. [**652:**7.2.2]

7.2.3 Documentation. The results of the DHA review shall be documented, including any necessary action items requiring change to the process materials, physical process, process operations, or facilities associated with the process. [**652:**7.2.3]

7.3* Methodology.

Δ **7.3.1 General.** The DHA shall include the following:

(1) Identification and evaluation of the process or facility areas where fire, flash fire, and explosion hazards exist
(2) Where such a hazard exists, identification and evaluation of specific fire and deflagration scenarios shall include the following:
    (a) Identification of safe operating ranges
    (b)* Identification of the safeguards that are in place to manage fire, deflagration, and explosion events
    (c) Recommendation of additional safeguards where warranted, including a plan for implementation

    [**652:**7.3.1]
(3) It shall be permitted to use a checklist to complete a DHA on an agricultural combustible dust. *(See Annex F for a sample checklist.)*

7.3.2 Material Evaluation.

Δ **7.3.2.1** The DHA shall be based on data obtained in accordance with Chapter 5 for material that is representative of the dust present. [**652:**7.3.2.1]

Chapter 8 Management Systems

8.1* Retroactivity. This chapter shall be applied retroactively to new and existing facilities and processes. [**652:**8.1]

8.2* General. The procedures and training in this chapter shall be delivered in a language that the participants can understand. [**652:**8.2]

8.3 Operating Procedures and Practices.

8.3.1* The owner/operator shall have written procedures that include operating its facility and equipment for the prevention of fires, deflagrations, and explosions from combustible particulate solids. [**652:**8.3.1]

8.3.2* The owner/operator shall establish safe work practices to address hazards associated with maintenance and servicing operations. [**652:**8.3.2]

8.3.2.1 The safe work practices shall apply to employees and contractors. [**652:**8.3.2.1]

N **8.4 Housekeeping.**

N **8.4.1 General. (Reserved)**

N **8.4.2 Methodology.**

N **8.4.2.1*** The facility shall develop and implement a written housekeeping program that establishes the frequency and method(s) determined best to reduce accumulations of fugitive agricultural dust on ledges, floors, equipment, and other inside exposed surfaces. Unless a greater threshold for housekeeping dust accumulation is prescribed in writing and justified by a documented risk assessment, the threshold housekeeping dust accumulation limit shall be 3.2 mm (1⁄8 in.) over 5 percent of the footprint area.

N **8.4.2.1.1*** Dust on floors, structural members, and other surfaces shall be removed concurrently with operations.

N **8.4.2.1.2*** Provisions for unscheduled housekeeping shall include specific requirements establishing time to clean local dust spills or transient releases. [**652:**8.4.6.3]

N **8.4.2.2 Vacuum Cleaning Method.**

N **8.4.2.2.1* Portable Vacuum Cleaners.** Portable electric vacuum cleaners, if used, shall be listed for use in Class II, Group G, Division 1 atmospheres as defined in *NFPA 70*.

N **8.4.2.2.2** Vacuum systems shall be grounded and bonded. Vacuum system hoses and couplings shall be static dissipative or conductive and grounded.

N **8.4.2.3 Sweeping, Shoveling, Scoop, and Brush Cleaning Method. (Reserved)**

N **8.4.2.4 Water Washdown Cleaning Method. (Reserved)**

N **8.4.2.5 Water Foam Washdown Systems. (Reserved)**

N **8.4.2.6 Compressed Air Blowdown Method.**

N **8.4.2.6.1** The use of compressed air or other means that cause dust to be suspended in air during removal from ledges, walls, and other surfaces shall be permitted only after all machinery in the area has been shut down and all sources of ignition controlled.

N **8.4.2.6.2** Areas in processing facilities shall be permitted to be cleaned with compressed air, provided that both of the following conditions are met:

(1) Airborne material will not envelop adjacent operating equipment.
(2) Prior to blowdown, areas and adjacent equipment are checked to ensure that no ignition sources are present.

N **8.4.2.7 Steam Blowdown Method. (Reserved)**

N **8.4.3 Training. (Reserved)**

N **8.4.4 Equipment. (Reserved)**

N **8.4.5 Vacuum Trucks. (Reserved)**

N **8.4.6 Reserved.**

N **8.4.7 Auditing and Documentation. (Reserved)**

8.5 Hot Work.

8.5.1* Hot work in facilities covered by this standard shall comply with the requirements of NFPA 51B, except as modified in this section.

8.5.2 Hot work performed outside of safe, designated areas shall follow 8.5.2.1 through 8.5.2.3.

8.5.2.1* A documented hot work permit system shall be used.

8.5.2.2 The hot work permit system shall include the following conditions:

(1) The area within 11 m (35 ft) of the work shall be cleaned of combustible dust.
(2) Other combustibles within 11 m (35 ft) of the work shall be moved or protected with covers, guards, or shields.
(3) Combustible floors or equipment in or below the work area shall be wet down or covered with damp sand, metal shields, or fire-retardant blankets or tarps.
(4) Equipment being worked on shall be thoroughly cleaned of combustible material and oil residues, and any exposed combustible linings shall be removed.
(5) Combustible dust or flammable vapor–producing machinery or operations in the area shall not be permitted to be operating during the work.
(6)* Fire protection or detection systems, if provided, shall be in operation during the work unless the work is being performed on the system. In the cases where fire or explosion protection systems present a life safety hazard, an active fire watch shall be permitted to be used while the fire protection system is impaired.
(7) Floor, wall ducts, and other openings within 11 m (35 ft) of the work shall be covered or closed, and all open spouts in the work area shall be sealed or plugged.
(8) A fire watch supplied with suitable portable extinguishers or a water hose shall be maintained during the work and for at least 60 minutes after the work is completed. In certain circumstances, the permit-authorizing individual shall be permitted to assess and document an extension of the fire watch or an alternative to active fire watch, such as a thorough wet down of the area after the work is complete.
(9) The duration of the permit system shall not exceed one shift.
(10)* Regular inspections of the work area shall be made to ensure that no smoldering fires develop, including a final inspection performed prior to closing the area for the day or weekend.
(11) Hot work shall not be permitted on equipment that is operating.

8.5.2.3 The person responsible for the hot work operations shall perform the following duties:

(1) Inspect the proposed work area to determine that the conditions of the permit system have been met
(2) Designate additional precautions as deemed necessary
(3) Sign the permit to authorize the work to begin

8.5.3 The hot work operations shall be stopped if the conditions of the permit change.

8.5.4 Upon completion of the work and after time has been allowed for cooling hot surfaces, the areas shall be restored to normal operation.

8.5.5 Fire protection or detection systems shall not be disabled unless the hot work could activate them. If so, such systems shall be restored to service promptly after the hot work task is completed.

N **8.5.6 Use of Portable Equipment.**

N **8.5.6.1*** Work activities that could present an ignition source but do not fit the definition of hot work, such as drilling, sawing, or use of hand-operated portable electrical equipment that does not comply with the electrical classification of the area where it is to be used, shall be permitted in accordance with 8.5.6.1.1 through 8.5.6.1.6.

N **8.5.6.1.1** The area affected by the work shall be thoroughly cleaned of combustible dust prior to commencing the work.

N **8.5.6.1.2** The area affected by the work shall be free from airborne combustible dust.

N **8.5.6.1.3** Equipment that contains combustible dust and is located near the work area shall be protected from the work.

N **8.5.6.1.4** When the work poses an ignition risk to the combustible dust within equipment, the equipment shall be shut down and cleaned prior to commencing such work.

N **8.5.6.1.5** Floor and wall openings within the work area shall be covered or sealed.

N **8.5.6.1.6** The work shall be performed on surfaces and equipment not directly handling combustible dusts.

8.5.6.2 Spark-producing portable power tools and propellant-actuated tools shall not be used where combustible dust is present.

8.5.6.3 When the use of spark-producing or propellant-actuated tools becomes necessary, the following procedures shall be performed:

(1) All dust-producing machinery in the area shall be shut down.
(2) The use of spark-producing or propellant-actuated tools shall be authorized by the use of a hot work permit.

8.5.6.4 After completion of the work requiring the use of propellant actuated tools, a check shall be made to be sure that no cartridges or powder charges are left on the premises where they could enter equipment or otherwise be accidentally discharged.

N **8.6 Personal Protective Equipment.**

N **8.6.1*** When flame-resistant clothing is used for protecting personnel from flash fires, it shall comply with the requirements of NFPA 2112. [**652:**8.6.1.3]

N **8.6.2** Flame-resistant garments shall be selected, procured, inspected, worn, and maintained in accordance with NFPA 2113. [**652:**8.6.1.5]

N **8.6.3 Limitations of PPE to Combustible Dust Flash Fires. (Reserved)**

N **8.6.4 Face, Hands, and Footwear Protection. (Reserved)**

8.7 Inspection, Testing, and Maintenance.

8.7.1* Equipment affecting the prevention, control, and mitigation of fires, deflagrations, and explosions shall be inspected, tested, and maintained in accordance with the applicable NFPA standard.

8.7.1.1 Where there is no applicable NFPA standard, equipment shall be inspected, tested, and maintained in accordance with manufacturers' recommendations, as modified by operational experience.

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

(1) Fire and explosion protection and prevention equipment
(2) Dust control equipment
(3) Safety devices
(4)* Electrical, process, and mechanical equipment, including process interlocks associated with fire and explosion protection and prevention
(5) Lubrication of bearings

8.7.3 The owner/operator shall have procedures and schedules for maintaining safe operating conditions for its facility and equipment in regard to the prevention, control, and mitigation of combustible dust fires and explosions. [**652:**8.7.3]

8.7.4* Where equipment maintenance deficiencies that affect the prevention, control, and mitigation of dust fires, deflagrations, and explosions are identified or become known, the owner/operator shall establish and implement a corrective action plan with a documented deadline.

8.7.5 Inspections and testing activities that affect the prevention, control, and mitigation of dust fires, deflagrations, and explosions shall be documented. [**652:**8.7.5]

8.7.6 An inspection of the operating area shall take place on an established schedule to help ensure that the equipment is in safe operating condition and that proper work practices are being followed.

8.8 Training and Hazard Awareness.

8.8.1* General safety training and hazard awareness training for combustible dusts and solids shall be provided to all affected employees. [**652:**8.8.2]

8.8.2* Employees, contractors, temporary workers, and visitors shall be included in a training program according to the potential exposure to combustible dust hazards and the potential risks to which they might be exposed or could cause. [**652:**8.8.1]

8.8.3* Job-specific training shall ensure that employees, contractors, and temporary workers are knowledgeable about fire and explosion hazards of combustible dusts and particulate solids in their work environment.

8.8.4* Where explosion protection systems are installed, training of affected personnel shall include the operations and potential hazards presented by such systems. [**652:**8.8.2.3]

8.8.5 Refresher training shall be provided annually.

8.8.6 The training shall be documented. [**652:**8.8.4]

8.9 Contractors.

8.9.1 Only knowledgeable contractors shall be employed for work involving the installation, repair, or modification of buildings (interior and exterior), machinery, and fire and explosion protection equipment that could adversely affect the prevention, control, or mitigation of fires and explosions. [**652:**8.9.2]

8.9.2* Contractor Training.

8.9.2.1 Contractors operating owner/operator equipment shall be trained and qualified to operate the equipment and perform the work. [**652:**8.9.3.1]

8.9.2.2 Contractor training shall be documented. [**652:**8.9.3.2]

8.9.2.3* Contractors working on or near a given process shall be made aware of the potential hazards from and exposures to fires and explosions. [**652:**8.9.3.3]

8.9.2.4 Contractors shall be trained and required to comply with the facility's safe work practices and policies in accordance with 8.3.2. [**652:**8.9.3.4]

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 area. [**652:**8.9.3.5]

8.9.2.6 Contractors shall receive refresher training annually.

8.10 Emergency Planning and Response. Each facility shall have a written emergency action plan on-site or electronically available that includes, but is not limited to, the following:

(1) A means of notification for occupants in the event of fire and explosion
(2) A preplanned evacuation assembly area
(3) A person(s) designated to notify emergency responders, including the fire department
(4) A facility layout drawing(s) showing egress routes, hazardous chemical locations, and fire protection equipment
(5) Location of a safety data sheet(s) for hazardous chemicals
(6) An emergency telephone number(s)
(7) Emergency response duties for occupants
(8) A person(s) designated to meet the offsite emergency responder(s) to coordinate the incident

8.10.1 Annual training regarding the emergency action plan shall be provided for all affected personnel.

8.10.2 The emergency action plan shall be coordinated with local emergency responders and include fire department prefire plans.

8.10.3* Fire-Fighting Operation.

8.10.3.1 Fires, when discovered, shall be reported promptly to facility management and emergency responders, including the fire department.

8.10.3.2 Burning material shall not be transferred into legs.

8.10.3.3 If a fire cannot be controlled promptly in its incipient stage, the endangered structure(s) shall be evacuated.

8.10.3.4 Bearing fires shall be extinguished with a gentle application of water fog onto the bearing for cooling.

8.10.3.4.1 If water is not available, other means of extinguishment shall be permitted to be used on the bearing fire, provided caution is taken to avoid the suspension of combustible dust.

8.10.3.4.2 If the bearing is located inside equipment, material flow shall be stopped, equipment shall be shut down, and extreme caution shall be used when equipment is opened.

8.10.3.5* Straight stream nozzles shall not be used on fires in areas where dust clouds can be generated.

8.10.3.5.1* Portable spray hoses located in areas with combustible dust shall be provided with nozzles that are listed or approved for use on Class C fires to limit the potential for generating unnecessary airborne dust during fire-fighting operations.

8.10.3.5.2 Straight stream nozzles or combination nozzles shall be permitted to be used to reach fires in locations that are otherwise inaccessible with the nozzles specified in 8.10.3.5.

8.11 Incident Investigation.

8.11.1* The owner/operator shall have a system to ensure that incidents that result in a fire, deflagration, or explosion are reported and investigated in a timely manner. [**652:**8.11.1]

8.11.2 The investigation shall be documented and include findings and recommendations. [**652:**8.11.2]

8.11.3 A system shall be established to address and resolve the findings and recommendations. [**652:**8.11.3]

8.11.4* The investigation findings and recommendations shall be reviewed with affected personnel. [**652:**8.11.4]

8.12 Management of Change.

N **8.12.1*** Documented procedures shall be established and implemented to manage proposed changes to process materials, combustible dust handling equipment, facilities, and fire and explosion protection devices that affect dust, fire, or explosion hazards.

8.12.1.1 The owner/operator shall require that a qualified person knowledgeable in the fire and deflagration hazards of agricultural or food dust review the proposed changes.

8.12.1.2 The qualified person shall consider whether or not the change would comply with NFPA 61 and if the change does not comply, then a method of compliance shall be determined.

N **8.12.2*** The procedures shall ensure that the following are addressed prior to any change:

(1)* The basis for the proposed change
(2)* Safety and health implications
(3) Authorization requirements for the proposed change

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

8.13* Documentation Retention.

8.13.1 The owner/operator shall establish a program and implement a process to manage the retention of documentation including, but not limited to, the following:

(1) Training records
(2) Equipment inspection, testing, and maintenance records
(3) Incident investigation reports
(4) Dust hazard analysis
(5)* Process and technology information
(6) Management of change documents
(7)* Contractor records

8.14 Management Systems Review.

8.14.1 The owner/operator shall evaluate the effectiveness of the management systems presented in this standard by conducting a periodic review of each management system. [**652:**8.14.1]

8.14.2 The owner/operator shall be responsible for maintaining and evaluating the ongoing effectiveness of the management systems presented in this standard. [**652:**8.14.2]

8.15* Employee Participation. Owner/operators shall include affected personnel in the control and mitigation of fire and explosion risk.

8.16 Storage of Oils, Flammable Liquids, and Liquefied Petroleum Gas (LP-Gas).

8.16.1 Flammable and combustible liquids shall be stored in closed containers, safety cans, flammable liquid cabinets, storage rooms, and so forth, as permitted in NFPA 30.

8.16.2 Portable LP-Gas containers located inside the facility shall be stored, used, and handled in accordance with NFPA 58.

8.17 Warning Signs.

8.17.1 Where personnel are exposed to bodily risk from installed fire or explosion prevention systems, such as inert gas systems used to reduce oxygen concentration or explosion suppression systems, equipment and buildings having such systems shall be provided with warning signs.

8.17.2 Warning signs shall indicate the potential dangers, shall state adequate precautions, and shall be posted at all entrances to the building or equipment.

8.18 Miscellaneous Storage in Grain-Handling Facilities.

8.18.1 Sacks, nonessential uninstalled machinery or parts, or other supplies shall not be stored in areas where the only other combustible material is the agricultural commodity that is being stored.

8.18.2 Miscellaneous storage shall not impede facility housekeeping or fire fighting.

Chapter 9 Hazard Management: Mitigation and Prevention

9.1 Reserved.

9.2 Building Design.

9.2.1 Risk Assessment. A documented risk assessment shall be permitted to be conducted to determine the level of building design and protection features to be provided, including, but not limited to, the measures addressed in Section 9.2.

N **9.2.2 Construction.**

9.2.2.1 The construction, renovation, modification, reconstruction, alteration, repair, addition, change of use or change of occupancy classification, demolition, and relocation of all buildings and structures shall comply with the governing building code, except as modified herein.

9.2.2.2* Enclosures built to segregate dust explosion hazard areas from other areas shall be designed such that they will not fail before the explosion pressure is vented to a safe outside location.

9.2.2.3 Electrical wiring and power equipment shall meet all applicable requirements of *NFPA 70*.

9.2.3 Building or Building Compartment Protection.

9.2.3.1 Masonry shall not be used for the construction of exterior walls or roofs of areas classified as Class II, Group G, Division 1 in *NFPA 70*.

9.2.3.1.1* The requirement in 9.2.3.1 shall not apply to masonry walls that are designed for explosion resistance to preclude failure of these walls so the explosion pressure can be vented safely to the outside.

9.2.3.2 Facilities that are designed for receiving, shipping, handling, and storing of bulk raw agricultural commodities and are located in a separate structure from grain processing or manufacturing areas and their associated raw material, ingredient, production, and finished product bins shall be located and constructed in accordance with the requirements of 9.2.3.2.1 through 9.2.3.2.4.

9.2.3.2.1 Structures housing personnel-intensive areas not directly involved in operations such as, but not limited to, those involved exclusively in administrative or clerical personnel groups, grain inspection and weighing supervision, or operations from control rooms shall be constructed in a location remote from storage silos and headhouse structures as specified in 9.2.3.2.2 through 9.2.3.2.4.

9.2.3.2.1.1 The requirement in 9.2.3.2.1 shall not apply to small control rooms contiguous to specific operations such as railcar and truck discharging or loading or to control rooms such as those used in feed mills for mixing operations.

9.2.3.2.2 Structures housing personnel-intensive areas shall not be constructed directly over subterranean tunnels through which grain-handling equipment or dust control system ductwork passes or over other tunnels that have direct openings into grain-handling areas.

9.2.3.2.2.1 The requirement in 9.2.3.2.2 shall not apply to small control room structures contiguous to specific operations such as railcar and truck discharging or loading.

9.2.3.2.3 Where reinforced concrete is used in silos and headhouses, the separation distance from personnel-intensive areas shall be at least 30 m (100 ft).

9.2.3.2.3.1 Distances less than 30 m (100 ft) but in no case less than 15 m (50 ft) shall be permitted where any of the following conditions exist:

(1) The property boundaries or other permanent constraints preclude 30 m (100 ft).
(2) Structures do not have inside legs.
(3) Structures have inside legs that are equipped with explosion protection equipment in accordance with 9.3.14.

9.2.3.2.4 Where the headhouse is constructed of structural steel or reinforced concrete framework with lightweight, explosion-relieving wall panels or does not contain inside or unprotected bucket elevators, the separation distance from personnel-intensive areas shall be at least 15 m (50 ft).

9.2.3.2.4.1 Distances less than 15 m (50 ft) shall be permitted if the property boundaries or other permanent constraints preclude 15 m (50 ft), but in no case shall distances less than 9 m (30 ft) be permitted.

9.2.3.3* Where provided, a lightning protection system shall be designed and installed in accordance with NFPA 780.

N **9.2.4 Life Safety. (Reserved)**

9.2.5 Interior Wall Construction.

9.2.5.1 Storage areas larger than 465 m^2 (5000 ft^2) and containing packaging, bagging, palletizing, and pelleting equipment shall be cut off from all other areas with fire barrier walls designed for a minimum fire resistance of 2 hours and designed in accordance with Chapter 8 of *NFPA 5000*.

9.2.5.2 Warehouse areas shall be designed in accordance with *NFPA 5000*.

9.2.5.3 Necessary openings in fire walls and fire barrier walls shall be kept to a minimum and be as small as practicable. Such openings shall be protected with listed self-closing fire doors, fire shutters, fire dampers, or penetration seals installed in accordance with Chapter 8 of *NFPA 5000*.

9.2.5.3.1 Fire doors, fire shutters, fire dampers, and fire penetration seals shall be listed and shall have a fire protection rating complying with NFPA *101*.

9.2.5.3.2 Hold-open devices, if used, shall be listed and shall activate and allow the door to close upon sensing at least one of the following:

(1) Heat
(2) Smoke
(3) Flames
(4) Products of combustion

9.2.5.4* Interior Surfaces. Horizontal surfaces shall be minimized to prevent accumulations of dust in all interior structural areas where significant dust accumulations could occur.

N **9.2.6 Separation of Hazard Areas from Other Hazard Areas and from Other Occupancies.**

N **9.2.6.1 Reserved.**

N **9.2.6.2 Use of Segregation.**

N **9.2.6.2.1** Physical barriers erected for the purpose of limiting fire spread shall be designed in accordance with local code.

N **9.2.6.2.2** Physical barriers erected to segregate fire hazard areas, including all penetrations and openings of floors, walls, ceilings, or partitions, shall have a minimum fire resistance rating based on the anticipated fire duration. [**652:**9.2.6.2.2]

N **9.2.6.2.3** Physical barriers, including all penetrations and openings of floors, walls, ceilings, or partitions, that are erected to segregate dust explosion hazard areas shall be designed to preclude failure of those barriers during a dust explosion in accordance with NFPA 68. [**652:**9.2.6.2.3]

9.2.6.3 Use of Separation.

9.2.6.3.1* Separation shall be permitted to be used to limit the dust explosion hazard or deflagration hazard area within a building if the separation is supported by a documented evaluation.

9.2.6.3.2* The required separation distance between the dust explosion hazard or deflagration hazard area 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 outside the process equipment
(4) Building and equipment design
(5) Nature of surrounding exposures

[**652:**9.2.6.3.2]

9.2.6.3.3 Either the separation area shall be free of dust or where dust accumulations exist on any surface, the color of the surface on which the dust has accumulated shall be readily discernible. [**652:**9.2.6.3.3]

9.2.6.3.4 Where separation is used to limit the dust explosion or deflagration hazard area, the minimum separation distance shall not be less than 35 ft (11 m). [**652:**9.2.6.3.4]

9.2.6.3.5* Where separation is used, housekeeping, fixed dust collection systems employed at points of release, and the use of physical barriers shall be permitted to be used to limit the extent of the dust explosion hazard or flash-fire hazard area. [**652:**9.2.6.3.5]

9.2.7 Means of Egress.

9.2.7.1 Means of egress shall be in accordance with NFPA *101*.

9.2.7.2 Where the horizontal travel distance to the means of egress is less than 15 m (50 ft) in normally unoccupied spaces, a single means of egress shall be permitted.

9.2.7.3 Bin decks shall have two means of egress that are remote from each other such that a single fire or explosion event will not likely block both means of egress.

9.2.7.3.1 One means of egress shall be required for bin deck areas where travel distance to the means of egress is less than 15 m (50 ft).

9.2.8 Marine Towers.

9.2.8.1 Marine towers shall be constructed of noncombustible materials.

9.2.8.2 Movable marine towers shall be provided with automatic or manually operated brakes.

9.2.8.2.1 Movable marine towers shall be provided with automatic or manual rail clamps.

9.2.8.2.2 Equipment to monitor wind velocity shall be installed on movable marine towers.

9.2.8.2.3 Rail clamps shall operate or be activated when the wind velocity is great enough to cause movement of the tower, even when brakes or gear drives are preventing the rail wheels from turning.

9.2.8.3 Movable marine towers shall have provisions for emergency tie-downs.

9.2.8.4 Marine vessel loading equipment, such as conveyors, spouts, or drags, shall have safety devices to prevent the equipment from falling if the operating cable(s) breaks.

9.3 Equipment Design.

Δ **9.3.1* Risk Assessment.** A documented risk assessment shall be permitted to be conducted to determine the level of protection to be provided, including, but not limited to, protection measures addressed in Section 9.3.

N **9.3.2 Design for Dust Containment. (Reserved)**

9.3.3 Pneumatic Conveying, Dust Collection, and Centralized Vacuum Cleaning Systems.

9.3.3.1* General.

9.3.3.1.1 Pneumatic conveying, dust collection, and centralized vacuum cleaning systems shall be installed in accordance with 9.3.3 and 9.3.5 through 9.3.9 of NFPA 654.

N **9.3.3.1.2** The systems shall be designed and maintained to ensure that the air–gas velocity used meets or exceeds the minimum required to keep the interior surfaces of all piping or ducting free of accumulations under all normal operating modes.

9.3.3.1.3 Pneumatic Conveying System Design. Systems that handle combustible dusts shall be designed by and installed under the supervision of qualified persons who are knowledgeable about these systems and their associated hazards.

9.3.3.2 General Design.

9.3.3.2.1* All system components shall be electrically conductive.

9.3.3.2.2 Bonding and grounding shall be provided for all components, including sight glasses and couplings.

9.3.3.2.3 Electrical wiring and power equipment shall meet all applicable requirements of *NFPA 70*.

9.3.3.2.4* Ingredient transport system installations whose sole function is to transfer ingredients shall be permitted to be installed inside of a building without explosion protection where all of the following requirements are met:

(1) The system is a negative or positive pressure pneumatic conveying system.
(2) The system, through its design, is isolated from the addition of mechanical or electrical energy and process activities, such as cooking or drying, by positive means, such as rotary valves, filters, normally closed valves, or sealed hoppers, from outside events that could trigger an event such as a flash fire or deflagration.
(3) The system is not a bulk raw grain transportation pneumatic system or dust collection system.

9.3.3.3 Piping, Valves, and Blowers.

9.3.3.3.1 Positive- and negative-type pressure systems shall be permitted. Where the blower discharge pressure and its conveying system are designed to operate at gauge pressures exceeding 103 kPa (15 psi), the system shall be designed in accordance with Section VIII of ASME *Boiler and Pressure Vessel Code*.

9.3.3.3.2 All piping and tubing systems shall be as follows:

(1) Supported to include the weight of material in a full or choked position
(2) Airtight and dusttight
(3) Assembled in such a manner as to provide convenient disassembly for cleaning

9.3.3.3.3 Pressure- and vacuum-relief valves shall be located, designed, and set to relieve pressure to protect the system components.

9.3.3.3.4 Multiple-direction valves shall be of airtight and dusttight construction and sized to effect a positive diversion of the product with a full cross-sectional open area. Diversion in one direction shall seal all other directions from air, dust, or product leakage.

9.3.3.4 Receiving and Shipping Conveyances.

9.3.3.4.1* All transport modes such as railcars (hopper cars, boxcars, or tank cars) and trucks (both receiving and shipping in bulk), into which or from which commodities or products are pneumatically conveyed, shall be electrically bonded to the plant ground system or earth grounded.

9.3.3.4.1.1 The requirement in 9.3.3.4.1 shall not apply to materials of processes involving inert materials, such as limestone at feed mills.

9.3.3.4.2 Flexible connections shall be electrically conductive, having a resistance not greater than 1 megohm.

9.3.3.4.3 All connections between the transport vehicles and the plant system shall be made on the outside of the building or in a dedicated shipping/receiving area that is separated from process areas and warehouses by walls or detachment.

9.3.3.5 Dust Collection Systems.

9.3.3.5.1 Fans and Blowers. Fans and blowers designed to convey combustible dusts through them shall be of spark-resistant construction Type A or B as described in ANSI/AMCA Standard 99, Standards Handbook, *Classifications for Spark Resistant Construction*.

9.3.3.5.2 Construction. All components of the dust collection system shall be constructed of noncombustible materials.

9.3.3.5.2.1 The requirement in 9.3.3.5.2 shall not apply to filter bags, filter media, liners, drive belts, wear parts, and flexible connector ducts.

9.3.3.5.3 Manifolding. Dust collection systems for one or more hammer mills or pulverizer mills shall not be manifolded with other types of machinery.

9.3.3.5.3.1 Conveyors, sifters, and hammer mills used for the sizing of oilseed meals and hulls shall be permitted to have a common dust collection system.

9.3.3.5.4 Separate Collection Systems. Each department in starch manufacturing and handling (i.e., starch drying, grinding, dextrine cooking) shall have a separate dust collection system.

9.3.3.5.5* Dust Liberation. Liberation of dust into the ambient air within a shed or structure from open pits or hoppers, such as truck or railcar dump pits, shall be reduced as much as practical by dust control.

9.3.3.5.6 Machinery Startup and Shutdown. Dust collection systems shall be in operation before startup of related machinery.

9.3.3.5.6.1 Shutdown of a dust collection system collecting only combustible dusts shall actuate an audible or visual signal that can be either seen or heard by the attendant.

9.3.3.5.6.2 Procedures shall be established, or an automatic sequence provided, to shut down related machinery if the dust collection system shuts down during operations.

9.3.3.5.6.3 Dust collection systems equipped with explosion venting or explosion suppression systems shall include a method of shutting down the system automatically when a deflagration event occurs within the air-material separator (AMS).

9.3.3.5.7 Filter Media Dust Collectors.

9.3.3.5.7.1 Filter media dust collectors shall have a monitoring device (such as a differential pressure gauge) to indicate pressure drop across the filter media.

9.3.3.5.7.2 Manufacturer's recommendations and specifications shall be followed concerning actions to be taken based on the indicated pressure drop across the filter media.

9.3.3.5.7.3 Where lightning protection is provided, it shall be installed in accordance with NFPA 780.

9.3.3.5.8* Dust Bins and Tanks.

9.3.3.5.8.1 Bins and tanks for the storage of grain dust shall be dusttight, constructed of noncombustible materials, and located outside the buildings or structures.

9.3.3.5.8.2 The dust bins and tanks shall have transfer systems that are separated from the upstream operations by rotary valves or choke seals, or through the use of other methods to reduce the likelihood of propagation of an explosion in accordance with NFPA 69.

9.3.3.5.9 Floor Sweeps. If provided, floor sweeps shall be on a separate, dedicated vacuum or dust collection system, provided the fan is located downstream of the filter.

9.3.3.6 Duct Systems.

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

9.3.3.6.1.1 Plastic or fiberglass ducts or pipes shall not be used.

9.3.3.6.1.2* Ductwork utilizing a combustible lining shall be permitted only in high impact areas.

9.3.3.6.2 Flexible Hose. Flexible hose shall conform to the following provisions:

(1) It shall be permitted for use with combustible materials only if it is made of static dissipative construction and properly grounded.
(2) It shall be permitted for connections and isolation purposes only properly grounded and less than 457 mm (18 in.) in length.

9.3.3.7 Centralized Vacuum Cleaning System.

9.3.3.7.1 Only static-conductive vacuum cleaning tools shall be used and shall be properly grounded to the hose end.

9.3.3.7.2 Only static-dissipative hoses shall be used and shall be properly grounded.

9.3.3.7.3 The air-material separator (AMS) used with this system shall comply with the requirements of 9.3.4.1 and comply with 9.7.3.1.

9.3.3.7.4* The AMS shall include filtration for the separation of the conveyed combustible dust from the conveying air stream.

9.3.3.7.5 The air-moving device shall be downstream of the AMS.

9.3.3.7.6 Cyclones used as primary AMS units shall be permitted only in combination with a filtered secondary AMS.

9.3.3.7.7 The system shall be designed to provide the conveying airflow velocity required to keep the conveyed material airborne in the ducting/piping at all times whether a single user or multiple active users are connected to the system.

9.3.3.7.8* The hose length and diameter shall be sized for the application and operation. [**652:**9.3.3.4.2]

9.3.3.7.9* Where ignition-sensitive materials are collected, vacuum tools shall be constructed of metal or static dissipative materials and provide proper grounding to the hose. [**652:**9.3.3.4.3]

9.3.4 AMS Locations.

9.3.4.1 Air-Material Separators.

9.3.4.1.1 Air-material separators connected to processes that are potential sources of ignition, such as hammer mills, ovens, and direct-fired dryers, and other similar equipment placed inside or outside of buildings shall be protected in accordance with 9.7.3.1.

9.3.4.1.1.1 Indoor air-material separators protected by explosion venting shall be located adjacent to an exterior wall and vented to the outside through straight ducts not exceeding 6 m (20 ft) in length.

9.3.4.1.1.2 Indoor air-material separators protected by explosion venting shall be designed so that the explosion pressures will not rupture the ductwork or the separator.

N **9.3.4.1.1.3*** The requirements in 9.7.3.1 shall not apply to an AMS with a dirty side volume of less than 0.2 m^3 (8 ft^3).

Δ **9.3.4.1.2** Cyclones with a 0.76 m (30 in.) diameter or less used as air-material separators shall be allowed to be placed inside buildings without explosion protection when the following conditions are present:

(1) The room, building, or other enclosure is not a Class I, Division 1 or 2 or Class II, Division 1 area as defined by Article 500 of *NFPA 70.*
(2) The material being processed has a minimum ignition energy of more than 10 mJ.
(3) The system is a closed process, excluding cleaning vacuum systems.
(4) The material being processed has a K_{St} of less than 200 bar-m/sec.

9.3.4.1.3* Filtered Air.

9.3.4.1.3.1* Recycling of air from air-material separators to buildings shall be permitted if the system is designed to prevent transmission of energy from a fire or explosion to the building.

9.3.4.1.3.2 Air that is returned inside the building or to air makeup systems shall be filtered to the efficiency of 0.02 g per dry standard cubic meter of airflow (0.008 grain per dry standard cubic foot of airflow).

9.3.4.1.3.3* Air from multiple pneumatic filters shall be permitted to be returned to the air makeup system.

9.3.4.1.3.4* Air from hammer mill filters shall not be returned to the air makeup system.

9.3.4.1.3.5* Air from filters used for classifying food products (purifiers) shall be permitted to be returned to the air makeup system.

9.3.4.1.4 Air from a multiple pneumatic conveying system, negative or positive, shall be permitted to be returned to the air makeup system.

9.3.4.2* Dust Collector Location. Dust collectors shall be located outside of buildings and shall be protected in accordance with 9.7.3.1.

9.3.4.2.1 Dust collectors shall be permitted inside of buildings if any of the following apply:

(1) Deflagration venting is provided in accordance with the requirements of NFPA 68.
(2) Dust collectors are equipped with an explosion suppression system designed according to NFPA 69.

9.3.4.2.2 If the dust collector is a centrifugal separator without bags, used for removing moisture from coolers that handle pelleted, extruded, or flaked grain and feed products, it shall be permitted inside or outside of buildings without explosion protection.

9.3.4.2.3 Bin vent dust collectors directly mounted without a hopper on a tank or bin, whose primary function is to filter air displaced during filling or blending operations and return dust directly to the bin, shall be permitted inside or outside of buildings without explosion protection. Filters that return air to inside of buildings shall be capable of a minimum efficiency of 0.02 g per dry standard cubic meter of airflow (0.008 grains per dry standard cubic foot of airflow).

9.3.4.2.4 Filters used for classifying food products with air (product purifiers) shall be permitted to be located inside or outside of buildings without explosion protection.

9.3.5 Recycle of AMS Clean Air Exhaust.

9.3.5.1* Pneumatic Conveyor Filtered Air.

9.3.5.1.1* Recycling of air from air-material separators to buildings shall be permitted if the system is designed to prevent transmission of energy from a fire or explosion to the building.

9.3.5.1.2 Air that is returned inside the building or to air makeup systems shall be filtered to the efficiency of 0.02 g per dry standard cubic meter of airflow (0.008 grain per dry standard cubic foot of airflow).

9.3.5.1.3* Air from multiple pneumatic filters shall be permitted to be returned to the air makeup system.

9.3.5.1.4* Air from hammer mill filters shall not be returned to the air makeup system.

9.3.5.1.5* Air from filters used for classifying food products (purifiers) shall be permitted to be returned to the air makeup system.

9.3.5.1.6 Air from a multiple pneumatic conveying system, negative or positive, shall be permitted to be returned to the air makeup system.

9.3.5.2* Dust Collector Filtered Air.

9.3.5.2.1* Recycling of air from collectors to buildings shall be permitted if the system is designed in accordance with methods found in NFPA 69, Chapter 11 and Chapter 12, to prevent a return of dust, combustion products, flammable vapors, heat, and flames into the building.

9.3.5.2.2 Filters that return air to the inside of buildings shall be capable of a minimum efficiency of 0.02 g per dry standard cubic meter of airflow (0.008 grains per dry standard cubic foot of airflow).

9.3.6 Duct Systems. (Reserved)

N **9.3.7 Sight Glasses. (Reserved)**

N **9.3.8 Abort Gates/Dampers. (Reserved)**

9.3.9 Bins, Tanks, and Silos.

9.3.9.1 Construction of bins, tanks, and silos shall conform to applicable local, state, or national codes.

9.3.9.2* Where explosion relief vents are provided on silos, bins, and tanks, they shall operate due to overpressure before the container walls fail.

9.3.9.3 Access doors or openings shall meet the following requirements:

(1) They shall be provided to permit inspection, cleaning, and maintenance and to allow effective use of fire-fighting techniques in the event of fire within the bin, tank, or silo.
(2) They shall be designed to prevent dust leaks.

9.3.9.4 Where a bin, tank, or silo has a personnel access opening provided in the roof or cover, the smallest dimension of the opening shall be at least 610 mm (24 in.).

N **9.3.10 Size Reduction. (Reserved)**

N **9.3.11 Particle Size Separation. (Reserved)**

N **9.3.12 Pressure Protection Systems. (Reserved)**

N **9.3.13 Material Feeding Devices. (Reserved)**

9.3.14 Bucket Elevator Legs.

9.3.14.1 All Legs.

9.3.14.1.1 Casing, head and boot sections, access openings, and connecting spouts shall be as dusttight as practicable and shall be constructed of noncombustible materials.

9.3.14.1.2* Inspection openings shall be provided in the boot section to allow clean-out of the boot and inspection of the alignment of the boot pulley and belt.

9.3.14.1.3 Inspection openings shall be provided in the head section to allow complete inspection of the head pulley lagging, the belt and pulley alignment, and the discharge throat of the leg.

9.3.14.1.4* Each leg shall be independently driven by motor(s) and drive train(s) capable of handling the full-rated capacity of the elevator leg without overloading.

9.3.14.1.4.1 Line shaft drives shall be acceptable for legs used in the milling industry as long as they are capable of handling the full-rated capacity of all connected equipment without overloading.

9.3.14.1.4.2 Multiple motor drives shall be interlocked to prevent operation of the leg upon failure of any single motor.

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

9.3.14.1.5* Each leg shall be provided with a speed sensor device that will cut off the power to the drive motor and actuate an alarm in the event the leg belt slows to 80 percent of normal operating speed. Feed to the elevator leg by mechanical means shall be stopped or diverted.

9.3.14.1.6 The use of plastic, rubber, and other combustible linings shall be limited to high-impact areas and wear surfaces.

9.3.14.1.7 The leg head section between the up and down casings shall be sloped at an angle of not less than 45 degrees.

9.3.14.1.8 All spouts intended to receive grain or dry ingredients directly from any leg shall be designed and installed to handle the full-rated elevating capacity of the largest leg feeding such spouts.

9.3.14.1.9 Legs shall have lagging installed on the head pulley to minimize slippage.

9.3.14.1.10* Leg belts and lagging shall have a surface resistivity not greater than 300 megohms per square.

9.3.14.1.11 Leg belts and lagging shall be fire resistant and oil resistant.

9.3.14.1.11.1 Oil-resistant lagging or belting shall not be required for bucket elevators used in flour mills or for handling inert materials.

9.3.14.1.11.2 Oil-resistant lagging or belting shall not be required for line shaft drives as used in the milling industry.

9.3.14.1.11.3 Belts shall be fire resistant by complying with the requirements of the Mine Safety and Health Administration (MSHA) 2G flame test for conveyor belting in 30 CFR 18, Section 18.65 (July 2006), or the flame test for belting in Part 13.2 of ASTM D378, *Standard Test Methods for Rubber (Elastomeric) Conveyor Belting, Flat Type*.

9.3.14.1.12* Monitors.

9.3.14.1.12.1* Inside legs shall have monitors at head, tail, and knee pulley bearings that indicate high bearing temperature or vibration detection.

9.3.14.1.12.2 Inside legs shall have monitors for head, tail, and knee pulley alignment and belt alignment.

9.3.14.1.12.3 Abnormal conditions shall actuate a visual or an audible and visual alarm requiring corrective action.

9.3.14.1.13 All garners, bins, or other receptacles into which material is spouted directly from legs, and which are not designed with automatic overflow systems, shall be equipped either with devices to shut down equipment or with high-level indicating devices with visual or audible alarms.

Δ **9.3.14.2* Legs Handling Bulk Raw Grain.**

Δ **9.3.14.2.1*** Legs handling bulk raw grain shall be installed either as an outside leg or as an inside leg with compliance with one of the following cases:

(1) Legs are located within 3 m (10 ft) of an exterior wall and are vented as outlined in 9.3.14.2.2 to the outside of the building and designed so that the explosion pressures will not rupture the ductwork or the leg.
(2) Legs are vented in accordance with NFPA 68.
(3) Legs are protected in accordance with NFPA 69.

9.3.14.2.2* All newly installed outside legs shall be provided with explosion relief panels located at intervals no greater than 6 m (20 ft) along the casings as shown in Figure 9.3.14.2.2(a) and Figure 9.3.14.2.2(b).

9.3.14.2.2.1 To minimize personnel exposure, explosion venting for outside legs shall start between 2.5 m to 3.5 m (8 ft to 12 ft) above grade, or the bottom of the explosion vent shall be within 0.3 m to 1 m (1 ft to 4 ft) after the leg penetrates the building roof.

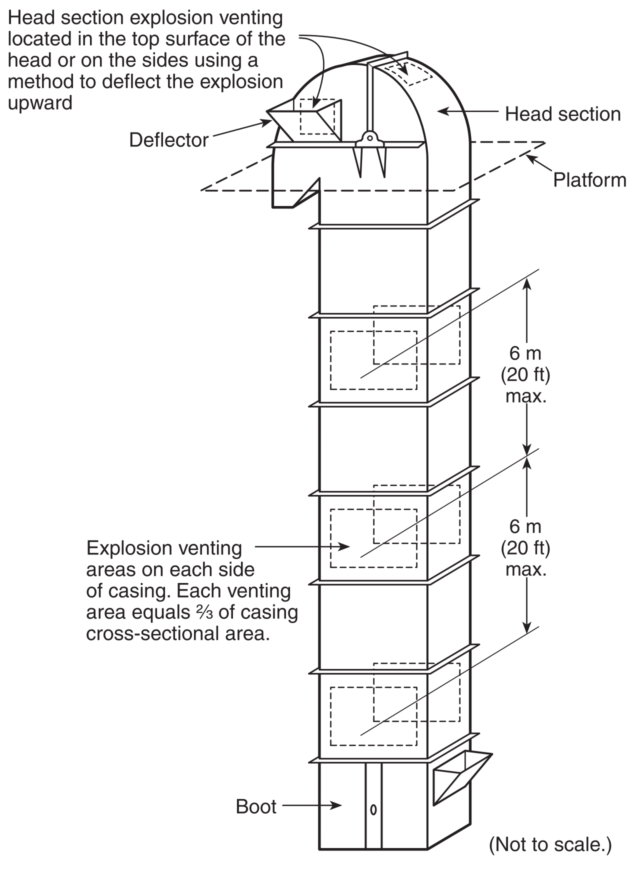
• **9.3.14.2.2.2** Venting shall not be required on portions of outside legs located below grade or passing through ground-level buildings.

9.3.14.2.2.3 Each side vent shall have a minimum area equivalent to two-thirds of the cross-sectional area of the leg casing.

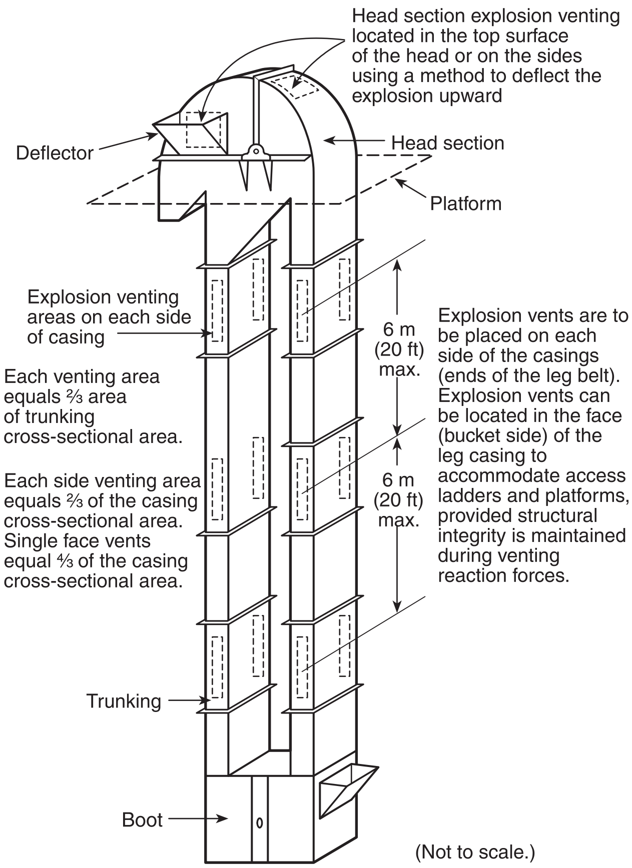
9.3.14.2.2.4 A single face vent shall be permitted to replace a pair of opposing side vents in those portions of a double-casing leg where either of the following situations exists:

(1) Side venting could expose personnel on access ladders or platforms.
(2) Structural interferences are present that would interfere with vent operation.

9.3.14.2.2.5 Single face vents shall be equal to the area of two side vents [four-thirds of the cross-sectional area of the leg casing as indicated in Figure 9.3.14.2.2(b)].



Δ **FIGURE 9.3.14.2.2(a) Typical Elevator Explosion Venting for a Single Casing Leg.**



Δ **FIGURE 9.3.14.2.2(b) Typical Elevator Explosion Venting for a Double Casing Leg.**

9.3.14.2.2.6 The head section of bucket elevators shall be provided with explosion vents in the top surface or on the sides using a method to deflect the explosion upward. The vent area shall be a minimum of 0.14 m^2 (5 ft^2) of vent area per 2.9 m^3 (100 ft^3) of head section volume. The largest vent area as practicable shall be used in the head section to help minimize the development of explosive pressure. Vents shall deploy when an internal pressure of 3.5 kPa to 6.9 kPa (0.5 psi to 1.0 psi) occurs.

9.3.14.2.2.7 Explosion relief panels shall be provided on the leg housing so the ducts will not be a collection point for dust during normal operations.

9.3.14.3 Legs Handling Materials Other Than Bulk Raw Grain That Present an Explosion Hazard.

9.3.14.3.1 Explosion venting of legs into buildings shall not be permitted unless a flame-arresting and particulate retention vent system in accordance with NFPA 68 is used.

9.3.14.3.2* Newly installed outside legs shall be equipped with explosion venting in accordance with 9.3.14.2.2.

9.3.14.3.2.1 The requirement in 9.3.14.3.2 shall not apply to those portions of outside legs, as defined in this standard, below grade or passing through ground-level buildings.

9.3.14.3.3* Legs or portions of legs that are located inside shall have the maximum practicable explosion relief area directly to the outside, a flame-arresting and particulate retention vent system in accordance with NFPA 68, or explosion suppression in accordance with NFPA 69.

9.3.15* Conveyors, Spouts, and Throws of Material.

9.3.15.1* Bulk material conveyor belts shall be designed to either relieve or stop if the discharge end becomes plugged.

9.3.15.2 Bulk material conveyor belts shall have belt alignment and hot bearing sensors at the head and tail.

9.3.15.3 Screw, drag, or en-masse conveyors shall be fully enclosed in metal housings and shall be designed to either relieve or stop if the discharge end becomes plugged.

9.3.15.4* Bulk material conveyor belts and lagging shall have a surface resistivity not greater than 300 megohms per square and shall be fire resistant and oil resistant.

9.3.15.4.1 Belts shall be fire resistant by complying with the requirements of the Mine Safety and Health Administration (MSHA) 2G flame test for conveyor belting in 30 CFR 18, Section 18.65 (July 2006), or the flame test for belting in Part 13.2 of ASTM D378, *Standard Test Methods for Rubber (Elastomeric) Conveyor Belting, Flat Type*.

9.3.15.5 Fixed spouts shall be dusttight.

9.3.15.6* Use of combustible lining shall be permitted in spouts and other handling equipment at impact points and on wear surfaces.

9.3.15.7 Portable, automatic distributing, and movable spouts shall be permitted in work areas, bin areas, and distribution areas and shall be as dusttight as practicable when in use.

9.3.15.8* Spouts that direct material into bins, tanks, or silos shall be designed and installed so that any foreign objects, such as metal or stones, in the material stream do not strike the walls of the container, as far as is practicable.

N **9.3.16 Mixers and Blenders.**

N **9.3.16.1** Mixers and blenders shall be designed to control the release of dust. [**654:**9.3.16.1]

N **9.3.16.2** Foreign materials shall be excluded or removed by magnets/screens as required.

N **9.3.16.3** Clearance and alignment of moving parts in equipment processing combustible particulates shall be checked at intervals established by the owner/operator based on wear experience, unless the equipment is equipped with vibration monitors and alarms, or routine manual monitoring is performed.

N **9.3.16.4** Mixers and blenders shall be made of metal, other noncombustible material, or a material that does not represent an increased fire load beyond the capabilities of the existing fire protection. [**654:**9.3.16.5]

N **9.3.16.5*** Where an explosion hazard exists as described in Chapter 7, protection shall be in accordance with Section 9.7.

N **9.3.16.6** Where a fire hazard exists, protection shall be in accordance with Section 9.8.

9.3.17 Dryers.

9.3.17.1* General Requirements. This section shall apply to grain, commodity product, spray, and starch dryers.

9.3.17.1.1 Dryers, within the scope of this standard, shall function to process materials that are subjected to heated air for the purpose of reducing their moisture content.

9.3.17.1.2* Other dryers used in further processing of agricultural commodities shall be outside the scope of this standard.

9.3.17.1.3* Dryers and auxiliary equipment shall be designed, operated, cleaned, and maintained to minimize combustible accumulations on those inside surfaces intended to be free of grain or product during drying.

9.3.17.1.4 Where an explosion hazard exists, protection shall be in accordance with 9.7.3.1.

9.3.17.2* Grain Dryers.

9.3.17.2.1* Location.

9.3.17.2.1.1 Dryers shall be located so as to minimize fire exposure to adjacent buildings and structures, including other dryers, to minimize ignition potential to operating and storage areas, and to provide access for fire fighting.

9.3.17.2.1.2 Dryers shall not be located inside grain-handling or grain storage structures.

9.3.17.2.2 Construction.

9.3.17.2.2.1 Dryers shall be constructed of noncombustible materials.

9.3.17.2.2.2 Dryers and related equipment shall be designed so that the fire hazard inherent in equipment operating at elevated temperatures is minimized.

9.3.17.2.2.3 Interior surfaces of dryers shall be designed to minimize the accumulation of material and to facilitate cleaning.

9.3.17.2.2.4 Dryers designed to recirculate a portion of the exhaust air shall have a means to minimize entrained particles from being reintroduced into the drying chamber.

9.3.17.2.2.5 Outward opening doors or openings shall be provided to allow access to all parts of the dryer and connecting spouts, inlet or outlet hoppers, and conveyors to permit inspection, cleaning, maintenance, and the effective use of portable extinguishers or hose streams.

9.3.17.2.2.6 In case of fire, dryers shall be designed with means for unloading (emergency dumping) of the dryer contents to a safe outside location in which the location and the manner does not cause fire exposure to adjacent buildings, structures, or equipment.

9.3.17.2.2.7 A method shall be provided for the safe handling of burning material and for the extinguishment of the burning material as it is emptied from the dryer.

9.3.17.2.3 Air Heating Systems.

9.3.17.2.3.1* Air heating systems shall include the heat source and associated piping or wiring and the circulating fan and associated ductwork used to convey the heated air to the dryer.

9.3.17.2.3.2* The air heater and its components shall be selected for the intended application, shall be compatible with the types of fuels to be used, and shall be designed for the temperatures to which they will be subjected.

9.3.17.2.3.3 Direct-fired air heating systems shall have a means to minimize airborne combustible material from entering the drying chamber.

9.3.17.2.3.4 Burner systems and their controls for dryers fired by fuel oil, natural gas, mixed gas, manufactured gas, or liquefied petroleum gas, as well as mixing components, shall comply with NFPA 86.

9.3.17.2.3.5 Liquefied petroleum gas vaporizing burner installations shall comply with NFPA 58.

Δ **9.3.17.2.3.6** Fuel systems, up to the point of connection to the burner, shall comply with the following as applicable:

(1) NFPA 30
(2) NFPA 31
(3) NFPA 54
(4) NFPA 58

9.3.17.2.4 Safety Controls.

9.3.17.2.4.1 Safety controls shall be designed, constructed, and installed such that required conditions of safety for operation of the air heater, the dryer, and the ventilation equipment are maintained.

9.3.17.2.4.2 The dryer and its auxiliary equipment shall be equipped with excess temperature limit controls arranged to supervise both of the following:

(1) Airstream between the fuel burner and the drying chamber air inlet
(2) Airstream at the discharge of the cooling and heating sections

9.3.17.2.4.3 Excessive temperatures detected by devices required by 9.3.17.2.4.2 shall initiate an automatic shutdown.

(A) The automatic shutdown shall accomplish all of the following:

(1) Shut off the fuel or heat to the burners.
(2) Stop the flow of product out of the dryer.
(3) Stop all airflow from fans into the dryer.
(4) Sound an alarm at a constantly-attended location or for the operator, or both, to prompt an emergency response.

(B) An emergency stop shall be provided that will enable manual initiation of the automatic shutdown.

9.3.17.2.4.4 All safety control equipment shall be nonrecycling and shall require manual reset before the dryer can be returned to operation.

9.3.17.2.5 Dryer Operation.

9.3.17.2.5.1 Operating controls shall be designed, constructed, and installed so that required conditions for safe operation of the air heater, dryer, and ventilation equipment are maintained.

9.3.17.2.5.2 The drying chamber shall have an operating control that maintains the temperature within prescribed limits.

9.3.17.2.5.3 Extraneous material that is not normally part of the grain as it is received from the farm and that would contribute to a fire hazard shall be removed before it enters the dryer.

9.3.17.2.6 Fire Detection and Protection.

9.3.17.2.6.1 A fire detection system shall be provided for the dryer when the operation is intermittent during the drying season and the dryer is shut down full or partially full of grain.

(A) The fire detection system shall sound an alarm in a constantly attended location.

(B) The fire detection system shall be permitted to be deactivated when the dryer has been thoroughly emptied and cleaned or when the dryer has been emptied, cleaned, and secured at the end of the drying season.

9.3.17.2.6.2 When operating practices prohibit the retention of any grain in the dryer during intermittent unattended shutdowns, a fire detection system shall not be required.

9.3.17.2.6.3* Means shall be provided for extinguishing fires within the drying chamber.

9.3.17.3 Product Dryers.

9.3.17.3.1 Drying units shall be equipped with remote power cutoff switches.

9.3.17.3.2 On direct-fired dryers, the air supply shall be filtered of all particles that could be a combustion hazard.

Δ **9.3.17.3.3** Fuel systems, up to the point of connection to the dryer burner, shall comply with the following as applicable:

(1) NFPA 30
(2) NFPA 31
(3) NFPA 54
(4) NFPA 58

9.3.17.3.4 Direct-fired dryers with an explosion hazard located within buildings shall be protected in accordance with 9.7.3.1.

9.3.17.3.5 The combustion and burner system and controls shall be designed, operated, and tested as required in NFPA 86.

9.3.17.4 Starch Dryers.

9.3.17.4.1 General. Starch dryers shall be designed and located in accordance with the requirements of 9.3.17.2.1 through 9.3.17.2.2.7.

9.3.17.4.2 Ignition Sources.

9.3.17.4.2.1* The interior heated surface of a starch dryer shall be designed and maintained to prevent the accumulation of starch that can attain a thickness or depth of 13 mm (½ in.) or more.

9.3.17.4.2.2* Inspection and clean-out doors shall be located at points in the system where spontaneous ignition is likely to occur, specifically where starch can build up and where starch is subject to continuous heat.

9.3.17.4.2.3 Inspection and cleaning of the areas in 9.3.17.4.2.1 and 9.3.17.4.2.2 shall be performed to minimize starch accumulations.

9.3.17.4.2.4 The combustion and burner systems and controls shall be designed, operated, and tested as required in NFPA 86.

9.3.17.4.3 Fire Detection, Alarm, and Interlocking Systems.

9.3.17.4.3.1 Every dryer shall have the means for detecting abnormal conditions that indicate the presence or potential of a fire.

(A) The detection of these conditions shall activate an alarm and automatically shut down the equipment and activate the extinguishing system.

(B) The design of an automatically-operated extinguishing system shall include provisions for the necessary personnel protective features required for inspection and cleaning of the dryers.

9.3.17.4.3.2 The dryer system, including auxiliary ducts, fans, and conveyors, shall be interlocked to provide a safe and orderly shutdown in the event of mechanical failure or abnormal operating conditions.

9.3.17.4.4 Suppression and Extinguishing Systems.

9.3.17.4.4.1* Each dryer located inside a building shall be protected by a permanently installed fire protection system, explosion suppression system, or both, in accordance with applicable NFPA standards.

(A) The system shall be actuated by fire or explosion detection devices that will sound an alarm and sequentially shut down the dryer.

(B) The fire extinguishing system shall be capable of manual actuation from locations that will be accessible during a fire in the dryer.

(C) The dryer shall not be returned to production until the fire protection or explosion suppression system has been restored.

9.3.17.4.4.2 Piping for extinguishing systems shall be located to minimize the possibility of destruction in case of an explosion.

9.3.17.4.4.3 The water supply for fire protection to buildings subject to explosion hazards shall be sectionalized in such a way that a water line break from an explosion can be readily isolated.

Δ **9.3.17.5 Spray Dryer Systems.**

N **9.3.17.5.1 General.**

N **9.3.17.5.1.1** Spray dryer systems shall include the spray dryer and associated fluid bed dryers, cyclones, and dust collectors with the connecting duct work.

N **9.3.17.5.1.2** A DHA, in accordance with Chapter 7, shall be performed on all spray dryer systems.

N **9.3.17.5.1.3** The DHA shall address the proper sequence of startup, shutdown, emergency stop, and normal operation.

N **9.3.17.5.1.4** Spray dryers shall be designed and located in accordance with the requirements of 9.3.17.2.1 through 9.3.17.2.2.7.

N **9.3.17.5.2 Safety Controls.**

N **9.3.17.5.2.1** Safety controls shall be designed, constructed, and installed such that required conditions of safety for operation of the air heater, dryer, and ventilation equipment are maintained.

N **9.3.17.5.2.2** The dryer and its auxiliary equipment shall be equipped with excess temperature limit controls arranged to supervise following:

(1) Airstream between the air heater and the drying chamber air inlet
(2) Airstream at the discharge of the cooling and heating sections

N **9.3.17.5.2.3** Excessive temperatures detected by devices required by 9.3.17.5.2.2 shall initiate an automatic shutdown.

N **(A)** The automatic shutdown shall accomplish all of the following:

(1) Shut off the fuel to the burners or heating system.
(2) Stop the flow of product out of the dryer.
(3) Stop all airflow from fans into the dryer.
(4) Sound an alarm at a constantly attended location or for the operator, or both, to prompt an emergency response.

N **(B)** An emergency stop shall be provided that will enable manual initiation of the automatic shutdown.

N **9.3.17.5.2.4** All safety control equipment shall be nonrecycling, requiring manual reset before the dryer can be returned to operation.

N **9.3.17.5.3 Dryer Operation.**

N **9.3.17.5.3.1** Operating controls shall be designed, constructed, and installed so that required conditions of safety for operation of the air heater, dryer, and ventilation equipment are maintained.

N **9.3.17.5.3.2** The drying chamber shall have an operating control that maintains the temperature within prescribed limits.

N **9.3.17.5.4 Fire Detection.**

N **9.3.17.5.4.1** Every dryer shall have the means for detecting abnormal conditions that indicate the presence or potential of a fire.

N **9.3.17.5.4.2** The detection of the conditions in 9.3.17.5.4.1 shall activate an alarm and automatically shut down the equipment.

N **9.3.17.5.4.3*** Means shall be provided for extinguishing fires within the drying chamber.

N **9.3.17.5.5 Explosion Protection.**

N **9.3.17.5.5.1** Spray dryer systems shall be protected in accordance with 9.7.3.1 unless a documented risk assessment determines a different level of protection is required.

N **9.3.17.5.5.2** Where installed, the explosion protection system shall be connected to the process control system. On a signal from the explosion control system, the process shall be shut down automatically.

N **9.3.17.5.5.3** Where required, the explosion protection system shall be designed in accordance with NFPA 69 or NFPA 68, or a combination of the two as determined appropriate by the DHA.

N **9.3.17.5.5.4** CO differential early fire detection and suppression systems shall be allowed as a tool to prevent deflagrations from occurring per the requirements of NFPA 69.

N **9.3.17.5.5.5** Where installed, the explosion protection system shall be permitted to be deactivated automatically during clean-in-place functions.

N **9.3.18 Transfer Points. (Reserved)**

9.3.19 Heat Transfer Operations.

9.3.19.1* Heat Transfer Systems.

9.3.19.1.1 Heat transfer devices utilizing air, steam, or vapors of heat transfer fluids shall be provided with pressure-relief valves where necessary.

9.3.19.1.1.1 Relief valves on systems employing combustible heat transfer media shall be vented to a safe outside location.

9.3.19.1.2 Heaters and pumps for combustible heat transfer fluids shall be located in a separate, dust-free room or building of noncombustible construction.

9.3.19.1.2.1 Buildings or rooms that contain heaters and pumps for combustible heat transfer fluids shall be protected by automatic sprinklers designed in accordance with NFPA 13 to control a fire involving the combustible heat transfer fluid.

9.3.19.1.2.2 Air for combustion shall be taken from a clean outside source.

9.3.19.1.2.3* Buildings or rooms that contain heat transfer equipment and boilers that use combustible heat transfer fluids shall be located in separate areas such that they do not communicate directly with areas that contain a dust explosion hazard.

9.3.19.1.2.4 Where combustible heat transfer fluids are used, doorways shall be curbed or ramped and floor drains shall be provided to direct spills of the heat transfer fluid to a safe location.

(A) Automatic sprinkler protection designed to control these fluid fires shall be provided in areas containing equipment that uses these fluids and in areas containing storage tanks for these fluids.

9.3.19.1.3 Enclosures for heat exchangers shall be constructed of noncombustible materials and shall have access openings for cleaning and maintenance.

9.3.19.1.4* Heat exchangers shall be located and arranged in a manner that does not allow combustible dust to accumulate on coils, fins, or other heated surfaces.

9.3.19.1.5 Heaters for heat transfer systems shall be provided with operating controls in accordance with NFPA 86.

Δ **9.3.19.2 Comfort Heating.**

9.3.19.2.1 In areas containing combustible dust, comfort heating, if provided, shall be appropriately rated for the area as defined in *NFPA 70*.

Δ **9.3.19.2.2** Boilers used to provide hot water or low-pressure steam for comfort heating shall be located in a nonhazardous area and shall be installed in accordance with the requirements of 9.3.19.1.2.

9.3.19.2.3 Steam or hot water supply pipes and hot air supply ducts to comfort areas shall be fitted with insulation having a continuous, nonporous covering and an insulation quality sufficient to keep the temperatures of the outer surface below 60°C (140°F) for personnel safety purposes and less than 121°C (250°F) for prevention of dust ignition.

9.3.20 Ventilation and Venting.

9.3.20.1 General.

9.3.20.1.1 In this section, ventilation shall refer to natural or mechanical movement of air necessary for normal operation and personnel comfort and safety.

9.3.20.1.2 Recirculating or recycling exhaust air ventilation systems for dust explosion hazard areas, if used, shall be equipped with filter systems capable of removing dust from the air.

9.3.20.1.3 Dust collection systems used in conjunction with ventilation systems shall comply with the provisions of 9.3.3.5 of this standard.

9.3.20.2 Venting of Bins, Tanks, and Silos.

9.3.20.2.1 The requirements for air displacement shall be as follows:

(1) Each bin, tank, or silo shall be provided with means for air displacement during filling or emptying.
(2) Displaced air shall not be discharged to the building atmosphere unless it is cleaned with a filter having a minimum efficiency of 0.02 g per dry standard cubic meter of airflow (0.008 grains per dry standard cubic foot of airflow).

9.3.20.2.2* Vents shall be designed to prevent plugging due to accumulations of dust.

9.3.20.2.3 Inclined vent stacks shall have clean-out doors or panels.

9.3.20.2.4 Bin vents shall be sized to handle the air displaced by either filling or emptying.

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9.3.21 Processing Machinery and Equipment.

9.3.21.1* General.

9.3.21.1.1 Receiving systems prior to the leg shall be equipped with one or more devices such as grating, wire mesh screens, permanent magnets, listed electromagnets, pneumatic separators, or specific gravity separators, to minimize or eliminate tramp material from the product stream.

9.3.21.1.1.1 Barge and ship receiving systems using legs as the primary reclaiming systems shall be allowed to have the tramp material protection after the unloading leg but prior to being handled in another leg or processing equipment.

9.3.21.1.2* Where tributary spouts or conveyors feed whole grain or grain products for size reduction into grinders, pulverizers, or rolling mills, they shall be equipped with properly installed permanent magnets or listed electromagnets, pneumatic separators, specific gravity separators, scalpers, or screens to exclude metal or foreign matter of a size larger than the grain being processed as far as is practicable.

9.3.21.1.3* Equipment shall be bonded and grounded to dissipate static electricity.

9.3.21.1.4 All processing machinery and components, such as magnets, shall be mounted to facilitate access for cleaning.

9.3.21.1.4.1 The requirement in 9.3.21.1.4 shall not apply where processing machinery is mounted on a tight-fitting base that prevents material from reaching inaccessible places beneath the machine.

9.3.21.1.5 Screw, drag, or en-masse conveyors shall be fully enclosed in metal housings and shall be designed to either relieve or stop if the discharge end becomes plugged.

9.3.21.2 Starch Processing Machinery and Equipment.

9.3.21.2.1 Carbon steel shall be avoided in the grinding chambers and moving parts of grinding mills in favor of brass, bronze, stainless steel, and other metals with lower sparking potential.

9.3.21.2.2 The reels or sieves of screens, scalpers, and similar devices shall be in dusttight enclosures.

9.3.21.2.3 Connecting ducts shall be one of the following:

(1) Metal
(2) Electrically conductive nonmetallic flexible connecting ducts having an electrical resistance not greater than 1 megohm

9.3.21.2.3.1 The requirement in 9.3.21.2.3 shall not apply to plastic tubing used for sample delivery systems.

9.3.21.2.4 Where more than one material source is connected to a common conveyor, air-material separator, or similar device, each source that is connected shall be equipped with a method to prevent propagation of a deflagration in accordance with NFPA 69.

9.3.21.2.5 Dry milling or grinding of starch shall be performed in a separate building with explosion relief or in a separate room isolated from other areas by interior walls designed according to 9.2.2.2.

9.3.21.2.5.1 The requirement in 9.3.21.2.5 shall not apply if the equipment can be designed to be protected in accordance with NFPA 69 by deflagration containment, explosion suppression, or inerting the volume to reduce oxygen such that combustion is not supported.

9.3.21.2.5.2 The requirement in 9.3.21.2.5 shall not apply if mills are provided with explosion venting to a safe outside location. If explosion vents ducts longer than 3 m (10 ft) are to be used, the milling equipment and explosion vent duct shall be designed to withstand the increased vented explosion pressure.

9.4 Ignition Source Control.

N **9.4.1* Retroactivity.** Unless otherwise specified, the requirements of Section 9.4 shall be applied retroactively. [**652:**9.4.1]

N **9.4.2* Risk Assessment.** A documented risk assessment shall be permitted to be conducted to determine the level of ignition source control to be provided including, but not limited to, the controls addressed in Section 9.4.

N **9.4.3 Hot Work. (Reserved)**

N **9.4.4 Hot Surfaces. (Reserved)**

9.4.5 Bearings.

9.4.5.1 Antifriction bearings shall be used on all machinery, conveyors, legs, and processing equipment.

9.4.5.1.1 Sleeve and friction-type bearings, plastic bearings, or oil-impregnated wood bearings shall be permitted for equipment operating at 150 rpm or less.

9.4.5.2 All bearings shall be maintained per manufacturers' recommendations and shall be kept free of dust, product, and excessive lubricant.

9.4.5.3 If a bearing is directly exposed to a combustible dust atmosphere that poses a deflagration hazard or is subject to dust accumulation that poses a deflagration hazard, the bearing shall be monitored for overheating by automated equipment, installed devices, or periodic manual checks on a frequency established by the owner/operator.

9.4.5.4* All bearings on legs and conveyors shall be located outside of machinery enclosures and isolated from the product stream to minimize exposure to dust and to be more accessible for inspection and service.

9.4.5.4.1 Antifriction support bearings on screw conveyors and similar equipment requiring bearings to be within the product stream shall be of the sealed type.

9.4.5.4.2 Sleeve and friction-type bearings shall be permitted for equipment operating at 150 rpm or less.

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9.4.6 Electrical Wiring and Equipment.

9.4.6.1 Electrical wiring and equipment shall comply with *NFPA 70*.

9.4.6.2* Electrical wiring and equipment in areas meeting the definition of Class II, Group G, Division 1 or 2 according to Article 500 of *NFPA 70* shall comply with Article 502 of *NFPA 70*.

9.4.6.2.1 The requirement in 9.4.6.2 shall not apply to electrical equipment that has been listed and installed as intrinsically safe according to Article 504 of *NFPA 70*.

9.4.6.2.2 The requirement in 9.4.6.2 shall not apply to electrical equipment that is housed in an enclosure that meets the applicable requirements of NFPA 496.

9.4.7* Electrostatic Discharges. Static electricity shall be dissipated by using bonding and grounding.

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N **9.4.8 Open Flames and Fuel-Fired Equipment. (Reserved)**

9.4.9 Engine-and Motor-Driven Equipment.

9.4.9.1 Engine- and motor-driven equipment used in confined Class II, Group G, Division 2 operating areas shall be equipped with safety devices designed to reduce the potential fire hazard and electrical shock hazard.

9.4.9.2* Engine- and motor-driven equipment shall meet the requirements of NFPA 505.

9.4.9.2.1 Front-end loaders or similar equipment used in flat storage areas or marine vessels to handle grain, meal, hulls, or other agricultural commodities shall not be required to meet the requirements of NFPA 505.

9.4.9.3 Spark arresters shall be used on the exhaust stacks of all diesel-powered units.

9.4.9.3.1 The requirement in 9.4.9.3 shall not apply to engines equipped with turbo-chargers.

9.4.9.3.2 The requirement in 9.4.9.3 shall not apply to road vehicles, such as grain delivery vehicles, locomotives, and other vehicles that do not operate in combustible dust-producing areas.

9.4.9.4* Refueling shall be conducted outdoors.

9.4.9.5* Surface dust shall be removed from engine- and motor-driven equipment at regular intervals during operation.

9.4.9.5.1 Cleaning of front-end loaders or other motor-driven equipment with compressed air shall not be conducted in hazardous locations.

9.4.9.5.2 Spark arresters shall be cleaned or replaced according to the manufacturer's recommendation.

9.4.9.6 Maintenance procedures shall comply with the manufacturer's instructions regarding replacement of insulation, covers, electrical enclosures, and parts of the electrical system designed to reduce chafing of insulation or termination failure.

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N **9.4.10 Process Air and Media Temperatures. (Reserved)**

N **9.4.11 Self-Heating. (Reserved)**

N **9.4.12 Friction and Impact Sparks. (Reserved)**

9.4.13 Smoking.

9.4.13.1* Smoking shall be permitted only in designated areas.

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9.4.14 Drive Belts.

9.4.14.1 Where a drive belt is used, the drive train shall be designed with a minimum service factor of 1.5 or higher if the manufacturer of the drive components recommends a higher service factor for continuous service for the type of equipment to be driven.

9.4.14.1.1 The requirement in 9.4.14.1 shall not apply to line shaft drives as used in the milling industry.

N **9.5 Pyrophoric Dusts. (Reserved).**

9.6 Dust Control.

9.6.1* General. Dust control as used in this chapter shall be the control of emission of airborne combustible dusts from process and conveying equipment or material transfer points.

9.6.2 Dust Emissions.

9.6.2.1* A method shall be used to prevent the escape of dust from process equipment into the surrounding environment.

9.6.2.1.1* Suppressants shall be permitted to be used for dust control.

9.6.2.1.2 In grain elevators, a method to prevent the escape of dust into surrounding areas shall be provided at leg boot sections, belt loaders, belt discharge or transfer points, trippers, turnheads, or distributors, and on unfiltered vents from which dust could be emitted into interior areas with displaced air.

9.6.2.1.3 Packaging and weighing systems, including fixed-scale hoppers and upper and lower bins and garners, shall be enclosed and equipped with a venting system or air aspiration to collect the dust normally emitted by rapid air displacement during filling and emptying, if necessary.

9.6.2.1.4 All machinery such as cleaners, scalpers, and similar devices normally used inside structures but not designed to be dusttight shall be provided with a means of controlling combustible dusts, if present.

9.6.2.2* Collected grain dust shall be permitted to be returned to the grain stream prior to or after being handled in a leg. Dust alone shall not be added directly to the leg and handled by itself. However, dust shall be permitted to be handled in an outside located leg that is used as part of a dust loadout system.

9.6.2.3 Dust returned to handling equipment other than a leg, storage, or process shall be returned downstream of the collection point in such a manner that it will not create dust emissions.

Δ **9.6.2.4*** A point-of-use dust collector shall be permitted to be mounted directly to conveying equipment in both indoor and outdoor locations, provided all of the following conditions are met:

(1) When the point-of-use dust collector is mounted to an enclosure, such as a bucket elevator leg, the enclosure shall have explosion protection per the provisions of this standard. The volume of the dirty air side and of the transition shall be included in the determination of explosion protection design.
(2) The point-of-use dust collector shall be mounted directly to the conveying equipment housing via a transition duct without an airlock.
(3) The transition between the point-of-use dust collector and the vented equipment shall be designed such that dust will release from the filter media and return to the equipment product stream and the transition is not a collection point for dust accumulation under normal operations.
(4) The cross-sectional area of the transition connection shall be equal to or greater than the cross-sectional area of the point-of-use dust collector.
(5) The point-of-use dust collector shall include an integral air-moving device on the clean side of the dust collector to maintain negative pressure.
(6) The point-of-use dust collector shall not be connected to any other pieces of equipment.
(7)* Point-of-use dust collectors that return air to the inside of buildings shall be capable of a minimum filtering efficiency of 0.02 g per dry standard cubic meter of airflow (0.008 grains per dry standard cubic foot of airflow).

N **9.6.3 Fans for Continuous Dust Control. (Reserved)**

9.7 Explosion Prevention/Protection.

9.7.1* General. Explosion prevention, relief, and venting, as used in this standard, shall encompass the design and installation of devices and systems to vent the gases and overpressure resulting from a deflagration occurring in equipment, rooms, buildings, or other enclosures so that damage is minimized.

9.7.1.1* Enclosure Requirements.

9.7.1.1.1* If a dust explosion hazard exists in rooms, buildings, or other enclosures under normal operating conditions, such areas shall be provided with explosion relief venting distributed over the exterior walls (and roof, if applicable) in accordance with NFPA 68.

9.7.1.1.1.1 The design of such explosion relief venting shall consider the limitations imposed by the structural design of the area.

9.7.1.1.1.2 The design shall offer the least possible resistance to explosion pressures.

9.7.1.1.1.3* Explosion relief panels, windows, or other venting devices shall be designed to prevent reclosing after relieving the explosion pressure and shall be attached to retention cables or restrained by equivalent means such that they will not become a hazardous projectile upon relief.

9.7.1.1.1.4 The requirement in 9.7.1.1.1 shall not apply to tunnels and pits where explosion venting is not practical due to confinement by soil, building constraints, or both.

Δ **9.7.2 Risk Assessment.** A documented risk assessment shall be permitted to be conducted to determine the level of protection to be provided, including, but not limited to, the measures addressed in Section 9.7.

9.7.3 Equipment Protection.

9.7.3.1* Equipment Requirements.

Δ **9.7.3.1.1** Equipment requiring explosion prevention shall be protected by one of the following:

(1) Oxidant concentration reduction in accordance with NFPA 69
    (a) Where oxygen monitoring is used, it shall be installed in accordance with ANSI/ISA 84.00.01, *Functional Safety: 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 in accordance with NFPA 68
(3) Deflagration pressure containment in accordance with NFPA 69
(4) Deflagration suppression systems in accordance with NFPA 69
(5) Dilution in accordance with NFPA 69
(6)* Dilution with a noncombustible dust to render the material noncombustible
(7)* Deflagration venting through a listed dust retention and flame-arresting device

9.7.3.1.1.1 If the method in 9.7.3.1.1(6) is used, test data for specific dust and diluent combinations shall be provided and shall be acceptable to the authority having jurisdiction.

9.7.3.1.2* The requirement in 9.7.1.1.1 shall not apply to bins and silos where explosion venting is not practical due to bin or silo geometry, building constraints, or both.

9.7.4 Equipment Isolation.

9.7.4.1* Isolation of Equipment.

Δ **9.7.4.1.1** Where a DHA has determined that isolation is necessary, isolation shall be provided to prevent deflagration propagation between connected equipment in accordance with NFPA 69.

9.7.4.1.2 Isolation devices shall not be required where oxidant concentration in the connected equipment has been reduced in accordance with 9.7.3.1.1(1) or when the dust has been rendered noncombustible in accordance with 9.7.3.1.1(6).

9.7.4.2* Deflagration Isolation of Upstream Areas.

Δ **9.7.4.2.1*** Where a DHA has determined that isolation is required, isolation shall be provided to prevent deflagration propagation from equipment through upstream ductwork to the work areas in accordance with NFPA 69.

9.7.4.3* Explosion venting shall be directed to a safe, outside location away from platforms, means of egress, or other potentially occupied areas or directed through a listed flame arresting and particulate retention device.

9.8 Fire Protection.

Δ **9.8.1 General.** Where installed, supervisory services shall comply with *NFPA 72*.

9.8.2 Reserved.

9.8.3 Fire Extinguishers.

9.8.3.1* Portable Fire Extinguishers. Portable fire extinguishers shall comply with NFPA 10.

9.8.4 Hose, Standpipes, Hydrants, and Water Supply.

9.8.4.1 Standpipe and Hose.

9.8.4.1.1 Standpipes and hoses, where installed, shall comply with NFPA 14.

9.8.4.1.2* Wet or dry standpipes shall be provided to all operating areas of head houses, processing structures with operating areas, and grain bin galleries located over 15 m (50 ft) above grade.

9.8.4.1.3* Wet or dry standpipes shall be installed in warehouses and packing areas with combustible contents where required by the AHJ.

9.8.4.1.3.1 The requirement in 9.8.4.1.3 shall not apply to bulk storage warehouses.

9.8.5 Automatic Sprinklers. Where installed, automatic sprinklers shall comply with NFPA 13.

9.8.5.1 Maintenance. Water-based extinguishing systems shall be maintained in accordance with NFPA 25.

9.8.6 Spark/Ember Detection and Extinguishing Systems. Where provided, spark/ember detection and extinguishing systems shall be designed, installed, and maintained in accordance with NFPA 15, NFPA 69, and *NFPA 72*. [**652:**9.8.6]

N **9.8.7 Special Fire Protection Systems. (Reserved)**

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.2 This standard is voluntary and follows the accredited NFPA practices. Public authorities with lawmaking or rule-making powers who are considering adoption of this standard should do so in a manner consistent with NFPA licensing provisions and should undertake an appropriate rule-making process consistent with the jurisdiction.

A.1.3.1 Examples of facilities covered by this standard include, but are not limited to, bakeries, grain elevators, feed mills, flour mills, milling, corn milling (dry and wet), rice milling, dry milk products, mix plants, soybean and other oilseed preparation operations, cereal processing, snack food processing, tortilla plants, chocolate processing, pet food processing, cake mix processing, sugar refining and processing, and seed plants.

A.1.4 The intent of the NFPA 61 committee is to address the essential requirements of NFPA 652 so that the user can rely primarily on NFPA 61.

A.1.6 This standard permits the use of performance-based design options. Guidelines on performance-based design options for combustible dust hazards can be found in Chapter 6 of this standard.

A.1.7.2 A given equivalent value could be approximate. [**652:**A.1.7.2]

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.2.4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A.3.3.1 Agricultural Combustible Dust. Typically, agricultural combustible dust is material 500 μm or smaller in diameter or 500 μm or smaller in one dimension that has a K_{St} less than 200, a minimum ignition energy (MIE) greater than 30 mJ, a P_{max} less than 10 bar, and a minimum explosible concentration (MEC) greater than 40 g/m^3 when suspended or dispersed in air. Data for typical agricultural dust can be found in A.5.2.2.

Δ **A.3.3.2 Air-Material Separator (AMS).** Examples include the following:

(1) Cyclonic separator (cyclone) — a device utilizing centrifugal forces and geometry to separate the conveying air/gas from the majority of the conveyed material. The efficiency of this separation is based upon many factors such as the geometry of the cyclone, material particle size and density, and air/gas mass flow. Generally, this unit is considered only an initial or primary separator, and additional separation devices are applied to meet air pollution control requirements.
(2) Dust collector — a device utilizing filter media to separate fine dust particles from the conveying air/gas stream. Such devices often have automatic methods for continuous filter cleaning in order to maintain the operational efficiency of the device. Typically the filter medium is either cartridges or bags. The operating pressure of this device is usually limited by its shape and physical construction.
(3) Filter receiver — similar to a dust collector but designed for higher differential pressure applications.
(4) Scrubber — a device utilizing geometry, physical barriers, and/or absorption methods, along with a fluid (e.g., sprays and streams) to separate and collect gases and/or dusts.
(5) Electrostatic precipitator — a device that utilizes differences in electrical charges to remove fine particulates from the air stream.
(6) Final filter — a high-efficiency device commonly utilizing a pre-filter and a secondary filter within an enclosure to provide the last particulate removal step before the air is discharged from the system. Final filters are commonly used when the air stream is recirculated to occupied areas. This device can provide protection against the failure of a dust collector or filter receiver upstream of the device. A high efficiency particulate air (HEPA) filter is an example.

[**654**, 2020]

Δ **A.3.3.3 Air-Moving Device (AMD).** An air-moving device is a fan or blower. A general description of each follows:

(1) Fans
   (a) A wide range of devices that utilize an impeller, contained within a housing, that when rotated create air/gas flow by negative (vacuum) or positive differential pressure.
   (b) These devices are commonly used to create comparatively high air/gas volume flows at relatively low differential pressures.
   (c) These devices are typically used with ventilation and/or dust collection systems.
   (d) Examples are centrifugal fans, industrial fans, mixed or axial flow fans, and inline fans.
(2) Blowers
   (a) A wide range of devices that utilize various-shaped rotating configurations, contained within a housing, that when rotated create air/gas flow by negative (vacuum) or positive differential pressure.
   (b) These devices are commonly used to create comparatively high differential pressures at comparatively low air/gas flows.
   (c) The most common use of these devices are with pneumatic transfer, high-velocity, low volume (HVLV) dust collection, and vacuum cleaning systems.
   (d) Examples are positive displacement (PD) blowers, screw compressors, multi-stage centrifugal compressors/blowers and regenerative blowers.

[**652,** 2019]

A.3.3.6 Bulk Raw Grain. Cleaning or drying does not constitute processing.

A.3.3.7 Centralized Vacuum Cleaning System. This system normally consists of multiple locations, known as hose connection stations, hard-piped to an air-material separator, using an air-moving device to provide the vacuum and induced air flow. The hoses and vacuum cleaning tools utilized with the system are designed to be static conductive and dissipative in order to minimize any risk of generating an ignition source. Low minimum ignition energy (MIE) materials will require special consideration in the system design and use. A primary separator can also be used if large quantities of materials are involved. However, most secondary AMS units are capable of handling the dusts without the addition of a primary cyclone.

A.3.3.9 Deflagration. The primary concern of this document is a deflagration that produces a propagating flame front or pressure increase that can cause personnel injuries or the rupture of process equipment or buildings. Usually these deflagrations are produced when the fuel is suspended in the oxidizing medium. [**654,** 2020]

A.3.3.11 Dust Collection System. A typical dust collection system consists of the following:

(1) Hoods — devices designed to contain, capture, and control the airborne dusts by using an induced air flow in close proximity to the point of dust generation (local exhaust zone) to entrain fugitive airborne dusts.
(2) Ducting — piping, tubing, fabricated duct, etc., used to provide the controlled pathway from the hoods to the dust collector (AMS). Maintaining adequate duct velocity (usually 4000 fpm or higher) is a key factor in the proper functioning of the system.
(3) Dust collector — an AMS designed to filter the conveyed dusts from the conveying air stream. Usually these devices have automatic methods for cleaning the filter media to allow extended use without blinding. In some systems, a scrubber or similar device is used in place of the filter unit.
(4) Fan package — an AMD designed to induce the air flow through the entire system.

[**654,** 2020]

The system is designed to collect only suspended dusts at the point of generation and not dusts at rest on surfaces. The system is also not designed to convey large amounts of dusts as the system design does not include friction loss due to solids loading in the pressure drop calculation. Thus, material loading must be minimal compared to the volume or mass of air flow. [**654,** 2020]

A.3.3.12 Dust Hazard Analysis (DHA). In the context of this definition, it is not intended that the dust hazards analysis (DHA) must comply with the process hazards analysis (PHA) requirements contained in OSHA regulation 29 CFR 1910.119, "Process Safety Management of Highly Hazardous Chemicals." While the DHA can comply with OSHA PHA requirements, other methods can also be used *(see Annex B of NFPA 652)*. However, some processes might fall within the scope of OSHA regulation 29 CFR 1910.119, and there could be a legal requirement to comply with that regulation. [**652,** 2019]

A.3.3.13 Enclosure. Examples of enclosures include a room, building, vessel, silo, bin, pipe, or duct. [**68,** 2013]

A.3.3.14 Explosion. For the purposes of this standard, the term *explosion* is equivalent to the term *deflagration* as identified in NFPA 68.

Δ **A.3.3.17 Flexible Intermediate Bulk Container (FIBC).** FIBCs are usually made from nonconductive materials. Electrostatic charges that develop as FIBCs are filled or emptied can result in electrostatic discharges, which might pose an ignition hazard for combustible dust or flammable vapor atmospheres within or outside the bag. The four types of FIBCs — Type A, Type B, Type C, and Type D — are based on their characteristics for control of electrostatic discharges. [**652,** 2019]

Δ **A.3.3.24 Minimum Explosible Concentration (MEC).** Minimum explosible concentration is defined by the test procedure in ASTM E1515, *Standard Test Method for Minimum Explosible Concentration of Combustible Dusts*. MEC is equivalent to the lower flammable limit for flammable gases. Because it has been customary to limit the use of the lower flammable limit to flammable vapors and gases, an alternative term is necessary for combustible dusts. [**652,** 2019]

The MEC is dependent on many factors, including particulate size distribution, chemistry, moisture content, and shape. Consequently, designers and operators of processes that handle combustible particulate solids should consider those factors when applying existing MEC data. Often, the necessary MEC data can be obtained only by testing. [**652,** 2019]

Δ **A.3.3.25 Minimum Ignition Energy (MIE).** The standard test procedure for MIE of combustible particulate solids is ASTM E2019, *Standard Test Method for Minimum Ignition Energy of a Dust Cloud in Air,* and the standard test procedure for MIE of flammable vapors is ASTM E582, *Standard Test Method for Minimum Ignition Energy and Quenching Distance in Gaseous Mixtures*. [**652,** 2019]

A.3.3.28 Pneumatic Conveying System. Generically, pneumatic conveying systems include a wide range of equipment systems utilizing air or other gases to transport solid particles from one point to another. Pneumatic conveying systems typically require a device to meter the material into the conveying system which is significantly different from the function of a dust collection system or central vacuum cleaning system. Pneumatic systems can also convey comparatively large masses of materials when compared to a dust collection system, where the mass of the dust (and resulting energy loss) is not normally considered in the design of the system.

Pneumatic conveying systems present a lower hazard than fugitive dust collectors and centralized vacuum systems. Pneumatic conveying systems allow greater control of the risk factors associated with combustible dusts, such as ignition sources. For this reason, the prescriptive requirements of this standard are different for pneumatic conveying systems.

A.3.3.32 Risk Assessment. A risk assessment is a process that performs the following:

(1) Identifies hazards
(2) Quantifies the consequences and probabilities of the identified hazards
(3) Identifies hazard control options
(4) Quantifies the effects of the options on risks of the hazards
(5) Establishes risk tolerance criteria (i.e., maximum tolerable levels of risk)
(6) Selects the appropriate control options that meet or exceed the risk acceptability thresholds

Items 1 through 3 are typically performed as part of a dust hazards analysis (DHA). [**652,** 2019]

Risk assessments can be qualitative, semi-quantitative, or quantitative. Qualitative methods are used to identify the most hazardous events. Semi-quantitative methods are used to determine relative hazards associated with unwanted events and are typified by indexing methods or numerical grading. Quantitative methods are the most extensive and use a probabilistic approach to quantify the risk based on both frequency and consequences. [**652,** 2019]

See SFPE *Engineering Guide to Fire Risk Assessment*, or AIChE *Guidelines for Hazard Evaluation Procedures,* for more information. [**652,** 2019]

Δ **A.4.1** Materials such as field dirt, limestone, and rock are not combustible.

A.4.1.3 Combustible particulate solids and dust hazard identification, assessment, and mitigation should address known hazards, including the following:

(1) Reactivity hazards (e.g., binary compatibility or water reactivity)
(2) Smoldering fire in a layer or pile
(3) Flaming fire of a layer or pile
(4) Deflagration resulting in flash fire (dust cloud combustion)
(5) Deflagration resulting in dust explosion in equipment
(6) Deflagration resulting in dust explosion in rooms and buildings

A.4.2.1.4 The AHJ is not considered qualified to add specific requirements and changes to food safety activities, food safety programs such as sanitation programs, or grain elevator standard generated plants.

A.4.2.3 Other stakeholders could also have mission continuity goals that necessitate more stringent objectives and more specific and demanding performance criteria. The protection of property, beyond maintaining structural integrity long enough to escape, is a mission continuity objective.

A.4.2.4 The intent is to prevent the collapse of the structure during the fire or explosion.

A.4.2.5 A facility or process system is usually designed using the prescriptive criteria until a prescribed solution is found to be infeasible or impracticable. The designer can then use the performance-based option to develop a design, addressing the full range of fire and explosion scenarios and the impact on other prescribed design features. Consequently, facilities are usually designed not by using only performance-based methods for all facets of the facility, but rather by using a mixture of both approaches as needed.

Δ **A.5.2** Testing actual material from a specific process or area of the facility will result in the most accurate results for the DHA, performance-based design, and hazard management options. Testing is not required to determine whether the material has combustibility characteristics where reliable, in-house, commodity-specific testing data or published data of well-characterized samples (i.e., particle size, moisture content, and test conditions) are available. Published data should be used for preliminary assessment of combustibility only. However, for protection or prevention design methods, the data can be acceptable after a thorough review to ensure that they are representative of owner/operator conditions. [**652:**A.5.2]

The protection or prevention designs are based on explosivity properties, which can vary based on the specific characteristics of the material. Historical knowledge and experience of occurrence or nonoccurrence of process incidents such as flash fires, small fires, sparkling fires, pops, or booms, or evidence of vessel, tank, or container overpressure should not be used as a substitute for hazard analysis. Process incidents are indications of a material or process resulting in combustibility or explosion propensity. Process incidents can be used as a guide to select samples for supplemental testing. [**652:**A.5.2]

The following material properties should be addressed by a DHA for the combustible particulate solids present:

(1) *Particle Size.* Sieve analysis is a crude and unreliable system of hazard determination. Its greatest contribution in managing the hazard is the ease, economy, and speed at which it can be used to discover changes in the process particulate. In any sample of particulate, very rarely are all the particles the same size. Sieve analysis can be used to determine the fraction that would be generally suspected of being capable of supporting a deflagration. For a sub-500 μm fraction:
   (a) Data presented in terms of the percent passing progressively smaller sieves.
   (b) Particles that have high aspect ratios can produce distorted, particle size results.
(2) *Particle Size Distribution.* The particle size distribution of a combustible particulate solid is an important parameter in assessing an explosion hazard. Particle size implies a specific surface area (SSA) and affects the numerical measure of other parameters such as *MEC, MIE,* dP/dt_{max}, P_{max}, *and* K_{St}. Spherical particles greater than 500 μm are generally not considered deflagratory. Most combustible particulate solids include a range of particle sizes in any given sample. The DHA should anticipate and account for particle attrition and separation as particulate is handled.
(3) *Particle Shape.* Due to particle shape and agglomeration, some particulates cannot be sieved effectively. Particulates with nonspheric or noncubic shapes do not pass through a sieve as easily as spheric or cubic particles. For this purpose, long fibers can behave just as explosively as spherical particulates of a similar diameter. This leads to underestimation of small particle populations and to underassessment of the hazard. Particulates with an aspect ratio greater than 3:1 should be suspect. When particulates are poured into vessels, it is common for the fine particles to separate from the large, creating a deflagration hazard in the ullage space.
(4) *Particle Aging.* Some combustible particulate solid materials could undergo changes in their safety characteristics due to aging. Changes in morphology and chemical composition, for example, can occur from the time a sample is collected to the time it is tested. For materials that are known to age, care must be taken in packaging and shipment. The use of vacuum seals, or an inert gas such as nitrogen, could be required to ensure that the tested sample has not changed appreciably due to aging. The lab should be notified in advance of shipment that the material is sensitive to change due to age so that they will know how to handle it and store it until it is tested.
(5) *Particle Attrition.* The material submitted for testing should be selected to address the effects of material attrition as it is moved through the process. As particulates move through a process they usually break down into smaller particles. Reduction in particle size leads to an increase in total surface area to mass ratio of the particulate and increases the hazard associated with the unoxidized particulate.
(6) *Particle Suspension.* Particle suspension maximizes the fuel–air interface. It occurs wherever the particulate moves relative to the air or the air moves relative to the particulate, such as in pneumatic conveying, pouring, fluidizing, mixing, and blending, or particle size reduction.
(7) *Particle Agglomeration.* Some particulates tend to agglomerate into clumps. Agglomerating particulates can be more hazardous than the test data imply if the particulate was not thoroughly deagglomerated when testing was conducted. Agglomeration is usually affected by ambient humidity.
(8) *Triboelectric Attraction.* Particles with a chemistry that allows electrostatic charge accumulation will become charged during handling. Charged particles attract oppositely charged particles. Agglomeration causes particulate to exhibit lower explosion metrics during testing. Humidification decreases the triboelectric effect.
(9) *Hydrogen Bonding.* Hydrophilic particulates attract water molecules that are adsorbed onto the particle surface. Adsorbed water provides hydrogen bonding to adjacent particles, causing them to agglomerate. Agglomeration causes particulate to exhibit lower explosion metrics during testing. Desiccation reduces this agglomerated effect.
(10) *Entrainment Fraction.* The calculation for a dust dispersion from an accumulated layer should be corrected for the ease of entrainment of the dust. Fuel chemistry and agglomeration/adhesion forces should be considered. The dispersion is generally a function of humidity, temperature, and time. Particle shape and morphology and effective particle size should be considered.
(11) *Combustible Concentration.* When particles are suspended, a concentration gradient will develop where concentration varies continuously from high to low. There is a minimum concentration that must exist before a flame front will propagate. This concentration depends on particle size and chemical composition and is measured in oz/ft^3 (g/m^3). This concentration is called the minimum explosible concentration (MEC). A dust dispersion can come from a layer of accumulated fugitive dust. The concentration attained depends on bulk density of dust layer [measured in oz/ft^3 (g/m^3)], layer thickness, and the extent of the dust cloud. Combustible concentration is calculated as follows in Equation A.5.2:

[A.5.2]

$$\text{Combustible concentration} = \text{Bulk density} \times \frac{\text{Layer thickness}}{\text{Dust cloud thickness}}$$

(12) *Competent Igniter*. Ignition occurs where sufficient energy per unit of time and volume is applied to a deflagratory particulate suspension. Energy per unit of mass is measured as temperature. When the temperature of the suspension is increased to the autoignition temperature, combustion begins. Ignitability is usually characterized by measuring the minimum ignition energy (MIE). The ignition source must provide sufficient energy per unit of time (power) to raise the temperature of the particulate to its autoignition temperature (AIT).

(13) *Dustiness/Dispersibility*. Ignition and sustained combustion occurs where a fuel and competent ignition course come together in an atmosphere (oxidant) that supports combustion. The fire triangle represents the three elements required for a fire. Not all dusts are combustible, and combustible dusts exhibit a range in degree of hazard. All combustible dusts can exhibit explosion hazards accompanied by propagation away from the source. In the absence of confinement, a flash-fire hazard results. If confined, the deflagration can result in damaging overpressures. Deflagration is the process resulting in a flash fire or an explosion. The heat flux from combustible metal flash fires is greater than organic materials. The four elements for a flash fire are the following:

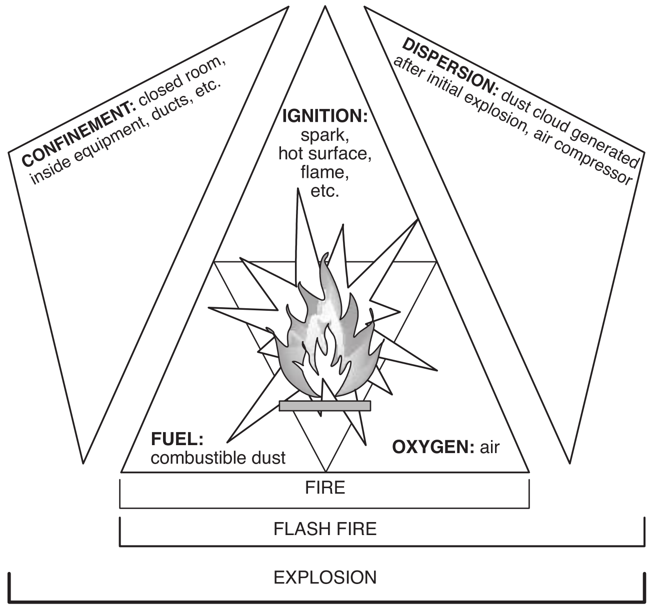
(a) A combustible dust sufficiently small enough to burn rapidly and propagate flame
(b) A suspended cloud at a concentration greater than the minimum explosion concentration
(c) The atmosphere to support combustion
(d) An ignition source of adequate energy or temperature to ignite the dust cloud

[**652:**A.5.2]

A dust explosion requires the following five conditions (*see Figure A.5.2*):

(1) A combustible dust sufficiently small enough to burn rapidly and propagate flame
(2) A suspended cloud at a concentration greater than the minimum explosion concentration
(3) Confinement of the dust cloud by an enclosure or partial enclosure
(4) The atmosphere to support combustion
(5) An ignition source of adequate energy or temperature to ignite the dust cloud

[**652:**A.5.2]



Δ **FIGURE A.5.2 Elements Required for Fires, Flash Fires, and Explosions. [652:Figure A.5.2]**

Δ **A.5.2.2** Data can be from samples within the facility that have been tested or data can be based on whether the material is known to be combustible or not. There are some published data of commonly known materials, and the use of these data is adequate to determine whether the dust is a combustible dust. For well-known commodities, published data are usually acceptable. A perusal of published data illuminates that there is often a significant spread in values. It is useful, therefore, to compare attributes (such as particle distribution and moisture content) in published data with the actual material being handled in the system whenever possible. Doing so would help to verify that the data are pertinent to the hazard under assessment. Even test data of material can be different from the actual conditions. Users should review the conditions of the test method as well to ensure that it is representative of the conditions of the facility. Where that is not possible, the use of worst-case values should be selected. Composition and particle size are two parameters that are useful to identify the number and location of representative samples to be collected and tested. *(See Section 5.5 for information on sampling.)*

Table A.5.2.2 contains examples of test data for selected agricultural dusts with known explosion data parameters. Other databases, such as the IFA (Institute for Occupational Safety and Health of the German Social Accident Insurance), GESTIS-DUST-EX Database Combustion, are available for data on explosion characteristics of dusts.

Please note that the information provided in the table is for the specific agricultural dust sample tested. Explosion severity and ignition sensitivity parameters are greatly influenced by many factors, including particle size distribution, particle morphology, and moisture content. Differences in specific material composition and possible contamination will also affect explosibility parameters. Thus, the information in Table A.5.2.2 will not apply in all cases.

If dealing with an agricultural dust with unknown explosion or ignition sensitivity when designing explosion protection or developing risk mitigation strategies, consider testing the dust in accordance with the relevant ASTM, ISO, or CEN standards so the data being used is as applicable as possible.

A.5.3 Some materials have multiple potential physical hazards such as combustibility, explosibility, decomposition, and propensity to self-heat.

N **Table A.5.2.2 Test Data — Agricultural Dusts**

Dust Name	Test Report Date	Sample Dried	Percent Moisture as Tested (%)	Median Particle Size as Received (μm)	Median Particle Size as Tested (μm)	Percent <200 (or <250) Mesh as Tested (%)	P_{max} (bar g)	K_{St} (bar m/sec)	Minimum Explosive Concentration (MEC) (g/m³)	Minimum Ignition Energy (mJ)
Alfalfa concentrate	1997	Yes	2.1	Unk	36	99	6.7	94	NT	NT
Alfalfa powder	2011	Yes	4.5	Unk	103	100	7.9	75	NT	NT
Angel food cake mix	2012	No	4.1	107	41	100	7.5	132	NT	NT
Apple	Unk	Unk	Unk	Unk	155	Unk	6.7	34	125	NT
Barley	2016	Yes	2.3	Unk	28	Unk	8.7	192	75–100	10–30
Barley (barley dust)	2011	Yes	2.6	Unk	83	(83.8)	7.5	107	NT	NT
Betaine – nutraceutical anhydrous betaine	2018	Yes	0.6	Unk	<45	100	9.0	286	190	NT
Canola dust	2016	Yes	2.5	Unk	12	Unk	6.2	40	60–75	10–30
Canola meal	2016	Yes	2.4	Unk	59	Unk	7.1	91	110–125	100–300
Canola meal dust	2003	No	6.4	Unk	149	(59.8)	6.2	15	NT	NT
Carrageen	1992	Yes	3.8	Unk	Unk	100	8.5	140	NT	NT
Carrageenan	1995	Yes	1.2	Unk	47	100	5.2	32	NT	NT
Carrot	1997	Yes	4.0	Unk	29	97	6.9	65	NT	NT
Cereal dust	2003	Yes	4.9	Unk	94	80	6.6	96	265	NT
Cheesy pasta (corn starch and various spices)	2014	Unk	7.9	Unk	45	80	7.2	99	NT	30–100
Chili (corn starch and various spices)	2014	Unk	7.0	Unk	79	65	6.6	60	NT	30–100
Cocoa bean shell dust	2016	Yes	4.4	Unk	52	100	6.7	42	NT	NT
Cocoa powder	2009	Yes	3.9	Unk	194	50	8.0	162	65	100–180*
Coconut shell dust	1990	Unk	6.5	Unk	Unk	80	6.8	111	NT	NT
Coffee grounds dust	2009	Yes	4.0	Unk	40	100	7.7	158	NT	NT
Coffee dust – coarse particles	Unk	Unk	4.8	Unk	321	0.4	6.9	55	NT	160*
Coffee dust (instant coffee)	2016	Yes	2.4	Unk	45	100	6.8	101	NT	NT
Coffee (green)	2009	Yes	4.6	Unk	57	100	7.6	116	NT	NT
Coffee creamer (French vanilla)	2006	Yes	3.1	Unk	57	(94.6)	7.6	156	NT	NT
Corn maize	Unk	Unk	Unk	Unk	165	55	8.7	117	30	>10
Corn meal	1996	Yes	1.6	Unk	589	8	7.0	35	NT	NT
Cornstarch	2013	Unk	11.4	Unk	45	98	7.8	139	NT	NT
Cornstarch – coarse particles	2006	Yes	2.2	Unk	217	(62.5)	7.9	186	NT	30–60*
Cotton (flocks, pulverized)	Unk	Unk	Unk	Unk	44	100	7.2	24	NT	NT
Cotton lint dust	2006	Yes	4.8	Unk	180	(43.6)	8.6	88	NT	NT
Cottonseed (expeller, silo entrance)	Unk	Unk	Unk	Unk	245	(50)	7.7	35	125	NT

(continues)

N **Table A.5.2.2** *Continued*

Dust Name	Test Report Date	Sample Dried	Percent Moisture as Tested (%)	Median Particle Size as Received (μm)	Median Particle Size as Tested (μm)	Percent <200 (or <250) Mesh as Tested (%)	P_{max} (bar g)	K_{St} (bar m/sec)	Minimum Explosive Concentration (MEC) (g/m^3)	Minimum Ignition Energy (mJ)
Dried distillers dried grains w/solubles (DDGS)	2016	No	3.8	Unk	26	Unk	7.6	135	75–100	10–30
Dried distillers dried grains (yellow corn) w/solubles (DDGS)	2009	Yes	4.2	Unk	225	(43.8)	6.5	42	NT	NT
Dried distillers dried grains (wheat) w/ solubles (DDGS)	2011	Yes	4.4	Unk	189	(67.1)	7.5	105	NT	NT
Fudge brownie mix	2012	No	4.8	291	221	(65.3)	5.8	43	NT	NT
Garlic powder	1988	Unk	Unk	Unk	Unk	Unk	8.6	164	NT	NT
Garlic powder, onion powder extract loc bac and salt (from dust collector)	2010	Yes	2.3	Unk	176	(35.3)	4.0	15	NT	NT
Gluten meal	Unk	Unk	Unk	Unk	150	Unk	7.7	110	125	NT
Gluten – wheat	1999	Unk	5.2	Unk	81	(96)	7.3	137	NT	NT
Grain dust – mixed (wheat, corn, beans)	2016	Yes	3.3	Unk	Unk	48	7.1	108	NT	NT
Grain dust – mixed (wheat, corn, beans)	2016	No	4.4	Unk	33	Unk	8.3	170	60–75	10–30
Grain dust – mixed (reintroduced from dust collector)	2003	No	8.3	Unk	65	(83.1)	7.7	129	NT	NT
Grass dust	Unk	Unk	Unk	Unk	200	Unk	8.0	47	125	NT
Hops, malted	Unk	Unk	Unk	Unk	490	Unk	8.2	90	NT	NT
Hops dust (overhead ceiling structure)	2006	No	8.3	Unk	54	(98)	7.4	159	75	NT
Lemon peel dust	1999	No	9.5	Unk	38	(95.6)	6.8	125	NT	NT
Lemon pulp dust	1997	Yes	2.8	Unk	180	(61)	6.7	74	NT	NT
Linseed, soya (dust from silo)	Unk	Unk	Unk	Unk	30	100	8.0	50	NT	NT
Locust bean gum	1992	Unk	1.7	Unk	Unk	100	7.8	78	NT	NT
Malt	1995	No	10.5	Unk	72	(95)	7.5	170	NT	NT
Maltodextrin	2015	Yes	2.7	Unk	45	100	8.1	125	100	NT
Maltodextrin flavoring	2015	Yes	2.7	Unk	47	100	9.2	207	NT	NT
Milk powder	1998	Yes	3.1	Unk	41	(99.5)	7.5	145	NT	NT
Oat flour	2013	Yes	4.5	Unk	107	(87.1)	6.3	82	NT	NT
Oat grain dust from aspirator	2017	Yes	4.4	245	113	(63.1)	7.0	51	NT	NT
Oat bran dust	2010	No	8.0	Unk	195	(78.3)	6.8	77	80	NT
Olive pellets	Unk	Unk	Unk	Unk	Unk	100	10.4	74	125	>1000
Onion powder	1988	Unk	Unk	Unk	Unk	Unk	9.0	157	NT	NT

(continues)

N **Table A.5.2.2** ***Continued***

Dust Name	Test Report Date	Sample Dried	Percent Moisture as Tested (%)	Median Particle Size as Received (μm)	Median Particle Size as Tested (μm)	Percent <200 (or <250) Mesh as Tested (%)	P_{max} (bar g)	K_{St} (bar m/sec)	Minimum Explosive Concentration (MEC) (g/m^3)	Minimum Ignition Energy (mJ)
Parmesan sauce mix (corn starch and spices)	2014	No	6.7	Unk	66	(84.9)	6.1	45	NT	30–100
Parsley (dehydrated)	1988	Unk	5.4	Unk	Unk	63.3	7.5	110	NT	NT
Parsley (dried)	2015	Unk	4.5	Unk	132	(72)	6.4	67	NT	NT
Pea fiber (>95% pea dust)	2013	Yes	3.3	206	107	(74.8)	6.4	68	NT	NT
Peach powder, hot-spray-dried (hygroscopic)	Unk	Unk	Unk	Unk	140	Unk	8.4	81	60	NT
Peanut hull dust from aspirator	1999	Unk	9.9	Unk	90	(98.4)	7.4	165	NT	NT
Peanut meal and skins	1993	Unk	3.8	Unk	Unk	Unk	6.4	45	NT	NT
Peat dust (from overhead ceiling structure)	Unk	Unk	Unk	Unk	49	66	8.4	81	60	NT
Potato dust (>95% from aspirator)	2013	Unk	5.0	Unk	45	(99.7)	8.5	93	NT	NT
Potato flour	Unk	Unk	Unk	Unk	65	100	9.1	69	125	NT
Potato flakes (90% potato, 10% water)	2009	Unk	Unk	Unk	313	(26.3)	7.3	38	NT	NT
Potato starch	Unk	Unk	Unk	Unk	28	100	8.2	116	NT	NT
Rice dust	1992	Unk	2.5	Unk	Unk	(50)	7.7	118	NT	40–120*
Rice flour	2010	Unk	12.2	Unk	45	100	7.7	140	65	NT
Rice starch	Unk	Unk	Unk	Unk	18	90	10.0	190	NT	NT
Rye dust (from aspirator)	2014	Yes	3.7	Unk	45	100	8.5	139	NT	NT
Rye flour (from silo)	2009	Unk	7.8	Unk	57	100	7.1	100	NT	NT
Rye meal	2000	Unk	6.2	Unk	45	(64.4)	7.3	140	NT	NT
Semolina	2001	Unk	13.6	Unk	57	100	7.0	109	NT	NT
Snack seasoning	2006	Unk	4.7	Unk	203	(70.7)	5.1	34	510	NT
Sorghum	2016	No	4.2	Unk	18	Unk	8.1	124	100–125	10–30
Soybean dust	1992	Yes	2.1	Unk	Unk	100	7.5	125	NT	NT
Soybean flour (defatted)	2015	Unk	3.7	Unk	45	100	7.7	148	NT	NT
Spice powder	1988	Unk	10.0	Unk	Unk	Unk	7.8	172	NT	NT
Sugar dust	2015	Yes	1.6	Unk	45	100	7.1	188	NT	NT
Sugar dust (beet)	2018	Yes	1.6	Unk	<45	100	5.8	84	NT	NT
Sugar dust (beet)	2018	Yes	1.0	Unk	<45	100	5.4	74	NT	NT
Sugar dust (beet-cooler baghouse)	2014	Yes	1.0	Unk	<45	100	8.0	146	NT	12
Sugar (granulated)	2006	Yes	0.6	Unk	76	(73.6)	6.3	122	NT	NT
Sugar (powdered)	2006	No	13.0	Unk	45	100	7.0	122	NT	30*
Sunflower seed dust	1996	No	9.7	Unk	500	(17)	7.8	92	NT	NT
Tea (from overhead beams)	1998	No	6.3	Unk	77	(72.3)	7.6	102	NT	NT

(continues)

N **Table A.5.2.2** ***Continued***

Dust Name	Test Report Date	Sample Dried	Percent Moisture as Tested (%)	Median Particle Size as Received (μm)	Median Particle Size as Tested (μm)	Percent <200 (or <250) Mesh as Tested (%)	P_{max} (bar g)	K_{St} (bar m/sec)	Minimum Explosive Concentration (MEC) (g/m^3)	Minimum Ignition Energy (mJ)
Tobacco blend	1990	Yes	1.0	Unk	120	100	8.0	124	NT	NT
Tomato (powder, hot-spray-dried, highly hygroscopic)	Unk	Yes	1.0	Unk	120	100	8.0	124	NT	NT
Walnut dust	1988	Unk	6.0	Unk	Unk	72	8.4	174	NT	NT
Wheat flour (whole grain)	2009	Yes	2.7	Unk	58	100	7.7	145	NT	<300
Wheat grain dust	Unk	Unk	Unk	Unk	80	Unk	9.3	112	60	NT
Wheat starch	Unk	Unk	Unk	Unk	20	Unk	9.8	132	60	25–60*
Wheat starch	2010	Unk	11.5	Unk	45	(98.9)	7.6	155	130	>500
Wheat cereal 55%, rice flour 20%	2012	Unk	2.8	Unk	187	(64.7)	5.7	28	NT	NT
Xanthan gum	1996	Unk	8.6	Unk	45	(99)	7.5	61	NT	NT
Yellow cake mix	2012	Unk	2.7	354	219	(30.6)	6.3	73	NT	NT
Yucca seed dust (raw)	1995	Unk	12.7	Unk	403	(29.9)	6.2	65	NT	NT
Yucca seed dust (hydrolyzed)	1995	Unk	5.5	Unk	194	(64)	7.0	156	NT	NT

Unk: Unknown. NT: Not Tested.

*Data is not from this product test. It is from the SFPE *Handbook of Fire Protection Engineering*, 4th Edition, Table 3-18.2 of a similar product.

Notes:

(1) *Please note that the information provided in this table is for the specific agricultural/food dust sample tested. Explosion severity and ignition sensitivity parameters are greatly influenced by many factors such as particle size, shape, and moisture content. Differences in specific mixture composition and possible contamination will also affect explosibility parameters. The information in this table should be used for general hazard assessment and not be used for design purposes.*

(2) Normalized to 1 m^3 test vessel pressures, per ASTM E1226, *Standard Test Method for Explosibility of Dust Clouds*.

(3) See also Table F.1(a) in NFPA 68 for additional information on agricultural dusts with known explosion hazards.

(4) For those agricultural dusts without known explosion data, the dust should be tested in accordance with established standardized test methods.

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A.5.4.1.2 Results of the preliminary screening test can have one of the following four results:

(1) No reaction
(2) Glowing but no propagation along the powder train
(3) Propagation, but too slow to include the test material in Division 4.1
(4) Propagation sufficiently fast to qualify for inclusion in Division 4.1

[**652:**A.5.4.1.2]

If the results of the screening test show no reaction or glowing in the specific form, that material can be considered noncombustible and does not fall under the requirements of this document. If the results of the screening test show glowing but no propagation along the powder train, the material in the specific form should be considered a limited-combustible material. Hazard analysis should be conducted to determine the extent to which the requirements of this document are applicable. [**652:**A.5.4.1.2]

It is recommended for general safety that the full requirements be met. If the results of the screening test show propagation of the powder train, the material in the specific form should be considered a limited-combustible material and full compliance with the requirements of this document be met. If the results of the screening test show propagation of the powder train sufficiently fast that the form is classified as a Division 4.1 material, hazard analysis should focus on additional protocols and compliance with other NFPA standards. [**652:**A.5.4.1.2]

A.5.4.3.3 Testing a worst-case (finest) particle size distribution will provide a conservative determination of the combustibility of the material. *(See Table A.5.4.4.1.)* [**652:**A.5.4.3.2]

A.5.4.3.4 Tests should typically be performed in accordance with the test standard recommendations. For example, most ASTM combustible dust test methods recommend testing the sample at less than 5 percent moisture by weight and particle size that is at least 95 percent sub-200 mesh (75 μm) screen by weight. This might require drying and grinding or sieving of samples. The thought behind this approach is to obtain near worst-case test data for accumulations that could be found within a facility [i.e., accumulations of dry fines, typically sub-200 mesh (75 μm), at some locations or changes in processes] and, by doing so, ensure conservatism in the hazard assessment and design of protection equipment. [**652:**A.5.4.3.3]

This typically produces a built-in safety factor for the tests, as the testing laboratory does not know if the samples are a good representation of the dust from the facility. By performing the test in this manner, it typically assumes a worst-case scenario to account for dust accumulations not factored in by the facility. [**652:**A.5.4.3.3]

On the other hand, testing material "as received" can result in a more realistic determination of the true nature of the hazard under assessment. Additionally, in some cases the as-received material could present a greater hazard than the dried fine fraction of the material. For instance, some samples might consist of a mixture of fine noncombustible material and coarse combustible material, where the fine fraction is a lower hazard than the as-received material. Similarly, some water-reactive materials could present a greater hazard with some moisture present than they would when dried. Determining the moisture content and particle size fraction of a dust sample is of considerable importance and should be done in consultation with experts or someone familiar with the process and material. [**652:**A.5.4.3.3]

A.5.4.4.1 Refer to Table A.5.4.4.1 for standard test methods for determining explosibility characteristics of dusts that are used for the DHA, performance-based design method risk assessments, and hazard management of combustible dusts. [**652:**A.5.4.4.1]

ASTM E2021, *Standard Test Method for Hot-Surface Ignition Temperature of Dust Layers*, uses a constant temperature hot plate to heat the dust on one side only. Routine tests use a 12.7 mm (0.5 in.) thick layer, which might simulate a substantial build-up of dust on the outside of hot equipment. However, since the ignition temperature normally decreases markedly with increased dust layer thickness, the method allows layer thickness to be varied according to the application. [**652:**A.5.4.4.1]

ASTM E2019, *Standard Test Method for Minimum Ignition Energy of a Dust Cloud in Air*, is used to determine the MIE for any given fuel concentration. The method uses the lowest energy, stored by a capacitor, that when released as a spark will ignite dust cloud–oxidant mixtures. By testing a range of concentrations, the lowest MIE is determined for the optimum mixture. Observed MIE and MIE values are highly sensitive to the test method, particularly the spark electrode geometry and characteristics of the capacitor discharge circuit. Dust ignition energy standard ASTM E2019 describes test methods in current use that have been found to yield comparable results; however, it is a "performance standard," whereby the methodology adopted must produce data within the expected range for a series of reference dusts. [**652:**A.5.4.4.1]

ASTM E1491, *Standard Test Method for Minimum Autoignition Temperature of Dust Clouds*, is used to determine the dust cloud autoignition temperature (AIT). The test involves blowing dust into a heated furnace set at a predetermined temperature. The dust concentration is systematically varied to find the lowest temperature at which self-ignition occurs at ambient pressure, known as the minimum autoignition temperature (MAIT). A visible flame exiting the furnace provides evidence for ignition. Four different furnaces are described in ASTM E1491 (0.27-L Godbert-Greenwald Furnace, 0.35-L BAM Oven, 1.2-L Bureau of Mines Furnace, and 6.8-L Bureau of Mines Furnace). Each yields somewhat different MAIT data, the largest deviations occurring at the greatest MAIT values. However, the lower AIT range is of more practical importance and here the agreement is better (for example 265 ± 25°C for sulfur). [**652:**A.5.4.4.1]

ASTM E1226, *Standard Test Method for Explosibility of Dust Clouds*, is used to determine the pressure and rate of pressure rise for suspended combustible dusts. The measurement of the explosibility parameters (P_{max} and K_{St}) requires the reproducible generation of a near homogeneous dust cloud inside a containment vessel of known volume. The explosibility parameters P_{max} (maximum pressure) and K_{St} (maximum rate of pressure rise of the worst-case concentration times the cube root of the test volume) are obtained from such measurements. The determination of a P_{max} and K_{St} for a material first establishes that it is an explosible dust. A bench scale test method in ASTM E1226 involves a vessel at least 20 L in volume in which a dust cloud is formed using the discharge of a small cylinder of compressed air. After a prescribed time delay, the highly turbulent dust cloud is ignited using a strong ignition source of known energy. Pressure is monitored versus time by appropriate transducers and expressed as pressure, P_{ex}, and pressure rate of rise, dP/d_{tex}. Dust concentration is varied to determine the maxima of both parameters. Particle size and moisture are other variables that must be considered. Particle size should be less than 75 μm ensuring a design that is conservative. [**652:**A.5.4.4.1]

The primary use of the test data P_{max} and K_{St} is for the design of explosion protection systems: venting, suppression, and isolation. Vent designs provide a relief area that will limit damage to the process equipment to an acceptable level. The required vent area is calculated using equations from NFPA 68 and requires knowledge of the process — volume, temperature, operating pressure, design strength, vent relief pressure — and of the fuel, P_{max} and K_{St}. Suppression is the active extinguishment of the combustion and again limits the explosion pressure to an acceptable level. Suppression designs require similar process and hazard data in order to determine the hardware requirements such as size, number, and location of containers, detection conditions, and the final or reduced explosion pressure. Isolation — the prevention of flame propagation through interconnections — requires the same process and hazard data to determine hardware needs and locations. The extent of testing should depend on what the scenario or evaluation such as explosion venting for a dust collector would require K_{St} and P_{max}. [**652:**A.5.4.4.1]

Published data can be used for preliminary assessment only; they should not be used for design. While some materials are well-characterized, tables with explosibility properties often lack specific information such as particle size; therefore, it is recommended that literature values that do not provide particle size information be used with extreme caution. This document, NFPA 499, NFPA 68, and NFPA 484 have lists of combustible and explosible metals and dusts that are used for guidance or as informational references only and are not to be used for design purposes. Composition, particle size and distribution, and moisture content are the three factors known to strongly influence test results. It is recognized that some industries have historical data on the same material; therefore, the frequency, number, and extent of testing where historical data exists should be made by informed judgment. The owner/operator assumes the risk of using data from tables and historical data. A person or team performing a DHA should scrutinize and make informed judgments about historical and published data and its applicability to the process. [**652:**A.5.4.4.1]

Table A.5.4.4.1 Standard Test Methods to Determine Explosibility Properties

Method	Property
ASTM E2019, *Standard Test Method for Minimum Ignition Energy of a Dust Cloud in Air*	Minimum ignition energy (MIE) of dust cloud in air
ASTM E1491, *Standard Test Method for Minimum Autoignition Temperature of Dust Clouds*	Minimum ignition temperature (T_c) of dust clouds
ASTM E1226, *Standard Test Method for Explosibility of Dust Clouds*	Maximum explosion pressure (P_{max}), rate and maximum rate of pressure rise (dP/dt), and explosion severity (K_{St})
ASTM E1515, *Test Method for Minimum Explosible Concentration of Combustible Dusts*	Minimum explosible concentration (MEC)
ASTM E2021, *Standard Test Method for Hot-Surface Ignition Temperature of Dust Layers*	Minimum ignition temperature (T_c) of dust layers
ASTM E2931, *Test Method for Limiting Oxygen (Oxidant) Concentration of Combustible Dust Clouds*	Limiting oxygen concentration (LOC)

[**652:**Table A.5.4.4.1]

N **A.5.4.4.4** If the material is a mixture of fine, noncombustible, and coarse combustible material, the fine fraction might not represent the most conservative sample. See 5.5.2. [**652:**A.5.4.4.4]

Δ **A.5.5** Special consideration should be given to samples from equipment in facilities such as dust collectors, impact equipment, silos and bins, processing equipment, ovens, furnaces, dryers, conveyors, bucket elevators, and grain elevators. [**652:**A.5.5.3]

If a sample is from a dust collection or pneumatic conveying system, the sample should be a representative of the hazard subject to evaluation. [**652:**A.5.5.3]

Samples should be collected from rooms and building facilities where combustible dusts can exist, including rooms where abrasive blasting, cutting, grinding, polishing, mixing, conveying, sifting, screening, bulk handling or storage, packaging, agglomeration, and coating are performed. [**652:**A.5.5.3]

Where there are numerous or a range of products and processes, worst-case samples can be used with DHA to assess the hazards. Performance-based design allows the user to identify and sample select materials instead of the prescriptive approach where all materials are collected and tested. Where multiple pieces of process equipment are present and contain essentially the same material, a single representative sample can be acceptable. While the composition can be constant, attrition and separation based on particle size should be assessed. If and where attrition occurs, samples should be collected from such process equipment from start to finish and representative of the material with reduced particle size. For example, a belt conveyor can have larger particles on the belt but finer dusts along the sides or under or at the bottom of the conveyor. The sampling plan should include samples of the accumulated fines as one sample and a sample from the center of the belt as a second separate sample. Material to be used for the screening tests and for the determination of material hazard characteristics such as K_{St}, MIE, T_c, and so forth, should be collected from the areas or inside equipment presenting the worst-case risk. [**652:**A.5.5.3]

Some processes, such as grinding, require further evaluation. Grinding can result in a broad range of particle sizes. A representative sample should be tested. Combustible particulate solids include dusts, fibers, fines, chips, chunks, flakes, or mixtures of these. The term *combustible particulate solid* addresses the attrition of material as it moves within the process equipment. Particle abrasion breaks the material down and produces a mixture of large and small particulates, some of which could be small enough to be classified as dusts. Consequently, the presence of dusts should be anticipated in the process stream, regardless of the starting particle size of the material. [**652:**A.5.5.3]

Samples should be collected in a safe manner without introducing an ignition source, dispersing dust, or creating or increasing the risk of injury to workers.

The more information about a sample that is collected and tested, the more useful it is to manage, monitor stability, or track changes in the process and materials where a hazard is present or absent. Changes in the process or materials that require further testing will have a baseline for explaining any difference in physical hazard. Any dust sample collected from on top of a press should be identified as different from a sample collected from inside a vessel or container if the sample is susceptible to chemical changes (i.e., oxidation, hygroscopic) over time. [**652:**A.5.5.4.1]

A.5.5.1.2 The sampling plan should include the following:

(1) Identification of locations where fine particulates and dust are present
(2) Identification of representative samples
(3) Collection of representative samples
(4) Preservation of sample integrity
(5) Communication with the test laboratory regarding sample handling
(6) Documentation of samples taken
(7) Safe sample collection practices

Some materials are subject to change, such as oxidization or other chemical reaction, that could affect the test results. Precautions such as inerting or vacuum packing should be taken to preserve the test sample integrity. Other sample preservation considerations include the possibility of moisture reactions and polymerization reactions. [**652:**A.5.5.1.3(4)]

A.5.5.2 If the dust sample is a mixture, the amount or concentration of each constituent should be determined by laboratory analysis. Common methods for an analysis of mixture composition include material separation, mass fraction analysis, energy dispersive x-ray spectroscopy, Fourier transform infrared spectroscopy, inductively coupled plasma spectroscopy, and x-ray fluorescence spectroscopy.

A.6.1.2 See A.4.2.5.

Δ **A.6.1.3.1** The SFPE *Engineering Guide to Performance-Based Fire Protection* describes the documentation that will be provided for a performance-based design. [**652:**A.6.1.3.1]

Proper documentation of a performance-based design is critical to design acceptance and construction. Proper documentation will ensure that all parties involved understand the factors necessary for the implementation, maintenance, and continuity of the fire protection design. If attention to detail is maintained in the documentation, there should be little dispute during approval, construction, startup, and use. [**652:**A.6.1.3.1]

Poor documentation could result in rejection of an otherwise good design, poor implementation of the design, inadequate system maintenance and reliability, and an incomplete record for future changes or for testing the design forensically. [**652:**A.6.1.3.1]

Δ **A.6.1.4** Chapter 5 of NFPA *101* provides a more complete description of the performance-based design process and requirements. In addition, the SFPE *Engineering Guide to Performance-Based Fire Protection* outlines a process for developing, evaluating, and documenting performance-based designs. [**652:**A.6.1.4]

A.6.1.4.1 The sources, methodologies, and data used in performance-based designs should be based on technical references that are widely accepted and used by the appropriate professions and professional groups. This acceptance is often based on documents that are developed, reviewed, and validated under one of the following processes:

(1) Standards developed under an open consensus process conducted by recognized professional societies, codes or standards organizations, or governmental bodies
(2) Technical references that are subject to a peer-review process and published in widely recognized peer-reviewed journals, conference reports, or other publications
(3) Resource publications, such as the SFPE *Handbook of Fire Protection Engineering*, are widely recognized technical sources of information

[**652:**A.6.1.4.1]

The following factors are helpful in determining the acceptability of the individual method or source:

(1) Extent of general acceptance in the relevant professional community, including peer-reviewed publications, widespread citations in technical literature, and adoption by or within a consensus document
(2) Extent of documentation of the method, including the analytical method itself, assumptions, scope, limitations, data sources, and data reduction methods
(3) Extent of validation and analysis of uncertainties, including comparison of the overall method with experimental data to estimate error rates, as well as analysis of the uncertainties of input data, uncertainties and limitations in the analytical method, and uncertainties in the associated performance criteria
(4) Extent to which the method is based on sound scientific principles
(5) Extent to which the proposed application is within the stated scope and limitations of the supporting information, including the range of applicability for which there is documented validation, and considering factors such as spatial dimensions, occupant characteristics, and ambient conditions, which can limit valid applications

[**652:**A.6.1.4.1]

In many cases, a method will be built from and include numerous component analyses. Such component analyses should be evaluated using the same acceptability factors that are applied to the overall method, as outlined in items A.6.1.4.1(1) through A.6.1.4.1(5). [**652:**A.6.1.4.1]

A method to address a specific fire or explosion safety issue, within documented limitations or validation regimes, might not exist. In such a case, sources and calculation methods can be used outside of their limitations, provided that the design team recognizes the limitations and addresses the resulting implications. [**652:**A.6.1.4.1]

The technical references and methodologies to be used in a performance-based design should be closely evaluated by the design team, the AHJ, and possibly a third-party reviewer. The strength of the technical justification should be judged using criteria in items A.6.1.4.1(1) through A.6.1.4.1(5). This justification can be strengthened by the presence of data obtained from fire or explosion testing. [**652:**A.6.1.4.1]

A.6.1.5 Relevant aspects that could require a re-evaluation include, but are not limited to, changes to the following:

(1) Information about the hazardous characteristics of the materials
(2) Information about the performance capabilities of protective systems
(3) Heretofore unrecognized hazards

Intentional changes to process materials, technology, equipment, procedures, and facilities are controlled by Section 8.12.

[**652:**A.6.1.5]

A.6.1.7 As used in this section, maintenance includes the preventive maintenance required for the design features that are part of the performance-based design and the requirement to maintain the design itself. [**652:**A.6.1.7]

A.6.1.7.1 Design features, including protection methods and means and administrative controls, should be included in preventive maintenance programs to ensure their continued operability. [**652:**A.6.1.7.1]

N **A.6.1.7.2** This is not intended to prohibit future variations in the design features but only that when modified these features are again subject to AHJ review. [**652:**6.1.7.2]

A.6.3.1.1 When evaluating tenable conditions, the toxicity of hazardous materials released as a result of a fire or explosion should be considered. [**652:**A.6.3.1.1]

Δ **A.6.4** The dust hazard analysis conducted according to the requirement in Chapter 7 might be useful in identifying the scenarios for Section 6.4. The fire and explosion scenarios defined in Section 6.4 assume the presence of an ignition source, even those scenarios limited by administrative controls (such as a hot work permit program). It is the responsibility of the design professional to document any scenario that has been excluded on the basis of the absence of an ignition source. [**652:**A.6.4]

A.6.4.1.1 A compartment is intended to include the area within fire-rated construction. [**652:**A.6.4.1.1]

A.6.4.2.5 For instance, some combustible metals can generate hydrogen when in contact with water. See NFPA 484 for additional information. [**652:**A.6.4.2.5]

Δ **A.6.5.1** The SFPE *Engineering Guide to Performance-Based Fire Protection* outlines a process for evaluating whether trial designs meet the performance criteria. [**652:**A.6.5.1]

A.7.1 This chapter provides the minimum requirements for performing a hazard assessment to identify and analyze the hazards presented by the presence of combustible particulate solids for the purpose of identifying relevant management strategies necessary to provide a reasonable degree of protection to life and property. [**652:**A.7.1]

The intent of this chapter is to establish a requirement to analyze the potential hazards of an operation regardless of size. The dust hazard analysis methodology is not necessarily the same as that in the OSHA process safety management (PSM) regulation and is not intended to trigger such a requirement. Annex B of NFPA 652 provides an example of how one might perform a DHA. [**652:**A.7.1]

A.7.1.2.2 Annex F provides a checklist as an example of how one might perform a DHA for an existing facility.

A.7.2.1 NFPA standards rely on the determination of "where an explosion hazard or deflagration hazard exists." There are other physical and health hazards to consider such as toxicity, reactivity with water, and so forth that can be considered when conducting a DHA. The DHA should consider the four conditions that are required for a deflagration:

(1) A combustible particulate solid of sufficiently small particle size to deflagrate
(2) A combustible particulate solid suspended in air to deflagrate (or other oxidizing medium)
(3) A combustion particulate solid suspension of sufficiently high concentration to deflagrate
(4) A competent igniter applied to the suspension of combustible particulate solids where the concentration is sufficient for flame propagation

[**652:**A.7.2.1]

A deflagration leading to an explosion will occur whenever all four criteria occur within a compartment or container at the same time. Since gravity is a concentrating effect and we always assume an ignition source is present unless we can prove one cannot exist, even under conditions of equipment failure, this list reduces to:

(1) A combustible particulate solid of sufficiently small particle size to deflagrate
(2) A means for suspending the combustible particulate solid in air (or other oxidizing medium)
(3) A sufficient concentration can be achieved

[**652:**A.7.2.1]

Most dust explosions occur as a series of deflagrations leading to a series of explosions in stages. While a single explosion is possible, it is the exception rather than the rule. Most injuries are the result of the "secondary" deflagrations rather than the initial event. Most "explosion" events are a series of deflagrations, each causing a portion of the process or facility to explode. Primary deflagrations lead to secondary deflagrations, usually fueled by accumulated fugitive dust that has been suspended by the following:

(1) Acoustic impulse waves of the initial, primary, deflagration
(2) Entrainment by deflagration pressure front

[**652:**A.7.2.1]

The majority of the property damage and personnel injury is due to the fugitive dust accumulations within the building or process compartment. The elimination of accumulated fugitive dust is critical and the single most important criterion for a safe workplace. [**652:**A.7.2.1]

Δ **A.7.2.2** The qualified person who is leading or performing the DHA should be familiar with conducting a DHA. The qualified person should also be familiar with the hazards of combustible dusts. Typically, a team performs a DHA. For some processes this team might be a little as two persons, or for larger and more complex processes, the team might require many more than two persons. This team is made of a variety of persons whose background and expertise can include the following:

(1) Familiarity with the process
(2) Operations and maintenance
(3) Process equipment
(4) Safety systems
(5) History of operation
(6) The properties of the material
(7) Emergency procedures

[**652:**A.7.2.2]

The individuals involved in the DHA could include facility operators, engineers, owners, equipment manufacturers, or consultants. [**652:**A.7.2.2]

N **A.7.3** There are multiple methods for completing a dust hazard analysis (DHA). These include, but are not limited to, checklists, "what-if" analysis, failure mode and effects analysis, fault tree analysis, and HAZOP. Additional guidance on performing a DHA is available in the NFPA *Guide to Combustible Dust,* and in the AIChE *Guidelines for Hazard Evaluation Procedures.* It is not the intent of this standard to require users to apply the Process Hazard Analysis provisions of OSHA regulations in 29 CFR 1910.119, "Process Safety Management of Highly Hazardous Chemicals," in developing a DHA.

A.7.3.1(2)(b) The hazard management document for all the areas of the process or facility compartment determined to be combustible dust hazards should include, but not be limited to, the following:

(1) Test reports
(2) Drawings
(3) Sizing calculations

Δ **A.8.1** It is not always possible or practical for existing facilities to be in compliance with the new provisions of a standard at the effective date of that standard. Therefore, "retroactivity" in 9.4.1 means that a plan should be established to achieve compliance within a reasonable time frame. [**652:**A.9.4.1]

A.8.2 See ANSI/AIHA Z10-2012, *Occupational Health and Safety Management Systems.* [**652:**A.8.2]

A.8.3.1 The operating procedures should address both the normal operating conditions and the safe operating limits. Where possible, the basis for establishing the limits and the consequences of exceeding the limits should also be described.

For manual operations, the procedures and practices should describe techniques, procedural steps, and equipment that are intended to minimize or eliminate combustible dust hazards.

Operating procedures and practices should be reviewed on a periodic basis, typically annually, to ensure that they are current and accurate.

Operating procedures created for other purposes can be used to meet this objective.

A.8.3.2 Safe work practices include, but are not limited to, hot work, confined space entry, lockout/tagout, and the use of personal protective equipment. *(See NFPA 51B.)* Consideration for extending the duration of the fire watch could be warranted based on characteristics of the material, equipment configuration, and conditions. In addition to the hazard of combustible dust safe work, practices should address the hazards of mitigation systems such as inerting and suppression.

A.8.4.2.1 This provision states an industry- or commodity-specific threshold housekeeping dust accumulation limit within the meaning of 8.4.6.2 of NFPA 652. The housekeeping program can be a stand-alone document or included as part of another document.

A.8.4.2.1.1 A relatively small initial dust deflagration can disturb and suspend in air dust that has been allowed to accumulate on the horizontal and vertical surfaces of a building or equipment. This dust cloud provides fuel for the secondary deflagration, which can cause damage. The reduction of significant additional dust accumulations is, therefore, a major factor in reducing the hazard in areas where a dust hazard can exist.

A.8.4.2.1.2 One example of a transient release of dust is a temporary loss of containment due to a failure of a seal in process equipment or conveying systems. Table A.8.4.2.1.2 provides an example of an unscheduled housekeeping procedure to limit the time that a local spill or transient releases of dust are allowed to remain before cleaning the local area to less than the threshold housekeeping dust accumulation. The “level accumulation” of combustible dust should be established in the housekeeping program based on the risk of flash fires and secondary explosions from the dust hazard analysis. [**652:**A.8.4.6.3]

A.8.4.2.2.1 Vacuum cleaning systems are preferred for removal of static dust on surfaces in order to prevent resuspension of the dust in ambient air, as is often caused by brushing down with brooms or using compressed air. Where the surfaces are inaccessible or create a hazard to employees working from stepladders or in hazardous positions while handling vacuum hoses and tools, alternative means should be followed under the conditions specified in 8.4.2.2.1. *(See also 9.6.2.1.)*

A.8.5.1 OSHA 29 CFR 1910.272 also establishes requirements for hot work in grain-handling operations. Hot work includes activities such as welding, cutting, grinding, brazing, powder-driving equipment, hot riveting, burning, or other flame/spark/slag-producing activities.

A.8.5.2.1 See the permit form example in Annex A of NFPA 51B.

A.8.5.2.2(6) Hot work inside equipment where chemical suppressants, inerting, or steam suppression systems are used for fire and explosion protection would require these systems to be disabled or removed to meet the life safety objectives required for a confined space entry.

A.8.5.2.2(10) Regular inspections for up to 3 hours after the hot work activity and fire watch is completed can help to reduce the potential for smoldering fires to go unnoticed. A review of hot work fires in industrial occupancies showed that hot work fires have been experienced beyond the 1-hour fire watch. Some of the conditions that could lead to a fire occurring after the fire watch include combustible construction with concealed spaces, storage of bulk piles of combustible material, such as packaging material or sacks of product, combustible exterior roof coverings, and combustible cores in walls. *(See FM Global Data Sheet 10-3, Hot Work Management.)*

N **A.8.5.6.1** Ideally, all work that creates an ignition source should be done in a safe environment. When that is not possible and work has to be performed in a classified area, the performance of the work should be controlled through an ignition source control program/permit. Examples of work activities that would be associated with an ignition source control permit include concrete chipping, sand blasting, drilling into structural steel, and use of portable electric hand tools for tasks in classified areas on equipment not directly handling combustible dusts.

Δ **A.8.6.1** Facilities handling agricultural combustible dust are not typically required to use flame-resistant garments under normal operating condition.

Δ **A.8.7.1** Examples of applicable standards include the following:

(1) NFPA 10.
(2) NFPA 11.
(3) NFPA 12.
(4) NFPA 12A.
(5) NFPA 13.
(6) NFPA 14.
(7) NFPA 15.
(8) NFPA 16.
(9) NFPA 17.
(10) NFPA 25.
(11) NFPA 68.
(12) NFPA 69.
(13) NFPA 221.
(14) NFPA 750.
(15) NFPA 2001.

Δ **Table A.8.4.2.1.2 Unscheduled Housekeeping**

Level Accumulation	Longest Time to Complete Unscheduled Local Cleaning of Floor-Accessible Surfaces (hours)	Longest Time to Complete Unscheduled Local Cleaning of Remote Surfaces (hours)
1	8	24
2	4	12
3	1	3

[**652:**Table A.8.4.6.3]

A.8.7.2(4) Protection systems and associated interlocks should be inspected, calibrated, and tested in the manner in which they are intended to operate, with written records maintained for review. In this context, "test" implies a nondestructive means of verifying that the system will operate as intended. For active explosion protection systems, this can involve the disconnection of final elements (e.g., suppression discharge devices or fast-acting valve actuators) and the use of a simulated signal to verify the correct operation of the detection and control system. Testing can also include slow-stroke activation of fast-acting valves to verify unrestricted travel. Some devices, such as explosion vent panels, suppression discharge devices, and some fast-acting valve actuators, cannot be functionally "tested" in a nondestructive manner; therefore only periodic, preventive, and predictive inspection, maintenance, and replacement (if necessary) is applied.

Inspection and maintenance requirements for explosion vents and other explosion protection systems are found in NFPA 68 and NFPA 69, respectively.

Examples of safety devices include motion sensors, leg and conveyor belt alignment systems, bearing vibration and temperature monitoring, plug detectors, pressure sensors, and level indicators.

A.8.7.4 Corrective actions should be expedited on high-risk hazards (those that could result in a fatality or serious injury). Where in-kind repairs cannot be promptly implemented, consideration should be given to providing alternate means of protection. [**652:**A.8.7.4]

A.8.8.1 All plant personnel, including management, supervisors, and operating, housekeeping, and maintenance personnel, should receive general awareness training for combustible dust hazards, commensurate with their job responsibilities, including training on locations where hazards can exist on site, appropriate measures to minimize hazards, and response to emergencies. [**652:**A.8.8.2]

A.8.8.2 Safety of a process depends on the employees who operate it and the knowledge and understanding they have of the process. It is important to maintain an effective and ongoing training program for all employees involved. Operator response and action to correct adverse conditions, as indicated by instrumentation or other means, are only as good as the frequency and thoroughness of training provided. [**652:**A.8.8.1]

A.8.8.3 Safe work habits are developed and do not occur naturally. The training program should provide enough background information regarding the hazards of the materials and the process so that the employees can understand why it is important to follow the prescribed procedures. Training should address the following:

(1) The hazards of their working environment and procedures in case of emergencies, including fires, explosions, and hazardous materials releases
(2) Operating, inspection, testing, and maintenance procedures applicable to their assigned work
(3) Normal process procedures as well as emergency procedures and changes to procedures
(4) Emergency response plans, including safe and proper evacuation of their work area and the permissible methods for fighting incipient fires in their work area
(5) The necessity for proper functioning of related fire and explosion protection systems
(6) Safe handling, use, storage, and disposal of hazardous materials used in the employees' work areas
(7) The location and operation of fire protection equipment, manual pull stations and alarms, emergency phones, first-aid supplies, and safety equipment
(8) Equipment operation, safe startup and shutdown, and response to upset conditions

[**652:**A.8.8.2.1]

A.8.8.4 The extent of this training should be based on the level of interaction the person is expected to have with the system. For example, operators need to be aware of the hazards presented by explosion suppression systems but might not need to know how to operate the suppression system (e.g., interfacing with the system control panel or locking out devices). Maintenance personnel, on the other hand, might need to know how and when to lock out the devices and how to return the system to its operational state. [**652:**A.8.8.2.3]

A.8.9.2 It is suggested that annual meetings be conducted with regular contractors to review the facility's safe work practices and policies. Some points to cover include to whom the contractors would report at the facility, who at the facility can authorize hot work or fire protection impairments, and smoking and nonsmoking areas. The owner/operator does not necessarily need to provide the training to the contractor. [**652:**A.8.9.3]

A.8.9.2.3 In addition to the combustible dust fire and explosion hazards, contractors should also be made aware of other potential process and occupational hazards. There can be combustible materials other than the combustible dusts in the equipment or immediate vicinity where contractors might be working. Combustion of dusts can generate toxic products, and some combustible dusts are acutely toxic. [**652:**A.8.9.3.3]

A.8.10.3 The following are incipient fire-fighting techniques for agricultural dust fires:

(1) *Leg Fires.* Material flow into a leg should be stopped and the leg should be shut down. Leg fires should be extinguished by water fog or gentle application of water. Fires should be located by feeling the leg casing for heat or observing discoloration of metal. If the location is unknown, water should be applied first in the boot section, then in the bin-pulley access door, and last in the head section.
(2) *Conveyor Belt Fires.* The conveyor belt should be shutdown (halted). Conveyor belt fires should be extinguished by application of water. Material flow to the conveyor belt should be stopped. If necessary, the belt should be cut to isolate the fire.
(3) *Dryer Fires.* Dryer fires should be extinguished by removing burning material from the dryer or gentle application of water. Fuel to burners, fans, and material flow into the dryer and from the facility should be stopped. If necessary, emergency dump should be used to remove material from the dryer.
(4) *Concrete Bin or Silo and Steel Tank Fires.* Concrete bin or silo fires should be extinguished by wetting the top surface of the material with gentle application of water at a low flow rate directly to the burning materials, and then removal of burning material from the bin or silo directly to the outside. Water fog should be applied to walls and to the underside of the roof to reduce airborne dust. Fire should be located by thermometer probes, thermographic photography, or feeling heat on bin or silo surfa-

ces. Openings to the bin or silo should be sealed to limit oxygen entry. Material flow to and from the bin or silo should be stopped. Fire-fighting operations should be done from outside the bin or silo. Fires should be isolated by selective unloading of material near the fire into a steel tank.

(5) *Fumigant or Chemical Fires.* Fires involving fumigants containing phosphine should be extinguished by inert material or non-aqueous agent used for Class B fires. Water should not be used for phosphine fires to avoid exothermic reaction and development of explosive gases.

(6) *Water Gas Reaction.* Application of small amounts of water on glowing grain in a partially confined space, such as a grain silo, and in the presence of air can generate a water gas reaction. The glowing grain must be at a temperature of at least 700°C to 800°C (1290°F to 1470°F), and initial water contact might not cool the mass of glowing grain below 600°C (1110°F). The partial oxidation reduction between carbon and water forms carbon monoxide and hydrogen as follows:

[A.8.10.3(6)a]

$$C + H_2O \rightarrow CO + H_2$$

In the presence of oxygen (air), the carbon monoxide and hydrogen burn, immediately releasing heat as follows:

[A.8.10.3(6)b]

$$C + H_2O + O_2 \rightarrow CO_2 + H_2O + 19{,}440 \text{ J/g } (8350 \text{ Btu/lb})$$

In a partially confined space, the combustion energy will rapidly pressurize the space beyond what the silo walls or tops can withstand, causing destruction of the silo.

A.8.10.3.5 Fire responders should be cautioned when using straight stream nozzles in the vicinity of combustible dust accumulations that dust clouds can be formed and can be ignited by any residual smoldering or fire.

A.8.10.3.5.1 A nozzle listed or approved for use on Class C fires produces a fog discharge pattern that is less likely than a straight stream nozzle to suspend combustible dust, which could otherwise produce a dust explosion potential.

A.8.11.1 Events where there are injuries, equipment damage, or significant business interruption are subject to investigation.

In addition to investigation of fires and explosions, it is also a good practice to investigate near misses (events that could have resulted in fires or explosions under different circumstances) and all activations of active fire and explosion mitigation systems. It is important to educate facility personnel on the concept of what a near miss is and to clearly communicate their responsibility for reporting both incidents and near misses.

Near-miss events often indicate an underlying problem that should be corrected. See NFPA 654 for additional information. Barriers to reporting should be removed, as described in ANSI/AIHA Z10, *Occupational Health and Safety Management Systems.* Investigations should include workers and their representatives, as appropriate. [**652:**A.8.11.1]

The retroactivity of this chapter is not intended to require investigation of incidents that occurred prior to the adoption of this standard. [**654:**A.8.11.1]

A.8.11.4 The term *affected personnel* is intended to include members of employee organizations such as safety committees and employee representatives of various types. [**652:**A.8.11.4]

• *N* **A.8.12.1** The owner/operator can determine what type of change in process materials requires management of change based on what change is important to the process and what the process is designed to handle. Examples of fire and explosion protection devices include, but are not limited to, fire sprinklers, fire doors, fire walls, detection and alarm systems, explosion venting, explosion suppression systems, walls designed for segregation, and explosion-resistant walls.

In addition to the listed changes in 8.12.1, documented procedures should also be considered to manage proposed changes to staffing, job tasks, technology, and procedures that affect dust, fire, or explosion hazards. Establishing a documented procedure for managing changes will help identify when a qualified person is needed to assess the impact of change and to help track the outcomes of their review.

N **A.8.12.2** In addition to the items in 8.12.2, the following should be considered for inclusion in the documented procedure:

(1) Whether the change is temporary or permanent, including the authorized duration of temporary changes
(2) Modifications to operating and maintenance procedures
(3) Employee training requirements
(4) Results of characterization tests used to assess the hazard, if conducted

N **A.8.12.2(1)** The proposed change and why it is needed should be described. It should include sufficient technical information to facilitate review by the approvers, address adverse effects that could occur, and describe how such effects would be mitigated by the proposed change. [**652:**A.8.12.2(1)]

N **A.8.12.2(2)** Some fire and explosion protection systems introduce additional hazards into the process environment. These hazards can include, but are not limited to, energy in suppression canisters, asphyxiation hazards from inert gases, and mechanical laceration/amputation hazards from explosion isolation systems. While these are not fire or explosion hazards, they should be addressed as part of the management of change review per this document so that appropriate controls can be applied. [**652:**A.8.12.2(2)]

N **A.8.12.3** While implementation of the management of change procedure is not required for replacement in kind, it is critical that only qualified personnel are the ones who determine if the replacement is "in kind." These qualified personnel should be intimately familiar with the items listed in 8.12.2, as well as the broad scope of hazards associated with the particular process. [**652:**A.8.12.3]

Replacement "in kind" for raw materials. Care must be taken when substituting raw materials. There have been cases where a seemingly equivalent material substitution resulted in a large change in the process hazard. Not all safety properties of a material are characterized in, for example, an MSDS. Chemical composition might be identical, but quite different static ignition hazards due to bulk resistivity and charge relaxation rate can appreciably increase the hazard. Flowability differences can affect the hazard probability too. Differences in natural raw materials are generally less of a concern than manufactured materials in this regard. [**652:**A.8.12.3]

A.8.13 The creation and retention of documentation is necessary in order to implement and periodically evaluate the effectiveness of the management systems presented in this standard. Documentation in any form (e.g., electronic) should remain legible and be readily identifiable and accessible. The documentation should be protected against damage, deterioration, or loss, and retained for the applicable period specified in this standard. [**652:**A.8.13]

A.8.13.1(5) Process and technology information includes process performance parameters, properties of the materials being handled, and documents such as design drawings, design codes and standards used as the basis for both the process and the equipment, equipment manufacturers' operating and maintenance manuals, standard operating procedures, and safety systems operation. [**652:**A.8.13.1(5)]

A.8.13.1(7) Contractor records typically include information such as the contract documentation with scope of work and necessary insurance coverage, the contractor's safety programs, records demonstrating the contractor's safety performance, qualifications and certifications necessary for the work to be done, periodic evaluations of the contractor's work performance, and records demonstrating that the employees of the contractor have been trained to safely perform the assigned work. [**652:**A.8.13.1(8)]

A.8.15 Employee participation includes items such as, but not limited to, the following:

(1) An occupational health and safety committee
(2) Access to safety and health information
(3) Risk assessment, and implementation and review of risk control measures
(4) Incident and near miss investigations
(5) Inspections and audits
(6) Reporting unsafe conditions, tools, equipment, and practices
(7) Mentoring of new employees, apprentices, and for on-site orientation
(8) Identifying hazards with strong emphasis on high-risk jobs and the application of the hierarchy of controls
(9) In accordance with established and maintained procedures, appropriate arrangements ensuring any concerns, ideas, and input that employees and their representatives' share are received, considered, and responded to
(10) Employees removing themselves from work situations that they believe, with reasonable justification, present an imminent and serious danger to their safety or health

A.9.2.2.2 For information on designing to relieve explosion pressure, see NFPA 68.

A.9.2.3.1.1 For the purpose of this standard, masonry construction refers to stone, brick, gypsum, hollow tile, concrete block, and cinder block building units, or other similar building units or materials laid up unit by unit and set in mortar.

A.9.2.3.3 Guidance is provided in NFPA 780 for determining the need for lightning protection.

A.9.2.5.4 The suggested minimum angle of repose of dust is 60 degrees. Vertical surfaces should be smooth to facilitate cleaning. Horizontal surfaces should be minimized to prevent accumulation of dust.

A.9.2.6.3.1 A building could be considered as a single combustible dust hazard area, or as a collection of smaller, separated combustible dust hazard areas. When the owner/operator chooses to consider the building as a single area, then the hazard analysis should consider the entire building floor area, and the considerations for mitigation apply to the entire building. Where the combustible dust hazard areas are sufficiently distant to assert separation and the owner/operator chooses to consider each hazard area separately, the hazard analysis should consider each separated area, and the considerations for mitigation should be applied to each area independently. Due consideration should be given to overhead dust accumulations, such as on beams or ductwork, which would negate the use of separation to limit combustible dust hazard areas. If the separation option is chosen, a building floor plan, showing the boundaries considered, should be maintained to support housekeeping plans. [**652:** A.9.2.6.3.1]

A.9.2.6.3.2 Separation distance is the distance between the outer perimeter of a primary dust accumulation area and the outer perimeter of a second dust accumulation area. Separation distance evaluations should include the area and volume of the primary dust accumulation area as well as the building or room configuration. [**652:**A.9.2.6.3.2]

A.9.2.6.3.5 The assertion of separation must recognize the dust accumulation on all surfaces in the intervening distance, including floors, beam flanges, piping, ductwork, equipment, suspended ceilings, light fixtures, and walls. Process equipment or ductwork containing dust can also provide a connecting conduit for propagation between accumulation areas. In order to prevent flame propagation across the separation distance, the dust accumulation should be very low. The National Grain and Feed Association study, *Dust Explosion Propagation in Simulated Grain Conveyor Galleries*, has shown that a layer as thin as $\frac{1}{100}$ in. is sufficient to propagate flame in a limited expansion connection, such as an exhaust duct or a hallway. In the subject study, the flame propagated for at least 24.4 m (80 ft) in a gallery 2.4 m (8 ft) tall by 2.4 m (8 ft) wide. [**652:**A.9.2.6.3.5]

N **A.9.3.1** A means to determine protection requirements should be based on a risk assessment, with consideration given to the size of the equipment, consequences of fire or explosion, combustible properties and ignition sensitivity of the material, combustible concentration, and recognized potential ignition sources. Where multiple protections are prescriptively required, a risk assessment could determine that an adequate level of safety can be achieved with only some, or possibly none, of the prescribed protective measures. More specifically, while ignition source control without consideration of the potential consequences is generally not an accepted primary means of explosion protection, a risk assessment (which by definition requires consideration of the consequences) could determine that ignition source control provides an acceptable level of safety. [**652:**A.9.3.1]

A.9.3.3.1 Pneumatic conveying for product transport is to be distinguished from dust collection systems that are designed to handle airborne dust. Such airborne dust systems can be used in conjunction with pneumatic conveying and are covered in 9.3.3.5. Other gases used in this process include carbon dioxide and nitrogen. See Annex E for installation schematics depicting typical pneumatic conveying installation concepts.

A.9.3.3.2.1 For guidance on static electricity, see NFPA 77.

A.9.3.3.2.4 In plans developed to retrofit and address existing installations, ingredient transport systems that meet the specific definition are considered a lower risk activity and do not require retroactive addressing of deflagration risk, provided the system is protected from foreign material contamination, mechanical energy and size reduction activities, electrical sparks and arcs, and other identifiable ignition sources. The facility should be practicing GMP, have an HACCP plan to address contamination risks, and have a sanitation plan to address dust levels and prevent the potential for ignition sources external to the system and secondary dust deflagrations.

A.9.3.3.4.1 See NFPA 654.

A.9.3.3.5.5 Dust control in grain or product-receiving areas consists of air aspiration or dust containment during vessel or vehicle unloading. Dust control can be achieved by baffles or enclosures with air aspiration, dust suppression, choked feeding, special belt designs, slowdown techniques, or other methods.

A.9.3.3.5.8 NFPA 68 contains guidance on designing explosion vents to relieve deflagrations of combustible dusts in vessels having length-to-diameter (*L/D*) ratios of 3 or less. Separate storage of dusts within a facility is a greater hazard due to concerns with secondary explosions. The magnitude of an explosion in a dust bin is much greater than that in a grain bin. The storage of grain dust as an ingredient in feed mill or other processes should be in separate outside bins or in bins that have external walls that are equipped with explosion venting.

A.9.3.3.6.1 NFPA 91 is referenced in order to avoid extracting large amounts of text related to basic duct design. The amendments required by this chapter make the ducts acceptable for combustible dust applications.

A.9.3.3.6.1.2 High-impact areas can include elbows and joints where changes of direction occur. The use of noncombustible ceramic or steel linings is preferred.

A.9.3.3.7.4 Wet or dry filtration are both acceptable methods.

Δ **A.9.3.3.7.8** It is recommended that 38.1 mm (1.5 in.) and/or 50.8 mm (2.0 in.) I.D. hoses be used for housekeeping purposes. It is also recommended that 7.6 m (25 ft) maximum hose length be used. In most systems, the pressure losses (i.e., energy losses) through the hose represent more than 50 percent of the overall system differential pressure requirements. Shorter hose lengths can be used to improve system performance. [**652:**A.9.3.3.4.2]

Hoses of 38.1 mm (1.5 in.) I.D. are most commonly used for cleaning around equipment and for lighter duty requirements, while 50.8 mm (2 in.) I.D. hoses are used for larger dust accumulations and for cleaning large open areas. [**652:**A.9.3.3.4.2]

A.9.3.3.7.9 Ignition-sensitive materials typically have an MIE of 30 mJ or less. [**652:**A.9.3.3.4.3]

N **A.9.3.4.1.1.3** Small containers can pose an explosion hazard; however, explosion protection measures for these units are not always practicable. Consideration should be given to explosion hazards when electing to omit protection.

A.9.3.4.1.3 If the return air duct air–material separator fails, a control system should be provided to direct the return air to an auxiliary filter capable of effectively entraining the dust particles, or to produce an alarm and shut down the system.

A.9.3.4.1.3.1 For bin vents, see 9.3.4.2.3.

A.9.3.4.1.3.3 Filters used for air from negative mill pneumatics using cyclones for product separation should be permitted to be located inside of buildings without explosion venting. Clean air should be partially returned to the air makeup system. See the flow diagram in Figure A.9.3.4.1.3.3.

A.9.3.4.1.3.4 Filters used for hammer mills should be equipped with explosion venting. Clean air should not be returned to the air makeup system. See the flow diagram in Figure A.9.3.4.1.3.4.

A.9.3.4.1.3.5 Filters used for product purifiers should be permitted to be located inside of buildings without explosion venting. All clean air should be returned to the air makeup system. See the flow diagram in Figure A.9.3.4.1.3.5.

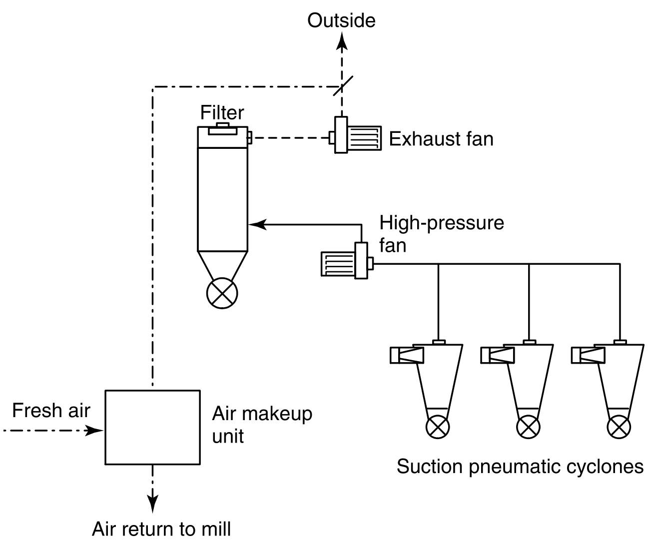
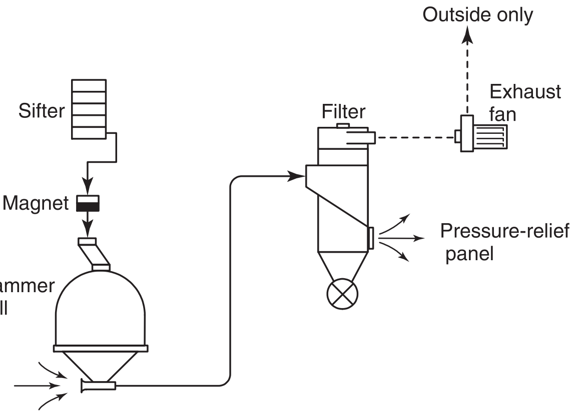


FIGURE A.9.3.4.1.3.3 Flow Diagram of Typical Pneumatic Filter Cyclone.



Δ **FIGURE A.9.3.4.1.3.4 Flow Diagram of Typical Hammer Mill Filter.**

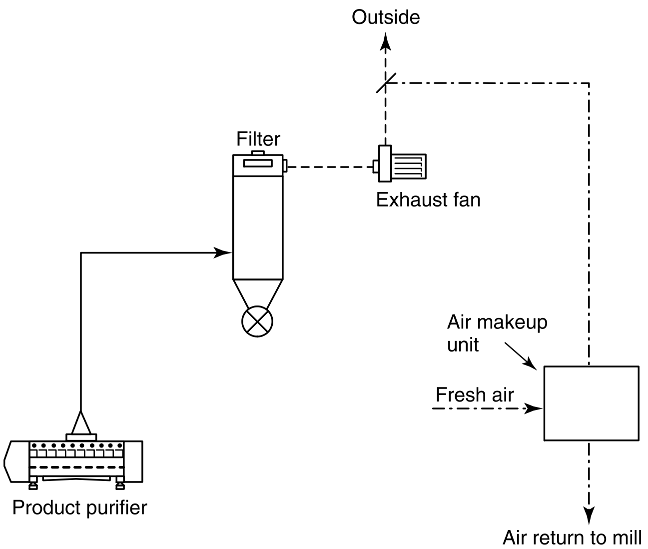


FIGURE A.9.3.4.1.3.5 Flow Diagram of Typical Product Purifier.

A.9.3.4.2 NFPA 68 provides information on this subject.

A.9.3.5.1 If the return air duct air-material separator fails, a control system should be provided to direct the return air to an auxiliary filter capable of effectively entraining the dust particles, or to produce an alarm and shut down the system.

A.9.3.5.1.1 For bin vents, see 9.3.4.2.3.

A.9.3.5.1.3 See A.9.3.4.1.3.3.

A.9.3.5.1.4 See A.9.3.4.1.3.4.

A.9.3.5.1.5 See A.9.3.4.1.3.5.

A.9.3.5.2 If the return air duct air–material separator fails, a control system should be provided to direct the return air to an auxiliary filter capable of effectively entraining the dust particles, or to produce an alarm and shut down the system.

A.9.3.5.2.1 For bin vents, see 9.3.4.2.3. Return air ducts should have a method to prevent excessive dust from returning to the plant in the case of filter failure. Methods include, but are not limited to, use of a diverter valve that exhausts return air outside, or a series of secondary filters in the return air line designed to collect the material if part of the filter medium fails.

A.9.3.9.2 See NFPA 68 for information on the design of explosion venting. Situations can occur in which it is not possible to provide calculated deflagration venting as described in NFPA 68. Such situations do not justify the exclusion of all venting. The maximum practical amount of venting should be provided, since some venting should reduce the damage potential. In addition, consideration should be given to other protection and prevention methods.

A.9.3.14.1.2 Access doors should be dusttight. Pits should be lighted and accessible and should provide ample room for cleaning, lubrication, repairs, and replacement of parts. Elevator boot sections and the spouts feeding them should be constructed so as to minimize choking of the boot.

A.9.3.14.1.4 Any motor or combination of motors utilized should be no larger than the smallest standard motor(s) capable of meeting this requirement.

A.9.3.14.1.5 Belt alignment monitoring devices are recommended for all elevator legs. Bearing monitoring systems are recommended for head, tail, and bend (knee) pulley bearings on elevator legs.

Δ **A.9.3.14.1.10** See A.9.3.15.4.

A.9.3.14.1.12 Not all bucket elevator operations are the same, and a DHA can be used to evaluate whether monitoring is required. The size, speed, type of material, presence of ignition sources, and amount of dust generated in the elevator should be taken into consideration in this evaluation. Smaller, slower bucket elevators that generate insufficient concentrations of combustible dust might not require monitoring. Prior to the 2013 edition of this standard, there was an exemption from monitoring for bucket elevators operating at less than 2.5 m/s (500 ft/min). Prior to the 2016 edition of this standard, there was an exemption from monitoring for bucket elevators operating at less than 106 m^3/hr (3750 ft^3/hr).

A.9.3.14.1.12.1 This requirement is also desirable for outside legs.

A.9.3.14.2 Prior to the 2013 edition of this standard, there was an exemption allowing bucket elevator legs handling bulk raw grain operating at less than 2.5 m/s (500 ft/min) to be installed as inside legs. Prior to the 2016 edition of this standard, there was an exemption allowing legs handling bulk raw grain operating at less than 106 m^3/hr (3750 ft^3/hr) to be installed as inside legs.

A.9.3.14.2.1 Inside legs located in concrete leg wells should be avoided. Where venting is provided for an inside bucket elevator, explosion vents should be directed to outside areas following the guidelines of NFPA 68 and distributing leg vents along the leg as recommended. Vents should never be directed to the inside of a structure. It is preferable to locate inside legs that are to be vented next to outside walls, to minimize the length of explosion relief ducts.

Explosion suppression devices can be used in conjunction with leg feed and discharge points to limit flame propagation into structures or other grain-handling equipment.

A.9.3.14.2.2 Explosion venting is recommended for all outside legs handling grain or grain products, regardless of size or use. All legs handling grain and other combustible materials, not just whole grain legs, are subject to an explosion. The leg is the most frequent location for a primary explosion to occur.

A.9.3.14.3.2 For guidance on explosion venting design guidelines, see A.9.3.14.2.2.

A.9.3.14.3.3 Not all bucket elevator operations are the same, and a DHA can be used to evaluate whether explosion protection is required. The size, speed, type of material, presence of ignition sources, and amount of dust generated in the elevator should be taken into consideration in this evaluation. Smaller, slower bucket elevators that generate insufficient concentrations of combustible dust might not require explosion protection. Prior to the 2013 edition of this standard, there was an exemption from explosion protection for bucket elevators operating at less than 2.5 m/s (500 ft/min). Prior to the 2016 edition of this standard, there was an exemption from explosion protection for bucket elevators operating at less than 106 m^3/hr (3750 ft^3/hr).

• **A.9.3.15** Throwing of grain for a considerable distance (i.e., not confined in spouts) should not be permitted unless absolutely necessary in open or semiconfined spaces, such as in barge and ship loading or in large bulk grain storage areas.

When using enclosed conveying equipment, an evaluation should be conducted to determine if ignition sources might be present and contained by the proposed enclosure. Dust collection should be considered with proper design to assure constant airflow and collection of the dust generated inside the enclosed area or device.

A.9.3.15.1 Each bulk material conveyor should be provided with a motion detector device that will cut off the power to the drive motor and actuate an alarm in the event of any slowdown equivalent to, or exceeding, 20 percent. Feed to the bulk material conveyors should be stopped or diverted.

A.9.3.15.4 CFR 1910.272(b)(2)(p)(2) requires that belting have a surface electrical resistance not greater than 300 megohms. Paragraph 9.3.15.4 requires that belting have a surface resistivity not greater than 300 megohms per square. Surface resistance in ohms and surface resistivity in ohms per square are two different specifications. Surface resistance is a point-to-point measurement. Surface resistivity is a measurement of resistance of a square unit of area and is the same regardless of the size of a material.

There is still much debate on the correct test method to use for each measurement, since it is dependent on a number of variables, including the type of material and its resistivity (how conductive or insulative the material is). This topic needs to be reviewed in much greater detail. Surface resistance and surface resistivity are not the only factors to consider. Volume resistivity should also be considered, along with the conductivity of the pulleys and the total resistance from the belt to ground.

According to NIBA — The Belting Association Technical Note 9, "Static Electricity Considerations" (2009), extensive studies by the British National Coal Board (BNCB) (1950-1966), reported by Barelay and summarized by Norman, found that belts with a surface electrical resistance of 1×10^9 ohms or under did not retain a static charge when run on a typical grounded conveyor, while those with a surface electrical resistance of 6×10^9 ohms and greater did retain a static charge. As a result of this work, the BNCB concluded that a maximum of 3×10^8 ohms resistance was a safe condition in new conveyor belts in underground coal mines.

The International Standards Organization (ISO), the National Coal Board of Britain, and the Canadian Standards Association (CSA) have selected 300 megohms (300×10^6 ohms or 3×10^8 ohms) as their definition of *static conductive.* In the United States, OSHA has also selected 300 megohms (300×10^6 ohms or 3×10^8 ohms) as the definition of *static conductive* for grain applications.

A.9.3.15.6 For equipment lined with combustible material (other than spouts), a means should be provided to have access for fire fighting. The use of noncombustible ceramic or steel linings is preferred. If combustible linings are used extensively, it is suggested that a firebreak of noncombustible lining material be used at a grain stream direction change point.

A.9.3.15.8 Spout openings in distributors and turnheads should be closed when not in use, to reduce the likelihood of propagation of flame through idle spouts.

N **A.9.3.16.5** The following information from FM 7-76, *Prevention and Mitigation of Combustible Dust Explosion and Fire*, Chapter 2.3.4.6, and CCPS/AIChE *Guidelines for Safe Handling of Powders and Bulk Solids*, Chapter 5.3.2, Blenders and Mixers, will be helpful when conducting a DHA.

When filling and emptying a mixer, mixer components must run only with tip velocities of ≤1 m/sec, safeguarded by technical measures (e.g., motor speed controller and shutdown system).

During operation in a closed condition, the rotational speed of the mixer parts (internal rotating elements) is not limited if the blades are completely covered by the material or if the filling level is 70 vol. % or more.

Circumferential velocities (tip speeds) of up to 10 m/sec can be tolerated during filling a mixer that is filled below 70 vol. % if the autoignition temperature (AIT) of the solids to be mixed is above the limits given in Table A.9.3.16.5.

Also refer to A.9.4.12.4 in NFPA 652 for blender tip speed criterion.

A.9.3.17.1 Static deposits of combustible dust on heated surfaces are subject to ignition due to carbonization of the dust. Understanding of the mechanism involved is lacking, but it does appear that there is no direct relationship between the temperature necessary to ignite a dust cloud and that necessary to ignite a dust layer. Rather, a time-versus-energy (temperature) relationship appears to be involved. The higher the temperature, the shorter the time needed for carbonization and subsequent ignition.

N **Table A.9.3.16.5 Autoignition Temperature (AIT) Limits**

MIE, mJ	1–3	3–10	10–30	30–100	100–300	300–1000	>1000
AIT Deg. C	530	500	465	430	395	360	325

The energy necessary to ignite a dust cloud has to be great enough to raise the dust particles to their ignition temperature and overcome heat losses to the surrounding air. The energy has to be of sufficient duration to ignite enough adjacent dust particles to sustain propagation of the flame front. A static dust deposit has none of the dynamic motion and heat losses of a dust cloud. Also, the insulating characteristics of organic dusts act to retard the heat loss from particles of dust in intimate contact with the heated surface. Thus, a lower temperature is necessary to establish the time–energy relationship leading to ignition. This behavior, combined with the fact that the ignition temperature of an organic dust is lowered by prolonged heat exposure, gives cause for concern over dust deposits on heated surfaces. The ignition of a dust layer and the subsequent quiescent burning can provide the pilot flame necessary to ignite a dust cloud.

A.9.3.17.1.2 For information on other dryers, see NFPA 86.

A.9.3.17.1.3 Spontaneous ignition is a primary cause of dryer fires and explosions. The requisites of this phenomenon are a heated surface or a hot airstream, a layer of product exposed to this heat, and time.

A.9.3.17.2 Typically, a grain dryer is a self-contained unit that processes bulk quantities of an agricultural commodity either by continuous flow or in batch quantities. The dryer is usually located on the plant property, adjacent to the elevator, storage building, or tank. The commodity, either directly from harvest or from interim storage, contains extraneous materials, partly as a result of harvesting, that have a tendency to interfere with the drying process and to contribute to fires within the dryer itself.

A.9.3.17.2.1 Particular attention is needed when adjacent buildings or structures are of combustible construction or have walls with vents, windows, or spout or conveyor openings.

A.9.3.17.2.3.1 The dryer can be direct fuel-fired (i.e., the products of combustion enter the drying chamber) or indirect fuel-fired (i.e., the products of combustion do not enter the drying chamber).

A.9.3.17.2.3.2 Typically, the firing rates of grain dryers are on a demand basis created by a temperature-measuring device located in the heated airstream prior to its contact with grain. The demand set point is chosen to produce the desired degree of dryness or moisture removal.

This control arrangement maintains the air temperature within the upper and lower temperature ranges of the measuring device. If the temperature range is exceeded, the burner firing rate is reduced, and when the temperature drops below the lower range, the burner firing rate is increased.

This control arrangement is satisfactory for most operating conditions, grain moisture content, and ambient temperature conditions. Operators usually recognize that they need to increase the dryer temperature setting if the grain is unusually wet and possibly slow down the rate of grain flow through the dryer. It has to be recognized that the burner needs to operate at abnormally high firing rates when the outside temperatures are unusually cold.

A.9.3.17.2.6.3 One or a combination of the following methods, depending on local conditions, should be used:

(1) Fixed water spray or automatic sprinkler systems with adequate water supplies (see NFPA 13 and NFPA 15)
(2) Hose lines, 38 mm (1½ in.), of sufficient length to reach all access openings on the dryer, connected to a 51 mm (2 in.) or larger water supply line (see NFPA 14)
(3) Small-diameter hose lines of sufficient length to reach all access openings on the dryer and supplied by the domestic water system
(4) Fixed water spray or automatic sprinkler systems supplied by a dry standpipe
(5) An adequately designed steam-smothering system
(6) Class A portable fire extinguishers

A.9.3.17.4.2.1 Spontaneous ignition is a primary cause of dryer fires and explosions. The requisites of this phenomenon are a heated surface or a hot airstream, a layer of product exposed to this heat, and time. In the case of starch, a catalyst appears to be water from leaks or condensation. Fires have occurred in such accumulations at normal operating temperatures of 177°C (350°F). Thus, the control of these elements through design, operation, cleaning, and maintenance will prevent explosions from this ignition source.

A.9.3.17.4.2.2 Typical points where spontaneous ignition is likely to occur include the following:

(1) Adjacent to steam coils that are subject to starch accumulation
(2) In tubes or ducts of dryers where starch can accumulate (e.g., in elbows below a vertical run where entrained dust will fall when the fan is shut off, where there is a sharp change of direction from vertical to horizontal, and where there is a marked change to a lower velocity, such as a duct leading into a cyclone)
(3) Near burners to detect carbon buildup

A.9.3.17.4.4.1 Where an outside dryer is provided with adequate explosion venting, fire protection or explosion suppression systems are not always necessary.

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N **A.9.3.17.5.4.3** See A.9.3.17.2.6.3.

A.9.3.19.1 Additional information and guidance for heat transfer systems can be found in NFPA 30 and NFPA 87.

A.9.3.19.1.2.3 Communication between hazardous and heat-producing areas should be arranged so that a fire partition, fire wall, and so forth, with all openings closed, is always between the hazard and the heat-producing area. The firebreak could be a nonhazardous room, entryway, airlock, and so forth, arranged so that the communicating opening between the room and the hazardous area will not be open when the communicating opening between the room and heat-producing area is open, and vice versa.

A communicating opening such as machinery doors is permitted, provided that these doors are kept locked and are only opened when either the hazardous area or the heat-producing area is shut down and will not cause a fire or explosion with the machinery door open.

A.9.3.19.1.4 See A.9.3.17.1.

A.9.3.20.2.2 If a vertical vent stack cannot be installed because of structural conditions, the vent should be permitted to be located in the side of the bin, below its top, or should be permitted to be installed at an angle of up to 30 degrees from vertical.

A.9.3.21.1 Openings of 64 mm × 64 mm (2½ in. × 2½ in.) should be used on grating for receiving pits, to limit entry of foreign objects. Larger openings could be needed to accommodate some materials, such as whole corncobs and hay cubes.

A.9.3.21.1.2 Such devices should be installed on hoppers, conveyors, or spouts that handle grain from truck dump pits, railcar dump pits, and barge or ship unloading systems prior to entry of the grain into subsequent conveyors, elevators, or processing machinery, to minimize the entry of tramp metal and other foreign objects.

A.9.3.21.1.3 NFPA 77 provides information on this subject.

N **A.9.4.1** It is not always possible or practical for existing facilities to be in compliance with the new provisions of a standard at the effective date of that standard. Therefore, "retroactivity" in 9.4.1 means that a plan should be established to achieve compliance within a reasonable time frame. [**652:**A.9.4.1]

N **A.9.4.2** A means to determine protection requirements should be based on a risk assessment, with consideration given to the size of the equipment, consequences of fire or explosion, combustible properties and ignition sensitivity of the material, combustible concentration, and recognized potential ignition sources. Where multiple protections are prescriptively required, a risk assessment could determine that an adequate level of safety can be achieved with only some, or possibly none, of the prescribed protective measures. More specifically, while ignition source control without consideration of the potential consequences is generally not an accepted primary means of explosion protection, a risk assessment (which by definition requires consideration of the consequences) could determine that ignition source control provides an acceptable level of safety. [**652:**A.9.4.2]

A.9.4.5.4 Pillow block bearings are preferred for head, tail, and bend pulleys.

A.9.4.6.2 NFPA 499 contains guidelines for determining whether an area should be categorized as a Class II area.

Δ **A.9.4.7** NFPA 77 provides information on this subject. For information about using flexible intermediate bulk containers, see 9.4.7.4 of NFPA 652.

Small static charges generated by clothing are typically not sufficient to ignite agricultural combustible dust.

A.9.4.9.2 Diesel-powered front-end loaders suitable for use in hazardous locations have not been commercially available. The following provisions can be used to reduce the fire hazard from diesel-powered front-end loaders used in Class II hazardous areas as defined in Article 500 of *NFPA 70*. [**654:**A.9.4.8.2]

(1) Only essential electrical equipment should be used, and wiring should be in metal conduit. Air-operated starting is preferred, but batteries are permitted to be used if they are mounted in enclosures rated for Type EX hazardous areas. [**654:**A.9.4.8.2(1)]
(2) Where practical, a water-cooled manifold and muffler should be used. [**654:**A.9.4.8.2(2)]
(3) Loaders that are certified to meet the Mine Safety and Health Administration (MSHA) criteria (formerly Schedule 31) found in 30 CFR 36, "Approved Requirements for Permissible Mobile Diesel-Powered Transportation Equipment," are also acceptable in lieu of A.9.4.9.2(1) and A.9.4.9.2(2). [**654:**A.9.4.8.2(3)]
(4) The engine and hydraulic oil compartments should be protected with fixed, automatic dry-chemical extinguishing systems. [**654:**A.9.4.8.2(4)]
(5) Loaders should have a high degree of maintenance and cleaning. Frequent cleaning (daily in some cases) of the engine compartment with compressed air could be necessary. Periodic steam cleaning also should be done. [**654:**A.9.4.8.2(5)]
(6) Loaders should never be parked or left unattended in the dust explosion hazard or dust fire hazard area. [**654:**A.9.4.8.2(6)]

A.9.4.9.4 Exterior docks should open at least on one side, and exterior platform areas should be considered to meet the "outdoor" provision.

A.9.4.9.5 Cleaning should be done at 4-hour intervals during periods of steady operation and at the end of each workday.

A.9.4.13.1 "NO SMOKING" signs should be posted.

A.9.6.1 Dust collection systems are designed to handle airborne dust as distinguished from pneumatic conveying for product transport.

A.9.6.2.1 Techniques to prevent or reduce dust generation and dispersal are vital to any dust control program. These techniques include the use of reduced handling speeds, dead boxes, choked feeding, snorkel loaders, dusttight enclosures, short vertical runs, cleaning, and dust suppressant, as well as many others. Preventive dust control is encouraged, since it can effectively reduce total dust control costs as well as the demands placed on the performance of subsequent dust control techniques outlined in Section 8.4 and 9.6.2.

Various oils and other liquids have been used as a dust suppressant. Each dust suppressant has its limitations and should be used with regard to applicable grain and food standards and regulations. Oil dust suppressants should not be applied directly into the leg, as there have been cases of belt slippage using oil. Application should be made in the transition spout between the receiving pit and the receiving leg. If this is not feasible, application can be made at a transfer point or discharge of a conveying system, or directly on a conveyor belt or into a screw auger. The idea is to apply the dust suppressant where there is grain turbulence, thereby allowing the dust suppressant to mix thoroughly.

N **A.9.6.2.1.1** Use of liquid dust suppression methods for dust control involves the use of fine, atomized, or fogging liquid sprays to limit the emission of combustible dusts. By using an atomized or fogging spray of liquid, which is often just water, dust can be controlled and prevented from accumulating in surrounding areas. This method is also often used in place of standard dust collection for both economical and operational reasons. [**652:**A.9.6.2]

A.9.6.2.2 Legs are the most frequent location of known primary dust explosions and can experience malfunctions, which can result in ignition of the returned dust. This section is not intended to apply to point-of-use dust collectors.

A.9.6.2.4 The purpose of this dust control method is to remove displaced air from the equipment so that it operates under a slightly negative pressure in order to reduce fugitive dust emissions from the equipment, keep the dust generated from the material being conveyed with the material, and eliminate the propagation hazard of interconnecting the conveying equipment with a central dust collection system. The dust is not removed from the equipment, and this approach does not lower the risk of a dust deflagration within the equipment itself. The point-of-use dust collector should be located near the material inlet point on the conveyor. Little dust should be drawn into the point-of-use collector.

When used on a bucket elevator leg, it is recommended that the point-of-use dust collector be installed in the down leg of the bucket elevator leg to facilitate dust release from the filters. The cross-sectional area of the transition between the duct and the leg casing should be 2.5 times the cross-sectional area of the dust collector inlet. The angle of the transition duct to the leg casing should be no less than 60 degrees.

This dust control method should be used in conjunction with a good housekeeping program, equipment maintenance strategy, and dust deflagration mitigation actions as required.

N **A.9.6.2.4(7)** Filtering efficiency specifications are provided by manufacturers. There are commercially available dust collectors using filters, both bag and cartridge type, that can be warrantied by the supplier to meet this specification for a specific application. The filtering efficiency can also be verified by testing of existing equipment.

A.9.7.1 To better understand the hazards of the operations and how to apply the provisions of this standard to a facility and operations, a hazard analysis can be conducted regarding the deflagration properties of the materials being handled, the equipment used, and the operations. See Table A.5.2.2 or use equivalent test data for deflagration properties of agricultural or food dusts.

It should be noted that the protections described in Section 9.7 might not, in themselves, eliminate explosion or deflagration propagation. Other means, when practicable, such as rotary valves, fast-closing valves, conveyor seals, or chokes can minimize propagation potential. Ultimately, if adequate explosion venting is provided or equipment fails, explosion propagation could still be possible. Additional information on deflagration isolation can be found in NFPA 69 and in the annex material of NFPA 654.

A.9.7.1.1 See NFPA 68 for information on the design of explosion venting.

N **A.9.7.1.1.1** These are locations in which combustible dust is in the air in quantities sufficient to produce explosive or ignitible mixtures under normal operating conditions, or locations where mechanical failure or abnormal operation of machinery or equipment could cause explosive or ignitible mixtures to be produced, and could also provide a source of ignition through simultaneous failure of electrical equipment, operation of protection devices, or other causes.

Situations can occur in which it is not possible to provide calculated deflagration venting as described in NFPA 68. Such situations do not justify the exclusion of all venting. The maximum practical amount of venting should be provided, since some venting should reduce the damage potential. In addition, consideration should be given to other protection and prevention methods.

A.9.7.1.1.1.3 If an explosion vent recloses after relieving an explosion pressure wave, an implosion can occur.

A.9.7.3.1 See A.9.7.1.

A.9.7.3.1.1(1)(b) The maximum allowable concentration of oxygen is very dependent on the material, its chemical composition, and, in the case of particulate solids, the particle sizes.

A.9.7.3.1.1(2) For deflagration relief venting through ducts, consideration should be given to the reduction in deflagration venting efficiency caused by the ducts.

A.9.7.3.1.1(6) This method is limited in effectiveness due to the high concentrations of inert material required and the potential for separation during handling. Other methods are preferred.

A.9.7.3.1.1(7) For information on dust retention and flame-arresting devices, see NFPA 68, Section 6.9.

N **A.9.7.3.1.2** When explosion protection methods (such as venting, suppression, etc.) in bins, silos, or tunnels cannot be fully utilized, all required prevention methods in this standard should be utilized (such as bearing sensors, belt alignment sensors, speed monitors, housekeeping, management systems, dust control systems, etc.).

Protection methods that could also be considered include, but are not limited to, separating the bin or silo from other structures and from areas where personnel are located; avoiding interventing the bins and silos; incorporating a weak seam roof into the bin or silo design; and arranging fill equipment in a manner such that the fill spouts are closed on bins and silos not being filled. An additional consideration could be calculating the surface area needed to do partial volume venting of a bin or silo to provide protection from a less-than-worst-case deflagration. For example, if a bin or silo is normally 75 percent full before the headspace is above the MEC, the venting calculation should be based on 25 percent of the silo volume.

A.9.7.4.1 Methods of explosion protection using containment, venting, and suppression protect the specific process equipment on which they are installed. Chokes, flame front diverters, and abort gates are not acceptable devices for explosion isolation due to lack of specific test standards to validate the design. However, these devices can still provide benefits such as reducing pressure transmitted to connected equipment. Determining the need for isolation is normally part of the DHA.

A.9.7.4.2 Exposures of concern include, but are not limited to, bagging operations and hand-dumping operations, where the discharge of a fireball from the pickup point endangers personnel.

A.9.7.4.2.1 A common example for the application of such isolation would be in the upstream ductwork associated with a dust collection system servicing a work area. Loading chutes less than 3 m (10 ft) in length and designed for gravity flow are not considered as ductwork. Determining the need for isolation is normally part of the DHA.

A.9.7.4.3 See NFPA 68 for information on determining the appropriate explosion venting area and arrangement. For information on venting bucket elevators, see the National Grain and Feed Association Research report, *Emergency Preplanning and Fire Fighting Manual — A Guide for Grain Elevator Operators and Fire Department Officials*.

A.9.8.3.1 Caution should be exercised in the selection of extinguishers for use on dusts; extinguishers with a high-pressure discharge could raise additional dust, resulting in further combustion or an explosion. See Annex B for supplementary information on fire protection.

A.9.8.4.1.2 An operating area is an area where personnel can be present to perform operational or maintenance tasks.

A.9.8.4.1.3 Examples of combustible contents are finished products and raw material in paper or cloth bags, cardboard boxes or containers, wood pallet storage, and packing material storage.

Annex B Supplementary Information on Fire Protection

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

B.1 Automatic Sprinklers. All areas containing combustible materials, except bulk storage tanks and bins, should be protected by suitable automatic sprinkler systems installed in accordance with NFPA 13 and NFPA 1.

B.2 Supervisory Services. For prompt detection of fires, either security service, an automatic fire detection system, or sprinkler waterflow and supervisory service should be provided. If security service is provided, routing and recording apparatus should meet the requirements of NFPA 601. Automatic fire detection systems to actuate local alarms or other suitable arrangements for automatically notifying the fire department should meet the applicable requirements of *NFPA 72*.

B.3 Hydrants. Either public or private hydrants should be provided for fire-fighting use. Hydrants should be fed by an adequate water supply.

B.4 Explosion Suppression. Explosion suppression systems designed for instantaneous detection and suppression of explosions are available for use in confined areas such as bins, tanks, dust collectors, and so forth. The use of such systems should be considered in unusually hazardous areas where other means of hazard control are not suitable. Such systems should meet the requirements of NFPA 69.

B.5 Fire-Fighting Operations. Hose streams should be used with great care to avoid creating dust clouds or causing structural damage to bins. Fog nozzles should be used.

B.6 Manual Fire Suppression. Those individuals responsible for manual fire suppression at these types of facilities should have a fire protection plan. This plan should meet the recommendations contained in the National Grain and Feed Association Research Report, *Emergency Preplanning and Fire Fighting Manual — A Guide for Grain Elevator Operators and Fire Department Officials.*

Annex C Supplementary Information on Fumigation

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

C.1 Definitions.

C.1.1 Fumigants as used in this annex are substances or mixtures that rapidly or progressively produce gases or vapors to control identified insects or other pests. Carbon dioxide and heat treatment and the use of diatomaceous earth are not included in this definition.

C.1.2 Pesticides, herbicides, and rodenticides are not considered to be fumigants. See NFPA 400 for information on storage of pesticides.

C.1.3 Fumigation is a process whereby commodities stored in a space, or the space itself, are subjected to the vapors, fumes, or gases produced by or from fumigants.

C.2 Regulatory Usage.

C.2.1 Fumigants should not be used in any manner inconsistent with the registered label or labeling.

C.2.2 The manner in which fumigants are sold, used, applied, stored, shipped, or otherwise handled, including disposal procedures, and the manner in which fumigations are conducted, are governed directly by the language of the label or labeling under which a fumigant is registered with the U.S. Environmental Protection Agency's Pesticide Registration Division, located in Washington, DC. It is a violation of federal law for any pesticide, including those registered as fumigants, to be used in any manner inconsistent with the registered label or labeling.

C.3 Fire and Explosion Prevention and Protection.

C.3.1 A thorough cleanup should be made, and all refuse, oily waste, and other combustible material, except that needing fumigation, should be removed from the area to be fumigated prior to the sealing of the premises.

C.3.2 All fire protection equipment such as sprinklers, alarms, and fire pumps should remain in operating condition during fumigation.

C.3.3 While the space is being sealed and during the fumigation and ventilation period, the use of matches, smoking materials, fires, and open flames, including flame-powered fumigant gas detection devices and any similar source of ignition, should be prohibited.

C.3.4 If it is necessary to heat the enclosure being fumigated during the fumigation, only enclosed steam or hot water systems should be used. The boiler thermostats should be effectively sealed off from the area being fumigated.

C.3.5 When buildings or other enclosures in which electric-powered equipment is located are being fumigated, all switches controlling electric power to the portion of the building being fumigated should be locked in the open position or all current-carrying conductors disconnected prior to fumigation. Electrical equipment that is explosionproof or rated for the area need not be locked out prior to and during fumigation.

C.3.6 Temporary remote control power leads with control switches located outside the fumigated space should be installed for powering circulating fans in the fumigated space. Such fans should be approved for the intended use.

C.3.7 Control valves for gas, oil, or other fuel systems, if in the area of fumigation, should be closed prior to the beginning of the fumigation operation.

C.4 Storage and Handling.

C.4.1 Fumigants, whether packaged in cartons, drums, bulk tanks, or other containers, should be stored in locked, dry, well-ventilated, enclosed areas.

C.4.2 Fire hazards as well as life and health hazards are caused by the misuse of fumigants. Direct contact of metal phosphide fumigants with water, acids, or many other liquids can cause rapid generation of hydrogen phosphide and a fire. Piling of tablets, pellets, prepacked ropes, or dust from their fragmentation can cause a temperature increase and confine the release of gas so that ignition could occur.

C.4.3 Fumigant storage areas should be properly posted to indicate the hazardous nature of the material being stored.

C.4.4 When fumigants are being handled, smoking, matches, open flames, or other sources of ignition should be prohibited in the vicinity of such handling. Metal phosphide fumigant containers should be opened outside or near well-ventilated areas and should be protected from water exposure. These containers should not be opened in a hazardous atmosphere.

C.4.5 Metal phosphide fumigants can react with water. Therefore, fumigation using metal phosphides should be avoided in wet grain. Containers of metal phosphide fumigants should be opened in open air because, under certain conditions, they can flash upon opening.

C.4.6 When fumigants are transferred from storage areas to the area of application, to commodities, or for space fumigation, only a quantity sufficient for a reasonable period of need should be moved. Unused fumigants should be returned to storage or disposed of as directed on the label.

C.5 Hazard Warning.

C.5.1 All areas where fumigants are stored should be posted, utilizing warning placards in accordance with NFPA 704.

C.5.2 It is preferable that fumigant storage areas be located in a secured, detached outside building of noncombustible construction.

C.5.3 All areas where fumigants are in use should be placarded according to the fumigant label.

Annex D Employee Health and Safety

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

D.1 Recognition. Employee health and safety in operations depends on the recognition of actual or potential hazards, controlling or eliminating these hazards, and training employees to work safely.

D.2 Guidelines. The following guidelines are recommended for the recognition, evaluation, and control of actual or potential hazards.

D.2.1 Training programs should be instituted to properly inform employees about the hazards involved in starch plants, with emphasis on the following areas:

(1) Fire and dust explosion hazards
(2) Sources of ignition and their control
(3) Confined spaces and bin entry and cleaning
(4) Fumigation
(5) Housekeeping
(6) Fire protection equipment

D.2.2 Emergency procedures to be followed in case of fire or explosion should be established. All employees should be thoroughly indoctrinated in these procedures.

D.2.3 Procedures should be established for the recognition and control of employee exposure to air contaminants.

D.2.4 Procedures should be established for locking out equipment under any conditions where startup of such equipment could subject employees to a hazardous situation.

D.2.5 The work area should be maintained in as clean, orderly, and sanitary a manner as working conditions allow.

D.2.6 Personal protective equipment should be required for each employee wherever bodily injury or health hazard is a possibility.

Annex E Schematics of Typical Pneumatic Conveying Installations

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

E.1 Installation Schematics. Figure E.1(a) through Figure E.1(i) show typical transfer systems.

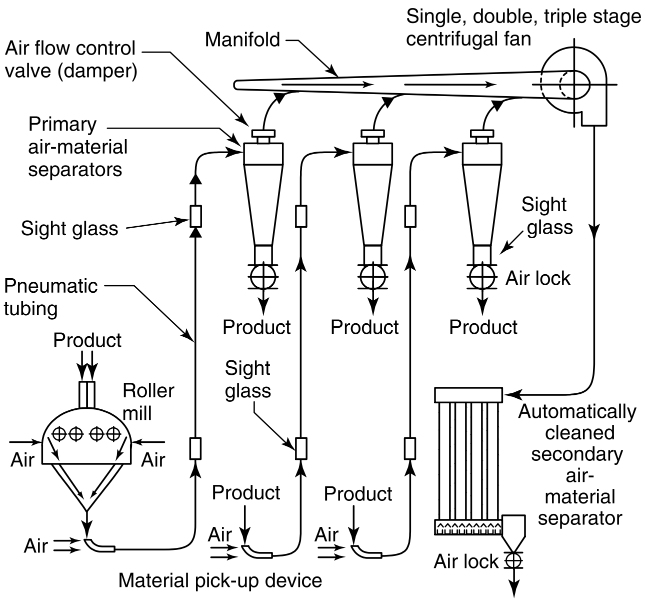

FIGURE E.1(a) Multiple Strand System, Negative Pressure Type, Typical for Cereal Mills.

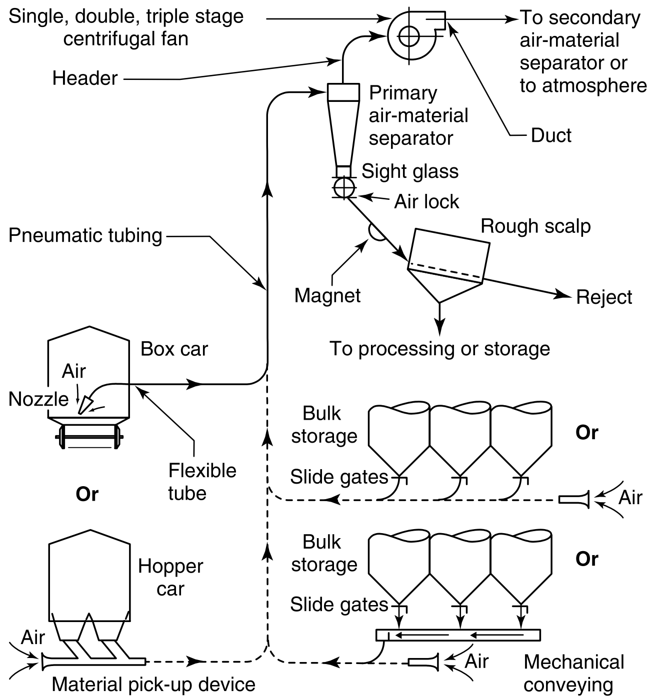

FIGURE E.1(b) Typical Car Unloader System, Negative Pressure Type, Low Capacity.

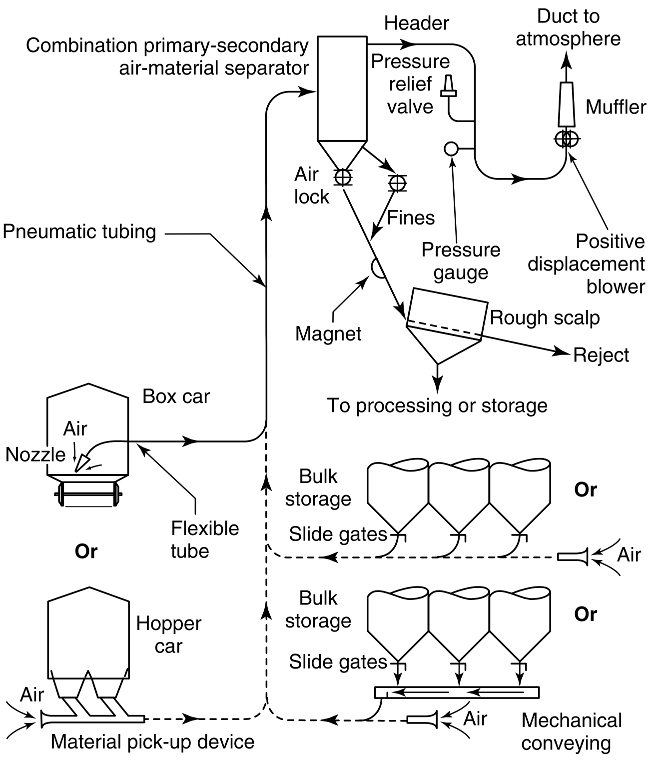

FIGURE E.1(c) Typical Car Unloader System, Negative Pressure Type, High Capacity.

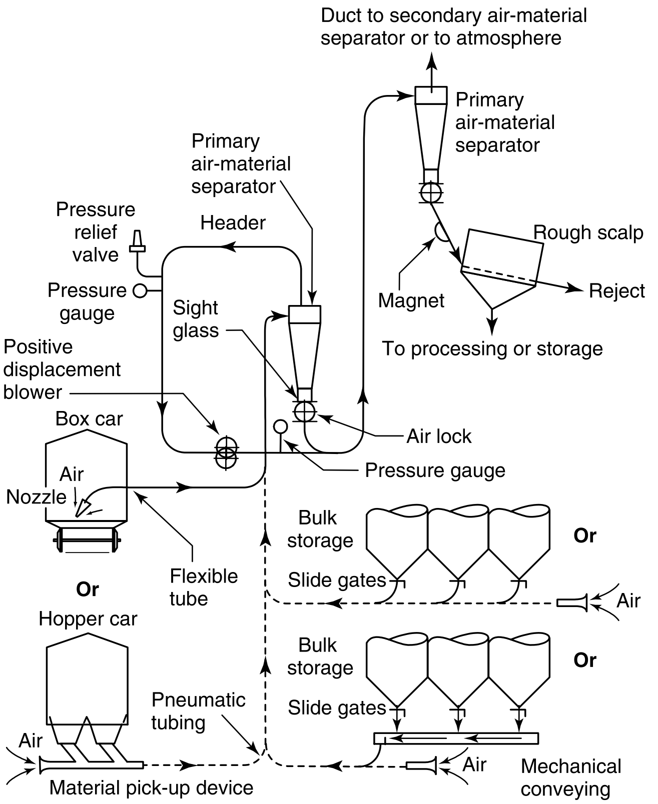

FIGURE E.1(d) Portable Car Unloader and Transfer System, Combination Negative Pressure Type and Positive Pressure Type, High Capacity.

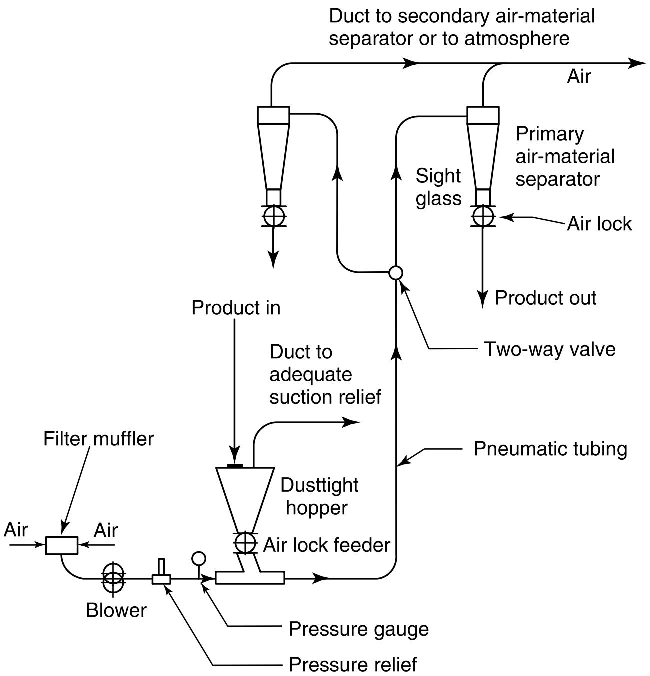

FIGURE E.1(e) Typical Transfer System, Positive Pressure Type, High Capacity.

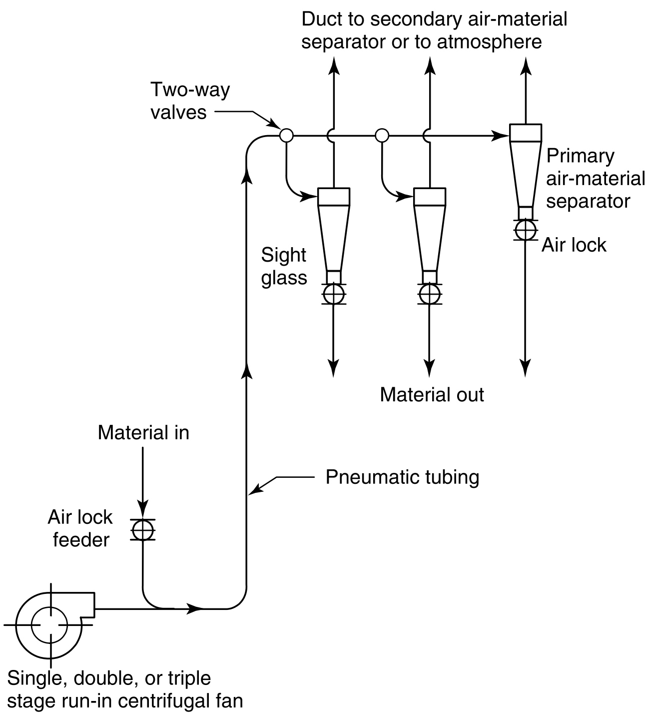

FIGURE E.1(f) Typical Transfer System, Positive Pressure Type, Low Capacity.

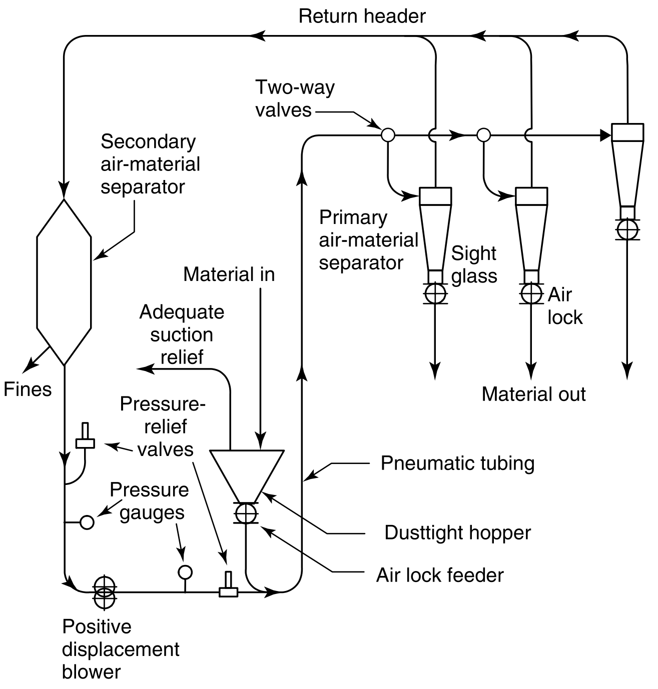

FIGURE E.1(g) Typical Recirculating Transfer System, Positive Pressure Type, High Capacity.

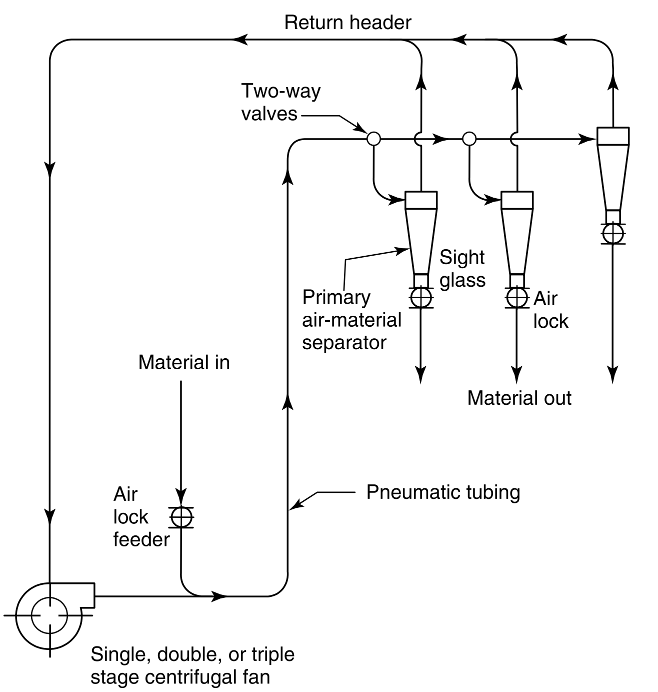

FIGURE E.1(h) Typical Recirculating Transfer System, Positive Pressure Type, Low Capacity.

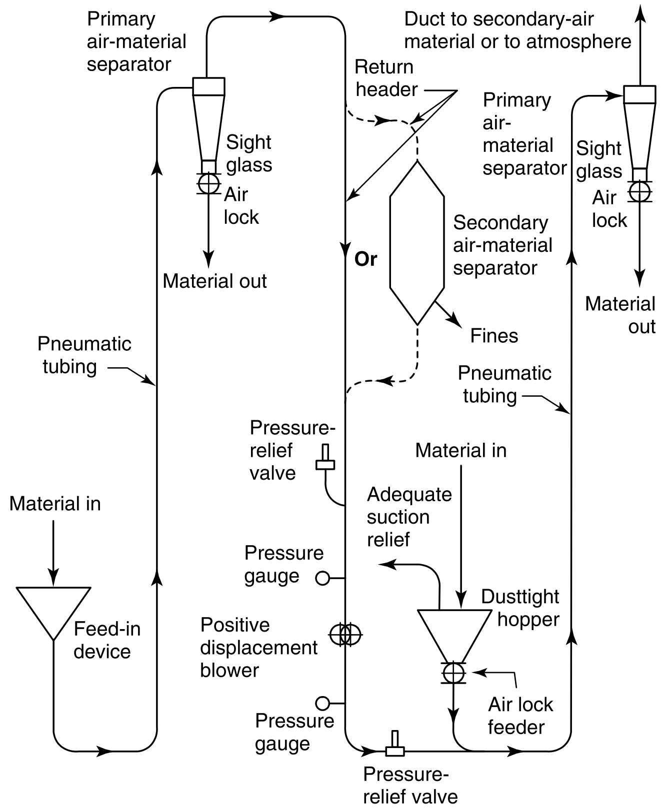

FIGURE E.1(i) Typical Transfer System, Combination Positive Pressure Type and Negative Pressure Type, High Capacity.

Annex F Checklist for Dust Hazard Analysis — Example for an Existing Facility

F.1 Introduction. This annex is intended to illustrate one example of how to develop a dust hazard analysis (DHA) for an existing facility. Other methods include, but are not limited to, "what-if" analysis, failure mode and effects analysis, fault tree analysis, and HAZOP. Additional guidance on performing a DHA is available in the *NFPA Guide to Combustible Dust* and in the AIChE *Guidelines for Hazard Evaluation Procedures.* It is not the intent of this standard to require users to apply the Process Hazard Analysis provisions of OSHA regulations in 29 CFR 1910.119, "Process Safety Management of Highly Hazardous Chemicals," in developing a DHA. The example is intentionally vague to allow users to match the complexity and extent of the analysis to the complexity and extent of the facility and its process.

F.2 Purpose. The purpose of a DHA is to identify hazards in the process and document how those hazards are being managed. The hazards addressed by this standard are the fire, deflagration, and explosion hazards of combustible dusts. There might be other hazards associated with a process, such as industrial hygiene, that are not covered in this annex. However, the process of analysis outlined in this annex could be applied to other hazards.

Δ **F.3 Checklist.** See Figure F.3 for an example of an agricultural and food dust hazard analysis (DHA) checklist.

AGRICULTURAL AND FOOD DUST HAZARD ANALYSIS (DHA) CHECKLIST

Completed document and associated reference material meets the requirements for documentation of "Dust Hazard Analysis (DHA)." A systematic review to identify and evaluate the potential fire, flash fire, or explosion hazards associated with the presence of one or more combustible particulate solids in a process or facility. [**652,** 2019]. It can be used at facilities that have simple conversion technologies, such as, but not limited to, grain elevators, flour mills, mix plants, cereal plants, and dough plants.

Date DHA completed: ______

Date DHA modified: ______

Date DHA reviewed: ______

For new processes that will be constructed and facility processes that are undergoing significant modification, the owner/operator shall complete DHAs as part of the project. For existing processes and facility compartments that are not undergoing significant modification, the owner/operator shall schedule and complete DHAs of bucket elevators, conveyors, grinding equipment, spray dryer systems, and dust collection systems by January 1, 2022. [**61:**7.1]

Facility owner: ______

Facility operator: ______

Person responsible for DHA: ______

Others involved in DHA: ______

The DHA shall be performed or led by a qualified person. [**652:**7.2.2] The owner/operator of a facility where materials determined to be combustible or explosible are present in an enclosure shall be responsible to ensure a DHA is completed in accordance with the requirements. [**652:**7.1.2]

1.0 MATERIALS EVALUATION		Yes	No	N/A	Comments	Action	Date Due
1.1	Is there a comprehensive list of all materials at the facility that present a credible combustible dust hazard?						
Hazard identification is based on the most recent Chapter 5 of NFPA 61. The list of materials should be kept in electronic or paper form and should reference the methods used to define hazards. In process, half product and mixes that contain dust less than 500 microns should also be listed and evaluated.							
1.2	Does the list include material data: sieve analysis, K_{St} testing, MIE (if warranted by K_{St} testing), and references used to define material characteristics, etc.?						
1.3	Location of list:						
1.4	Do any of the materials on the list have a K_{St} greater than 200?						
	If yes, where are these materials stored, transported, and used?						
Hazard identification is based on several factors. A higher than 200 K_{St} means the material is more energetic than a typical agricultural or food dust, and therefore these materials should be first on any facilities evaluation list. If all materials have similar K_{St} and other characteristics, the evaluation of the hazard can be simplified to a typical general case.							
1.5	Do any of the materials on the list have an MIE of less than 30 mJ?						
	If yes, where are these materials stored, transported, and used?						
If the MIE is found to be less than 30 mJ, an unusual static energy risk exists, and the facility must be prepared to institute special handling procedures to prevent dust ignition.							
1.6	Have P&IDs or similar documents been used to identify equipment and processes that need to be evaluated?						
Where are the processes and facility areas where flash fire and explosion hazards potentially exist?							
1.7	Location of system P&IDs highlighting equipment to be evaluated:						
1.8	Location of facility drawing illustrating areas of potential concern:						
1.9	Do you have a breakdown of the materials used in each process or facility area?						
	Where is this information kept?						
The DHA shall include the following: (1) Identification and evaluation of the process or facility areas where fire, flash fire, and explosion hazards exist (2) Where such a hazard exists, identification and evaluation of specific fire and deflagration scenarios shall include the following: (a) Identification of safe operating ranges (b) Identification of the safeguards that are in place to manage fire, deflagration, and explosion events (c) Recommendation of additional safeguards where warranted, including a plan for implementation [**652:**7.3.1]							
4.2.1.2 The objectives stated in NFPA 61, Section 4.2, shall be deemed to be met when, consistent with the goal in 4.2.1 and the provisions in NFPA 61, Sections 1.4 and 1.5, the following have been achieved: (1) The facility, processes, and equipment are designed, constructed, and maintained in accordance with the prescriptive criteria set forth in this standard. (2) The management systems set forth in this standard are implemented.							
If the material evaluated matches that of a typical agricultural of food dust, use of the prescriptive requirements in NFPA 61 meets the minimum requirements for mitigation of the hazard. If not, best practice requires a hazard analysis method appropriate to the size, complexity, and hazards of the process.							

2.0 BUILDING AND FACILITY DESIGN (NFPA 61, Section 9.2)		Yes	No	N/A	Comments	Action	Date Due
NFPA 70 defines location, hazard class, division, and group in Article 500.5. Class II locations are those that are hazardous because of the presence of combustible dust. In Division 1 locations, the hazard is present in quantities sufficient to produce explosive or ignitible mixtures. In Division 2 locations, the hazard might be present under abnormal operations. Group G includes agricultural and food dusts. "Unclassified" is used to describe low-hazard locations and areas with management and sanitation plans that prevent dust accumulation.							
This assessment is a best practice and is seen as a method of understanding what flaws a current structure has compared to NFPA 61 requirements prior to the 2020 edition.							
2.1	Has the construction, modification, renovation, change of use, or change of occupancy classification of all buildings and structures complied with all governing building codes?						
2.2	Has a qualified person evaluated the facility and determined locations that are Class II, Group G, Division 1 or Division 2, and where the facility should be considered unclassified due to cleaning practices or absence of combustible dust?						

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Δ **FIGURE F.3 Agricultural and Food Dust Hazard Analysis (DHA) Checklist.**

AGRICULTURAL AND FOOD DUST HAZARD ANALYSIS (DHA) CHECKLIST

2.0 BUILDING AND FACILITY DESIGN (NFPA 61, Section 9.2, continued)		Yes	No	N/A	Comments	Action	Date Due
2.3	Has a drawing or map of the rated areas been developed?						
	Where is this information kept?						
2.4	Are all areas determined to be Class II, Division 1 or 2 in full compliance with applicable requirements related to *NFPA 70*, Article 502?						
2.5	Do electrical wiring and power equipment meet all applicable requirements of *NFPA 70*, including those for hazardous locations, based on a review by a knowledgeable person?						
2.6	Are enclosures built to segregate dust explosion hazard areas from other areas designed such that they will not fail before the explosion pressure is vented to a safe outside location?						
2.7	Are there any areas classified as Class II, Group G, Division 1 that use masonry for the construction of exterior walls or roofs?						
	If yes, are the masonry walls designed for explosion resistance to preclude failure of these walls so the explosion pressure can be vented safely to the outside?						
2.8	Are structures housing personnel-intensive areas not directly involved in operations located remote from storage silos and headhouse structures, with the exception of small control rooms?						
2.9	Are any silos and headhouses constructed of reinforced concrete?						
	If yes: (a) Are they separated from personnel-intensive areas by at least 30 m (100 ft)?						
	(b) Do the structures have inside elevator legs?						
	If yes, is the structure equipped with explosion venting, or are the inside elevator legs equipped with explosion protection?						
2.10	Is a lightning protection system provided?						
	If yes, is it in accordance with NFPA 780?						
2.11	Are there any areas where separation is used to limit the dust explosion hazard or deflagration hazard area within a building? If yes, proceed to 2.12; if no, proceed to 2.15.						
2.12	Was the separation distance between the dust explosion or deflagration hazard area and surrounding exposures determined by an engineering evaluation, and is the distance at least 11 m (35 ft)?						
2.13	Is the separation area free of dust?						
	If no, where dust accumulations exist on any surface, is the color of the surface readily discernable?						
2.14	Are horizontal surfaces in the buildings minimized to prevent accumulations of dust in interior structural areas where significant dust accumulations could occur?						
2.15	Are storage areas larger than 465 m^2 (5000 ft^2) and containing packaging, bagging, palletizing, and pelleting equipment cut off from all other areas with fire barrier walls designed for a minimum fire resistance of 2 hours in accordance with Chapter 8 of *NFPA 5000*?						
2.16	Are warehouse areas designed in accordance with *NFPA 5000*?						
2.17	Are necessary openings in fire walls and fire barriers kept to a minimum, as small as practicable, and protected with listed self-closing fire doors, fire shutters, fire dampers, or penetration seals installed in accordance with Chapter 8 of *NFPA 5000*?						
2.18	If hold-open devices are used, are they listed and designed to activate and allow the door to close upon sensing at least one of the following: (1) heat, (2) smoke, (3) flames, or (4) products of combustion?						
2.19	Is adequate means of egress provided in accordance with NFPA *101*?						
2.20	Are bin decks provided with two means of egress remote from each other, such that a single fire or explosion event will not likely block both means of egress, or is the travel distance less than 15 m (50 ft) if only one means of egress is available?						

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Δ FIGURE F.3 *Continued*

AGRICULTURAL AND FOOD DUST HAZARD ANALYSIS (DHA) CHECKLIST

2.0 BUILDING AND FACILITY DESIGN (NFPA 61, Section 9.2, continued)		Yes	No	N/A	Comments	Action	Date Due
2.21	Do any MCCs require a pressurization system and alarm installed per code?						
2.22	Are there any deficient or nonconforming items identified?						
	If yes, was a plan written with estimated dates for bringing structure into compliance with this set of requirements?						
3.0 IGNITION SOURCE CONTROL (NFPA 61, Section 9.4)		**Yes**	**No**	**N/A**	**Comments**	**Action**	**Date Due**
3.1	Have grounding and bonding of pipes and equipment been universally applied to the system and its components to ensure static will be dissipated? (resistance to ground ≤ 1 megohm)						
3.2	Does any motor-driven equipment meet requirements of NFPA 505 and 9.4.9.2.1 through 9.4.9.6 of NFPA 61?						
3.3	Are antifriction bearings used on all machinery, conveyors, legs, and processing equipment?						
3.4	Are bearings kept free from dust, product, and excessive lubricant?						
3.5	Are bearings that are directly exposed to a dust deflagration hazard monitored for overheating?						
3.6	What form does the monitoring take? Describe the program or process and where information is kept.						
3.7	Are bearings on legs and conveyors located outside the machinery enclosures and protected from dust exposure?						
3.8	Are bearings accessible for inspection?						
3.9	Are support bearings on screw conveyors and other similar equipment sealed?						
3.10	Are pneumatic conveying systems installed in accordance with 9.3.3 and 9.3.5 through 9.3.9 of NFPA 654?						
3.11	Are all system components electrically conductive?						
3.12	Is a hot work program in place for dust hazard–rated areas to prevent hot work from being conducted, including the use of nonrated electric, pneumatic, or powder-driven tools, except when no dust-producing operations are taking place, and no combustible materials or dust is located in the vicinity of the operation? (See 21.26 - 21.42.)						
3.13	Are there any deficient or nonconforming items identified?						
	If yes, was a plan written with estimated dates for bringing structure into compliance with this set of requirements?						
4.0 BINS, TANKS, AND SILOS (NFPA 61, 9.3.9)		**Yes**	**No**	**N/A**	**Comments**	**Action**	**Date Due**
4.1	Does the construction of bins, tanks, and silos conform to applicable local, state, or national codes?						
4.2	Where explosion relief vents are provided on bins, tanks, and silos, are they rated to operate before the container walls fail?						
4.3	Do access doors or openings meet the following requirements: (1) They shall be provided to permit inspection, cleaning, and maintenance and to allow effective use of fire-fighting techniques in the event of fire within the bin, tank, or silo. (2) They shall be designed to prevent dust leaks.						
4.4	Where a bin, tank, or silo has a personnel access opening provided in the roof or cover, is the smallest dimension of the opening at least 610 mm (24 in.)?						
4.5	Are there any deficient or nonconforming items identified?						
	If yes, was a plan written with estimated dates for bringing structure into compliance with this set of requirements?						
5.0 MARINE TOWERS (NFPA 61, 9.2.8)		**Yes**	**No**	**N/A**	**Comments**	**Action**	**Date Due**
Does the facility or process include marine towers? If yes, complete 5.0; if no, skip to 6.0.							
5.1	Has the location of marine towers been included in the map and assessment in 2.2 and 2.3?						
5.2	Are marine towers constructed of noncombustible materials?						

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Δ FIGURE F.3 ***Continued***

AGRICULTURAL AND FOOD DUST HAZARD ANALYSIS (DHA) CHECKLIST

5.0 MARINE TOWERS (NFPA 61, 9.2.8, continued)		Yes	No	N/A	Comments	Action	Date Due
5.3	Are movable marine towers provided with automatic or manually operated brakes?						
5.4	Are movable marine towers provided with automatic or manual rail clamps?						
5.5	Do rail clamps activate when the wind velocity is great enough to cause movement of the tower, even when brakes or gear drives are preventing the rail wheels from turning?						
5.6	Is equipment to monitor wind velocity installed on movable marine towers?						
5.7	Do movable marine towers have provisions for emergency tie-downs?						
5.8	For marine vessel loading, do conveyors, spouts, and drags have safety devices to prevent the equipment from falling if the operating cable(s) break?						
5.9	Are there any deficient or nonconforming items identified?						
	If yes, was a plan written with estimated dates for bringing structure into compliance with this set of requirements?						
6.0 CONVEYORS, SPOUTS, AND THROWS OF MATERIAL (NFPA 61, 9.3.15)		**Yes**	**No**	**N/A**	**Comments**	**Action**	**Date Due**
6.1	Are bulk material conveyor belts designed to either relieve or stop if the discharge end becomes plugged?						
6.2	Are bulk material conveyor belts (grain handling or similar) equipped with belt alignment and hot bearing sensors at the head and tail?						
6.3	Are screw, drag, or en-masse conveyors fully enclosed in metal housings and designed to either relieve or stop if the discharge end becomes plugged?						
6.4	Are fixed spouts dusttight?						
6.5	Are combustible linings used in spouts or other handling equipment in any location other than wear points or impact points?						
6.6	Do ducts or conveyors that penetrate fire-rated walls or partitions have necessary mitigation to prevent fire propagation from area to area?						
6.7	Are there any deficient or nonconforming items identified?						
	If yes, was a plan written with estimated dates for bringing structure into compliance with this set of requirements?						
7.0 GENERAL EQUIPMENT DESIGN (NFPA 61, 9.3.3.2)		**Yes**	**No**	**N/A**	**Comments**	**Action**	**Date Due**
7.1	Are any ingredient transport systems present in the process per NFPA 61, 3.3.22? (This system shall be permitted to be installed inside of a building without explosion protection where all of the following requirements from 9.3.3.2.4 are met: (1) The system is a negative or positive pressure pneumatic conveying system. (2) The system, through its design, is isolated from the addition of mechanical or electrical energy and process activities such as cooking or drying, by positive means, such as rotary valves, filters, normally closed valves, or sealed hoppers, from outside events that could trigger an event such as a flash fire or deflagration. (3) The system is not a bulk raw grain transportation pneumatic system or dust collection system.)						
7.2	Are magnets and screens located upstream of equipment and arranged where they can be easily inspected and cleaned?						
7.3	Are e-stops installed and routinely tested to ensure appropriate function?						
7.4	On normal shutdown of any process that contains combustible dust, does the system maintain design air velocity until the material is purged from the system?						
7.5	If a conveyor runs adjacent to buildings or structures of combustible construction or adjacent to walls with vents, windows, or spout or conveyor openings, are there seals, chokes, or fast-closing valves to minimize propagation potential through these openings?						

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Δ FIGURE F.3 *Continued*

AGRICULTURAL AND FOOD DUST HAZARD ANALYSIS (DHA) CHECKLIST

7.0 GENERAL EQUIPMENT DESIGN (NFPA 61, 9.3.3.2, continued)		Yes	No	N/A	Comments	Action	Date Due
7.6	Are all connected fans suitable for material handling?						
7.7	Are there any deficient or nonconforming items identified?						
	If yes, was a plan written with estimated dates for bringing structure into compliance with this set of requirements?						
8.0 PIPING, VALVES, AND BLOWERS (NFPA 61, 9.3.3.3)		Yes	No	N/A	Comments	Action	Date Due
Positive- and negative-type pressure systems are permitted. Where the blower discharge pressure and its conveying system are designed to operate at gauge pressures exceeding 103 kPa (15 psi), the system shall be designed in accordance with Section VIII of ASME *Boiler and Pressure Vessel Code*.							
8.1	Are all piping and tubing systems airtight, dusttight, and grounded? (resistance to ground ≤ 1 megohm)						
8.2	Are all piping and tubing systems properly supported to include the weight of material in a full or choked position, and can they be disassembled for cleaning and unchoking in a safe and efficient manner?						
8.3	Are all pressure- and vacuum-relief valves located, designed, and set to relieve pressure to protect system components?						
8.4	Are multiple-direction valves of airtight and dusttight construction and sized to effect a positive diversion of the product, and does diversion in one direction seal all other directions from air, dust, or product leakage?						
8.5	Are there any deficient or nonconforming items identified?						
	If yes, was a plan written with estimated dates for bringing structure into compliance with this set of requirements?						
9.0 RECEIVING AND SHIPPING CONVEYANCES (NFPA 61, 9.3.3.4)		Yes	No	N/A	Comments	Action	Date Due
9.1	Do all transport modes such as railcars (hopper cars, boxcars, or tank cars) and trucks (both receiving and shipping in bulk), into which or from which potentially combustible commodities or products are pneumatically conveyed, electrically bonded to the plant ground system, or earth grounded? (resistance to ground ≤ 1 megohm)						
9.2	Are all systems protected with filters on the inlet air used for transporting the combustible material pneumatically?						
9.3	Are all trucks, railcars, and other containers being filled provided with filters designed to prevent dust liberation into the fill building or structure?						
9.4	Are unloading systems protected with magnets or magnet detection?						
9.5	Are receiving systems equipped with one or more devices (e.g., grating, wire mesh screens, permanent magnets, listed electromagnets, pneumatic separators, or specific gravity separators) to minimize or eliminate tramp material from the product stream?						
9.6	Are there any deficient or nonconforming items identified?						
	If yes, was a plan written with estimated dates for bringing structure into compliance with this set of requirements?						
10.0 DUST COLLECTION SYSTEMS PRESCRIPTIVE REQUIREMENTS (NFPA 61, 9.3.3.5)		Yes	No	N/A	Comments	Action	Date Due
10.1	Do any fans or blowers transport combustible dust through the fan or blower?						
	If yes, are fans built of spark-resistant construction?						
10.2	Are any dust control devices attached to equipment that grind, pulverize, mill, or hammer mill agricultural or food materials that are combustible isolated from other systems?						
	If no, is the manifolded dust equipment attached only to equipment that is used for sizing of oilseed meals or grain hulls?						
10.3	Does the dust collection system for hoppers and pits effectively control the dust and prevent it from leaving the system?						

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Δ **FIGURE F.3** *Continued*

AGRICULTURAL AND FOOD DUST HAZARD ANALYSIS (DHA) CHECKLIST

10.0 DUST COLLECTION SYSTEMS PRESCRIPTIVE REQUIREMENTS (NFPA 61, 9.3.3.5, continued)		Yes	No	N/A	Comments	Action	Date Due
10.4	Is the dust collection system interlocked with related machinery so that it starts up before the machinery and prevents machinery operation when out of service?						
10.5	Is there an alarm (visual or audible) that is tripped when a dust collection system collecting combustible dust is shut down?						
	Does the alarm trigger a shutdown process?						
	If the collection system emergency vents or suppression is activated by an explosion, does the system shut down?						
10.6	Is differential pressure across filter media tracked, and is the media changed based on the readings observed?						
10.7	Are all dust bins or tanks that store grain dust located outside the building structure, constructed of noncombustible material, and isolated with rotary valves or similar from the other portions of the system?						
10.8	Are all dust collectors located outside the facility and isolated with rotary valves or similar from the other portions of the system? If yes, skip to 10.10.						
10.9	Do all dust collectors located inside the building have deflagration venting based on NFPA 68 and/or an explosion suppression system based on NFPA 69? If no:						
	(a) Do these dust collectors handle only material generated as a by-product to removing moisture from an air stream? (e.g., coolers, extruders, wet grain flakes)						
	(b) Are these dust collectors located on the top of a bin and do they form a bin vent as defined in NFPA 61?						
	(c) Are the filters used only for classifying agricultural or food products with air (air classifier or purifiers)?						
	Is exhaust air from dust collectors/receivers returned to the building? If yes, see 14.0.						
10.10	Are there any deficient or nonconforming items identified?						
	If yes, was a plan written with estimated dates for bringing structure into compliance with this set of requirements?						

11.0 DUCT SYSTEMS PRESCRIPTIVE REQUIREMENTS (NFPA 61, 9.3.3.6)		Yes	No	N/A	Comments	Action	Date Due
11.1	Does the duct ever contain enough dust to support a deflagration (above 25% MEC)?						
11.2	Does the system conveying velocity, as designed, ensure that the interior surfaces of all piping or ducting is free of accumulations under all normal operating modes?						
11.3	Are flexible connections static-dissipative, bonded and grounded, resistance to ground ≤ 1 megohm?						
11.4	Is the duct lining noncombustible?						
11.5	Are all ducts that return air to the building inspected and cleaned at least annually?						
11.6	Are isolation devices provided to prevent deflagration propagation from equipment through upstream ductwork to the work areas?						
11.7	Have ducts that handle combustible dust particulate solids been designed and installed to conform with the requirements of NFPA 91 with the exception found in NFPA 61?						
11.8	Have nonconductive materials such as plastic or fiberglass been avoided in all duct systems that could potentially handle combustible dust?						
11.9	Does the duct draw in air from spaces where there are combustible dusts in hazardous quantities?						
11.10	Are horizontal ducts provided with access openings for the removal of combustible dusts?						
11.11	If isolation is used on the ductwork inside a building or structure, is the ductwork designed to withstand the flame speed and pressure of an isolated event?						
11.12	Are there any deficient or nonconforming items identified?						
	If yes, was a plan written with estimated dates for bringing structure into compliance with this set of requirements?						

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Δ **FIGURE F.3** *Continued*

AGRICULTURAL AND FOOD DUST HAZARD ANALYSIS (DHA) CHECKLIST

12.0 CENTRALIZED VACUUM CLEANING SYSTEMS (NFPA 61, 9.3.3.7)		Yes	No	N/A	Comments	Action	Date Due
Does the facility have a centralized vacuum cleaning system? If yes, complete 12.0; if no, skip to 13.0.							
12.1	On normal shutdown of the process, does the system maintain design air velocity until the material is purged from the system?						
12.2	Does the system provide minimum conveying velocities at all times, whether the system is used with single or multiple simultaneous operators?						
12.3	If a fire detection system is incorporated into the centralized vacuum, are safety interlocks in place for air-moving devices and process operations?						
12.4	If there are manifolded pickups on the central vacuum system, are they equipped with an isolation device?						
12.5	Are the central vacuum system hose stations located at strategic points (where dust emissions are known to occur)?						
12.6	Are only static-conductive vacuum cleaning tools used, and are they properly grounded to the hose end?						
12.7	Is flexible hose properly grounded to prevent static buildup?						
12.8	Are all vacuum truck hoses and couplings static-dissipative or conductive and grounded?						
12.9	Are there any deficient or nonconforming items identified?						
	If yes, was a plan written with estimated dates for bringing structure into compliance with this set of requirements?						

13.0 AIR-MATERIAL SEPARATORS (NFPA 61, 9.3.4.1.1 - 9.3.4.1.2)		Yes	No	N/A	Comments	Action	Date Due
13.1	Are all air-material separators connected to processes that are potential sources of ignition (e.g., hammer mills, ovens, direct-fired dryers, and other similar equipment regardless of location) protected by properly designed vents or suppression systems?						
13.2	Are interior separators protected so that explosion pressures will not rupture the ductwork or the device?						
13.3	Are there any devices on site smaller than 762 mm (30 in.) in diameter that are not protected because they meet the conditions found in NFPA 61, 9.3.4.1.2?						
13.4	Are AMS that handle more than 25% of the MIE of any combustible dust protected with appropriate explosion venting or inerting systems?						
13.5	Where are the explosion venting calculations or suppression design information located?						
13.6	Is there a means of preventing deflagrations from propagating down the ducts of AMS that return air to a building?						
13.7	Are there any deficient or nonconforming items identified?						
	If yes, was a plan written with estimated dates for bringing structure into compliance with this set of requirements?						

14.0 RECYCLING OF FILTERED AIR (NFPA 61, 9.3.4.1.3)		Yes	No	N/A	Comments	Action	Date Due
Does the facility recycle air from air-material separators? If yes, complete 14.0; if no, skip to 15.0.							
14.1	Is the air that is returned inside the building or to air-makeup systems filtered to the efficiency of 0.02 g per dry standard cubic meter of airflow (0.008 grain per dry standard cubic foot of airflow)?						
14.2	Is the air from hammer mill filters or other devices that add energy to the system discharged outside the facility?						
14.3	Is the collector or exhaust system provided with explosion suppression or isolation to prevent deflagration from the collector from entering the building?						
14.4	Are there any deficient or nonconforming items identified?						
	If yes, was a plan written with estimated dates for bringing structure into compliance with this set of requirements?						

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Δ **FIGURE F.3** ***Continued***

AGRICULTURAL AND FOOD DUST HAZARD ANALYSIS (DHA) CHECKLIST

15.0 BUCKET ELEVATOR LEGS (NFPA 61, 9.3.14)		Yes	No	N/A	Comments	Action	Date Due
Does the facility have fully enclosed bucket elevators or lifts that handle potentially combustible dust hazard materials? If yes, complete 15.0; if no, skip to 16.0. Note: Finished breakfast cereal product transported in open bottom lifts would be an example of a material NOT affected by this section.							
15.1	Are any bucket elevators located fully or partially inside of a building, structure, or tunnel?						
15.2	Are bucket elevators that move combustible materials that could generate dust hazard (casing, head and boot sections, access openings, and connecting conveyances) dusttight and constructed of noncombustible materials?						
15.3	Is explosion venting or suppression provided for each elevator leg?						
	If not, is isolation provided on the feed and discharge end with deflagration isolation in accordance with NFPA 69?						
15.4	Is each leg independently driven by motor(s) and drive train(s) capable of handling the full-rated capacity of the elevator leg without overloading?						
15.5	Are line shaft drives capable of handling the full-rated capacity of all connected equipment without overloading?						
15.6	Are multiple motor drives interlocked to prevent operation of the leg upon failure of any single motor?						
15.7	Can drive start an unchoked leg under full (100%) load?						
15.8	Is each leg provided with a speed sensor device that will cut off the power to the drive motor and actuate an alarm in the event the leg belt slows to 80% of normal operating speed, and will feed to leg be stopped or diverted?						
15.9	Has proper lagging been installed on system pulleys and related devices?						
15.10	Has proper monitoring equipment been installed to ensure that hot bearings, misalignment, and other abnormal conditions are detected before they cause a dangerous situation?						
15.11	Are all spouts intended to receive grain or combustible dust hazard materials directly designed and installed to handle the full-rated elevating capacity of the largest leg feeding such spouts?						
15.12	Are there any deficient or nonconforming items identified?						
	If yes, was a plan written with estimated dates for bringing structure into compliance with this set of requirements?						

16.0 PROCESSING MACHINERY AND EQUIPMENT (NFPA 61, 9.3.21)		Yes	No	N/A	Comments	Action	Date Due
16.1	Are receiving systems prior to elevator legs equipped with one or more devices such as grating, wire mesh screens, permanent magnets, listed electromagnets, pneumatic separators, or specific gravity separators?						
16.2	Are tributary spouts or conveyors that feed grain or grain products for size reduction into grinders, pulverizers, or rolling mills equipped with permanent magnets, listed electromagnets, pneumatic separators, specific gravity separators, scalpers, or screens to exclude metal or foreign matter?						
16.3	Is equipment bonded and grounded?						
16.4	Are processing machinery and components such as magnets mounted to facilitate access for cleaning?						
16.5	For starch grinding mills, is carbon steel avoided in the grinding chamber and for moving parts?						
16.6	Are the reels or sieves of screens, scalpers, and similar devices in dusttight enclosures?						
16.7	Are connecting ducts for starch-processing machinery metal or electrically conductive, nonmetallic or flexible connecting ducts having an electrical resistance not greater than 1 megohm?						
16.8	Where multiple starch material sources are connected to a common conveyor, air-material separator, or similar device, is each connected source equipped with deflagration isolation in accordance with NFPA 69?						

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Δ **FIGURE F.3** *Continued*

AGRICULTURAL AND FOOD DUST HAZARD ANALYSIS (DHA) CHECKLIST

16.0 PROCESSING MACHINERY AND EQUIPMENT, continued		Yes	No	N/A	Comments	Action	Date Due
16.9	Is dry milling or grinding of starch performed in a separate building with explosion relief or in a separate room isolated from other areas by interior walls designed not to fail before explosion pressure is vented to a safe, outside location? OR, is the grinding equipment designed to be protected in accordance with NFPA 68 or NFPA 69?						
16.10	Have all elevator legs handling bulk raw grain been assessed based on 9.3.14.2?						
16.11	Are there any deficient or nonconforming items identified?						
	If yes, was a plan written with estimated dates for bringing structure into compliance with this set of requirements?						
17.0 GRAIN AND SPRAY DRYER (NFPA 61, 9.3.17.2 - 9.3.17.5)		**Yes**	**No**	**N/A**	**Comments**	**Action**	**Date Due**
Does the facility have grain or spray dryers? If yes, complete 17.0; if no, skip to 18.0.							
17.1	Have each of the key equipment type designs been assessed based on requirements of NFPA 61, 9.3.17?						
17.2	Are there any deficient or nonconforming items identified?						
	If yes, was a plan written with estimated dates for bringing structure into compliance with this set of requirements?						
18.0 HEAT TRANSFER OPERATIONS (NFPA 61, 9.3.19)		**Yes**	**No**	**N/A**	**Comments**	**Action**	**Date Due**
Does the facility have heat transfer operations? If yes, complete 18.0; if no, skip to 19.0.							
18.1	Are heat transfer devices utilizing air, steam, or vapors of heat transfer fluids provided with pressure-relief valves where necessary?						
18.2	Are relief valves on systems employing combustible heat transfer media vented to a safe, outside location?						
18.3	Are heaters and pumps for combustible heat transfer fluids located in a separate, dust-free room or building of noncombustible construction that is protected by automatic sprinklers?						
18.4	Is air for combustion taken from a clean, outside source?						
18.5	Are enclosures for heat exchangers constructed of noncombustible materials and equipped with access openings for cleaning and maintenance?						
18.6	Are heat exchangers located and arranged in a manner that does not allow combustible dust to accumulate on coils, fins, or other heated surfaces?						
18.7	Are heat exchangers interlocked to shut down the heater and fluid transfer pumps upon activation of the fire protection and/or deflagration protection systems for any areas served by this system?						
18.8	Are heating units provided with a source of combustion air ducted directly from the building exterior or from an unclassified location?						
18.9	Are there any deficient or nonconforming items identified?						
	If yes, was a plan written with estimated dates for bringing structure into compliance with this set of requirements?						
19.0 VENTILATION AND VENTING (NFPA 61, 9.3.20)		**Yes**	**No**	**N/A**	**Comments**	**Action**	**Date Due**
19.1	Have each of the key equipment type designs been assessed based on requirements of NFPA 61, 9.3.20?						
19.2	Are there any deficient or nonconforming items identified?						
	If yes, was a plan written with estimated dates for bringing structure into compliance with this set of requirements?						
20.0 MITIGATION							
Dust Control		**Yes**	**No**	**N/A**	**Comments**	**Action**	**Date Due**
20.1	Have each of the key equipment type designs been assessed based on requirements of NFPA 61, Section 9.6?						

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Δ **FIGURE F.3** *Continued*

AGRICULTURAL AND FOOD DUST HAZARD ANALYSIS (DHA) CHECKLIST

20.0, MITIGATION, continued							
Dust Control, continued		Yes	No	N/A	Comments	Action	Date Due
20.2	Are there any deficient or nonconforming items identified?						
	If yes, was a plan written with estimated dates for bringing structure into compliance with this set of requirements?						
Explosion Prevention/Protection							
20.3	Have each of the key equipment type designs been assessed based on requirements of NFPA 61, Section 9.7?						
20.4	Are there any deficient or nonconforming items identified?						
	If yes, was a plan written with estimated dates for bringing structure into compliance with this set of requirements?						
Fire Protection		Yes	No	N/A	Comments	Action	Date Due
20.5	Have each of the key equipment type designs been assessed based on requirements of NFPA 61, Section 9.8?						
20.6	Are there any deficient or nonconforming items identified?						
	If yes, was a plan written with estimated dates for bringing structure into compliance with this set of requirements?						
21.0 HUMAN FACTOR		Yes	No	N/A	Comments	Action	Date Due
21.1	Does the facility have a sanitation program that includes cleaning and equipment integrity assessment based on dust releases and accumulations?						
21.2	Are all areas shown in 2.3 rated as unclassified due to equipment design and maintenance to prevent or limit dust releases, and do they include a sanitation program that calls for frequent cleaning to ensure they meet the requirements to remain unclassified?						
21.3	Does the sanitation program include requirements of NFPA 61, Section 8.4, Housekeeping?						
21.4	Are motor control centers (MCCs) pressurized to prevent dust infiltration?						
	If not, are they arranged to limit dust infiltration, and are they combined with an effective program to keep the room and cabinets free of dust accumulations?						
21.5	Does the housekeeping program address combustible dust accumulations at the following priority areas:						
	(a) Floors of enclosed areas containing grinding equipment?						
	(b) Floor areas within 10.7 m (35 ft) of inside bucket elevators?						
	(c) Floors of enclosed areas containing dryers located inside the facility?						
21.6	Are dust accumulations on ledges, walls, rafters, beams, ducts, and ceiling surfaces in identified priority areas maintained below acceptable limits [i.e., 0.32 cm (⅛ in.)]?						
21.7	Is there a plant hazard awareness training program?						
	Does it include the hazards associated with dust, dust accumulation, and deflagration?						
21.8	Where are the plant programs and records of inspection and training kept?						
21.9	Is smoking allowed in your facility? If yes, where?						
21.10	Are combustible dust hazard area identification procedures in place, and are all hazardous areas identified to employees and contractors (e.g., by sign, map, or other reference)?						
21.11	Before any activity that could cause dust to be suspended in air (e.g., the use of compressed air during cleaning of ledges, walls, beams, ducts, and surfaces), does the facility require that all nonrated electrical equipment be de-energized and all other known sources of ignition be removed or controlled?'						
21.12	Has a formal preventative maintenance program been established for dryers, dust collectors, flexible connectors, differential pressure gauges, bucket elevators, and any other dust handling/producing/processing equipment that specifically includes the verification of grounding and bonding?						

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Δ FIGURE F.3 *Continued*

AGRICULTURAL AND FOOD DUST HAZARD ANALYSIS (DHA) CHECKLIST

21.0 HUMAN FACTOR, continued		Yes	No	N/A	Comments	Action	Date Due
21.13	Are all critical safety systems inspected, tested, and/or calibrated per the OEM guidelines (as required by process safety assessment and NFPA facility standard)?						
21.14	Are all bearings maintained per the manufacturers' instructions or internal predictive maintenance program, and are they kept free of combustible dust, product, and excessive lubrication?						
21.15	Is there a contractor safety training program? Does it include awareness of the plant's dust hazards, hot work program, no smoking requirements per NFPA, and other requirements?						
21.16	Is there training for operators, maintenance personnel, and contractors on how to use and repair the central vacuum system?						
21.17	Is a means of fire-fighting (to include the use of water as an extinguishing agent) covered in operator, maintenance personnel, and contractor training?						
21.18	Are portable vacuums used for cleaning up combustible dusts listed for use in Class II areas?						
21.19	If a portable vacuum is used:						
	(a) Is it a conductive system?						
	(b) Are the hoses conductive and grounded, or static-dissipative?						
	(c) Is the fan protected from dust-laden air by a filter?						
21.20	If an electric portable vacuum is used, is the motor rated for a Class II, Division 1 location?						
21.21	Is there training for operators, maintenance personnel, and contractors on how to use and repair the portable vacuum systems?						
21.22	Is the portable vacuum used only for dry particulate solids so that the filter is always in place?						
21.23	Is there training for operators, maintenance personnel, and contractors on how to use and repair the portable vacuum system (e.g., conductive tools, ensuring that the exhaust dust does not disperse and suspend layers of dust deposits)?						
21.24	Does combustible dust accumulate on the overhead ductwork so that it could support a deflagration if dispersed?						
21.25	When a branch line is disconnected, blanked off, or otherwise modified, is the design of the entire system verified to ensure the whole system operates effectively?						
21.26	Is verifying that the ductwork is clean of combustible dusts a prerequisite to issuing hot work permits?						
21.27	Is there a hot work procedure in place before welding or cutting on ducts?						
21.28	Do maintenance and contract maintenance personnel receive training to learn that hot work produces localized heating of equipment and piping, as well as sparks, which can cause dust fires and explosions?						
21.29	Does the hot work permit reflect the intent of NFPA 51B?						
21.30	Is a new permit issued for every shift of hot work?						
21.31	Is equipment undergoing hot work always taken out of service and kept inoperable until the work is complete and equipment cooled?						
21.32	Have all hazards been cleared internally and externally from the equipment before starting hot work?						
21.33	Are all ignitible materials within 11 m (35 ft) removed or protected?						
21.34	Are all combustible dust layers within 11 m (35 ft) removed by cleaning before starting hot work?						
21.35	Has the area been checked for ignitible vapors and gasses?						
21.36	Are floors and structures in the work area covered with fire-proofed material or adequately wetted with water?						
21.37	Are welding shields present, if required, to protect passersby?						

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Δ **FIGURE F.3** ***Continued***

AGRICULTURAL AND FOOD DUST HAZARD ANALYSIS (DHA) CHECKLIST

21.0 HUMAN FACTOR, continued		Yes	No	N/A	Comments	Action	Date Due
21.38	If sparks could travel to an adjacent room through cracks or openings, have combustible materials all been moved or protected?						
21.39	Will any fire protection or detection systems be disabled as a result of this hot work?						
	If yes, is an active fire watch available?						
21.40	Is a trained fire watch present during the hot work and for 60 minutes after the hot work is completed?						
21.41	Are regular inspections of the work area made to ensure that no smoldering fires develop, including a final inspection performed prior to closing the area for the day or weekend?						
21.42	Have people responsible for the hot work operations received documented training to (1) inspect the proposed work area to determine that the conditions of the permit system have been met, (2) designate additional precautions as deemed necessary, and (3) sign the permit to authorize the work to begin?						
21.43	Is combustible dust training provided annually to staff involved in facility design and operation, including plant engineering and maintenance?						
21.44	Are contractors informed of all known/potential hazards related to their work as well as site safety rules to reduce combustible dust fire and explosion hazards, including, but not limited to, emergency action plans, hot work permits, avoiding potential ignition sources, grounding requirements, cleaning out of combustible material before commencing work, and prohibition of smoking in hazardous areas?						

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Δ FIGURE F.3 ***Continued***

Annex G Informational References

G.1 Referenced Publications. The documents or portions thereof listed in this annex are referenced within the informational sections of this standard and are not part of the requirements of this document unless also listed in Chapter 2 for other reasons.

Δ **G.1.1 NFPA Publications.** National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 1, *Fire Code*, 2018 edition.

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*, 2019 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 30, *Flammable and Combustible Liquids Code*, 2018 edition.

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

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

NFPA 87, *Standard for Fluid Heaters*, 2018 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 221, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls*, 2018 edition.

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

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

NFPA 499, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, 2017 edition.

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

NFPA 601, *Standard for Security Services in Fire Loss Prevention*, 2015 edition.

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

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, 2020 edition.

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, 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 2001, *Standard on Clean Agent Fire-Extinguishing Systems*, 2018 edition.

NFPA 5000®, *Building Construction and Safety Code*®, 2018 edition.

NFPA Guide to Combustible Dust, 2012 edition.

G.1.2 Other Publications.

G.1.2.1 AIHA Publications. American Industrial Hygiene Association, 3141 Fairview Park Drive, Suite 777, Falls Church, VA 22042.

ANSI/AIHA Z10, *Occupational Health and Safety Management Systems*, 2012.

G.1.2.2 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM E582, *Standard Test Method for Minimum Ignition Energy and Quenching Distance in Gaseous Mixtures*, 2007, reapproved 2013e1.

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

ASTM E1491, *Standard Test Method for Minimum Autoignition Temperature of Dust Clouds*, 2006 (2012).

ASTM E1515, *Standard Test Method for Minimum Explosible Concentration of Combustible Dusts*, 2014.

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

ASTM E2021, *Standard Test Method for Hot-Surface Ignition Temperature of Dust Layers*, 2015.

ASTM E2931, *Test Method for Limiting Oxygen (Oxidant) Concentration of Combustible Dust Clouds*, 2013.

G.1.2.3 IFA Publications. Institute for Occupational Safety and Health of the German Social Accident Insurance, Alte Heerstr. 111, 53757 Sankt Augustin, Germany.

GESTIS-DUST-EX Database Combustion, February 2001.

G.1.2.4 National Grain and Feed Association Publications. National Grain and Feed Association, 1400 Crystal Drive, Suite 260, Arlington, VA 22202.

Dust Explosion in Simulated Grain Conveyor Galleries, 1983 edition.

Emergency Preplanning and Fire Fighting Manual — A Guide for Grain Elevator Operators and Fire Department Officials, 1987.

N **G.1.2.5 NIBA Publications.** NIBA — The Belting Association, 22 North Carroll Street, Suite 300, Madison, WI 53703.

Technical Note 09, "Static Electricity Considerations," 2009.

G.1.2.6 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 1910.272, "Grain Handling Facilities."

Title 29, Code of Federal Regulations, Part 1910.119, "Process Safety Management of Highly Hazardous Chemicals."

Title 30, Code of Federal Regulations, Part 36, "Approved Requirements for Permissible Mobile Diesel-Powered Transportation Equipment."

Δ **G.1.2.7 Other Publications.**

AIChE *Guidelines for Hazard Evaluation Procedures*, 2008.

CCPS/AIChE *Guidelines for Safe Handling of Powders and Bulk Solids*, 2005.

FM Global Data Sheet 7-76, *Prevention and Mitigation of Combustible Dust Explosion and Fire.*

FM Global Data Sheet 10-3, *Hot Work Management.*

SFPE *Engineering Guide to Performance-Based Fire Protection*, 2006.

SFPE *Handbook of Fire Protection Engineering*, 2016.

G.2 Informational References. The following documents or portions thereof are listed here as informational resources only. They are not a part of the requirements of this document.

Industrial Ventilation, A Manual of Recommended Practice for Design, American Conference of Governmental Industrial Hygienists (ACGIH), 27th edition, 2010.

Δ **G.3 References for Extracts in Informational Sections.**

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

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

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, 2020 edition.

Index

Sequence of Events for the Standards Development Process

Once the current edition is published, a Standard is opened for Public Input.

Step 1 – Input Stage

- Input accepted from the public or other committees for consideration to develop the First Draft
- Technical Committee holds First Draft Meeting to revise Standard (23 weeks); Technical Committee(s) with Correlating Committee (10 weeks)
- Technical Committee ballots on First Draft (12 weeks); Technical Committee(s) with Correlating Committee (11 weeks)
- Correlating Committee First Draft Meeting (9 weeks)
- Correlating Committee ballots on First Draft (5 weeks)
- First Draft Report posted on the document information page

Step 2 – Comment Stage

- Public Comments accepted on First Draft (10 weeks) following posting of First Draft Report
- If Standard does not receive Public Comments and the Technical Committee chooses not to hold a Second Draft meeting, the Standard becomes a Consent Standard and is sent directly to the Standards Council for issuance (see Step 4) or
- Technical Committee holds Second Draft Meeting (21 weeks); Technical Committee(s) with Correlating Committee (7 weeks)
- Technical Committee ballots on Second Draft (11 weeks); Technical Committee(s) with Correlating Committee (10 weeks)
- Correlating Committee Second Draft Meeting (9 weeks)
- Correlating Committee ballots on Second Draft (8 weeks)
- Second Draft Report posted on the document information page

Step 3 – NFPA Technical Meeting

- Notice of Intent to Make a Motion (NITMAM) accepted (5 weeks) following the posting of Second Draft Report
- NITMAMs are reviewed and valid motions are certified by the Motions Committee for presentation at the NFPA Technical Meeting
- NFPA membership meets each June at the NFPA Technical Meeting to act on Standards with "Certified Amending Motions" (certified NITMAMs)
- Committee(s) vote on any successful amendments to the Technical Committee Reports made by the NFPA membership at the NFPA Technical Meeting

Step 4 – Council Appeals and Issuance of Standard

- Notification of intent to file an appeal to the Standards Council on Technical Meeting action must be filed within 20 days of the NFPA Technical Meeting
- Standards Council decides, based on all evidence, whether to issue the standard or to take other action

Notes:

1. Time periods are approximate; refer to published schedules for actual dates.
2. Annual revision cycle documents with certified amending motions take approximately 101 weeks to complete.
3. Fall revision cycle documents receiving certified amending motions take approximately 141 weeks to complete.

Committee Membership Classifications[1,2,3,4]

The following classifications apply to Committee members and represent their principal interest in the activity of the Committee.

1. M *Manufacturer:* A representative of a maker or marketer of a product, assembly, or system, or portion thereof, that is affected by the standard.
2. U *User:* A representative of an entity that is subject to the provisions of the standard or that voluntarily uses the standard.
3. IM *Installer/Maintainer:* A representative of an entity that is in the business of installing or maintaining a product, assembly, or system affected by the standard.
4. L *Labor:* A labor representative or employee concerned with safety in the workplace.
5. RT *Applied Research/Testing Laboratory:* A representative of an independent testing laboratory or independent applied research organization that promulgates and/or enforces standards.
6. E *Enforcing Authority:* A representative of an agency or an organization that promulgates and/or enforces standards.
7. I *Insurance:* A representative of an insurance company, broker, agent, bureau, or inspection agency.
8. C *Consumer:* A person who is or represents the ultimate purchaser of a product, system, or service affected by the standard, but who is not included in (2).
9. SE *Special Expert:* A person not representing (1) through (8) and who has special expertise in the scope of the standard or portion thereof.

NOTE 1: "Standard" connotes code, standard, recommended practice, or guide.

NOTE 2: A representative includes an employee.

NOTE 3: While these classifications will be used by the Standards Council to achieve a balance for Technical Committees, the Standards Council may determine that new classifications of member or unique interests need representation in order to foster the best possible Committee deliberations on any project. In this connection, the Standards Council may make such appointments as it deems appropriate in the public interest, such as the classification of "Utilities" in the National Electrical Code Committee.

NOTE 4: Representatives of subsidiaries of any group are generally considered to have the same classification as the parent organization.

Submitting Public Input / Public Comment Through the Online Submission System

Following publication of the current edition of an NFPA standard, the development of the next edition begins and the standard is open for Public Input.

Submit a Public Input

NFPA accepts Public Input on documents through our online submission system at www.nfpa.org. To use the online submission system:

- Choose a document from the List of NFPA codes & standards or filter by Development Stage for "codes accepting public input."
- Once you are on the document page, select the "Next Edition" tab.
- Choose the link "The next edition of this standard is now open for Public Input." You will be asked to sign in or create a free online account with NFPA before using this system.
- Follow the online instructions to submit your Public Input (see www.nfpa.org/publicinput for detailed instructions).
- Once a Public Input is saved or submitted in the system, it can be located on the "My Profile" page by selecting the "My Public Inputs/Comments/NITMAMs" section.

Submit a Public Comment

Once the First Draft Report becomes available there is a Public Comment period. Any objections or further related changes to the content of the First Draft must be submitted at the Comment Stage. To submit a Public Comment follow the same steps as previously explained for the submission of Public Input.

Other Resources Available on the Document Information Pages

Header: View document title and scope, access to our codes and standards or NFCSS subscription, and sign up to receive email alerts.

Current & Prior Editions	Research current and previous edition information.
Next Edition	Follow the committee's progress in the processing of a standard in its next revision cycle.
Technical Committee	View current committee rosters or apply to a committee.
Ask a Technical Question	For members, officials, and AHJs to submit standards questions to NFPA staff. Our Technical Questions Service provides a convenient way to receive timely and consistent technical assistance when you need to know more about NFPA standards relevant to your work.
News	Provides links to available articles and research and statistical reports related to our standards.
Purchase Products & Training	Discover and purchase the latest products and training.
Related Products	View related publications, training, and other resources available for purchase.

Information on the NFPA Standards Development Process

I. Applicable Regulations. The primary rules governing the processing of NFPA standards (codes, standards, recommended practices, and guides) are the NFPA *Regulations Governing the Development of NFPA Standards (Regs)*. Other applicable rules include NFPA *Bylaws*, NFPA *Technical Meeting Convention Rules*, NFPA *Guide for the Conduct of Participants in the NFPA Standards Development Process*, and the NFPA *Regulations Governing Petitions to the Board of Directors from Decisions of the Standards Council*. Most of these rules and regulations are contained in the *NFPA Standards Directory*. For copies of the *Directory*, contact Codes and Standards Administration at NFPA headquarters; all these documents are also available on the NFPA website at "www.nfpa.org/regs."

The following is general information on the NFPA process. All participants, however, should refer to the actual rules and regulations for a full understanding of this process and for the criteria that govern participation.

II. Technical Committee Report. The Technical Committee Report is defined as "the Report of the responsible Committee(s), in accordance with the Regulations, in preparation of a new or revised NFPA Standard." The Technical Committee Report is in two parts and consists of the First Draft Report and the Second Draft Report. (See *Regs* at Section 1.4.)

III. Step 1: First Draft Report. The First Draft Report is defined as "Part one of the Technical Committee Report, which documents the Input Stage." The First Draft Report consists of the First Draft, Public Input, Committee Input, Committee and Correlating Committee Statements, Correlating Notes, and Ballot Statements. (See *Regs* at 4.2.5.2 and Section 4.3.) Any objection to an action in the First Draft Report must be raised through the filing of an appropriate Comment for consideration in the Second Draft Report or the objection will be considered resolved. [See *Regs* at 4.3.1(b).]

IV. Step 2: Second Draft Report. The Second Draft Report is defined as "Part two of the Technical Committee Report, which documents the Comment Stage." The Second Draft Report consists of the Second Draft, Public Comments with corresponding Committee Actions and Committee Statements, Correlating Notes and their respective Committee Statements, Committee Comments, Correlating Revisions, and Ballot Statements. (See *Regs* at 4.2.5.2 and Section 4.4.) The First Draft Report and the Second Draft Report together constitute the Technical Committee Report. Any outstanding objection following the Second Draft Report must be raised through an appropriate Amending Motion at the NFPA Technical Meeting or the objection will be considered resolved. [See *Regs* at 4.4.1(b).]

V. Step 3a: Action at NFPA Technical Meeting. Following the publication of the Second Draft Report, there is a period during which those wishing to make proper Amending Motions on the Technical Committee Reports must signal their intention by submitting a Notice of Intent to Make a Motion (NITMAM). (See *Regs* at 4.5.2.) Standards that receive notice of proper Amending Motions (Certified Amending Motions) will be presented for action at the annual June NFPA Technical Meeting. At the meeting, the NFPA membership can consider and act on these Certified Amending Motions as well as Follow-up Amending Motions, that is, motions that become necessary as a result of a previous successful Amending Motion. (See 4.5.3.2 through 4.5.3.6 and Table 1, Columns 1-3 of *Regs* for a summary of the available Amending Motions and who may make them.) Any outstanding objection following action at an NFPA Technical Meeting (and any further Technical Committee consideration following successful Amending Motions, see *Regs* at 4.5.3.7 through 4.6.5) must be raised through an appeal to the Standards Council or it will be considered to be resolved.

VI. Step 3b: Documents Forwarded Directly to the Council. Where no NITMAM is received and certified in accordance with the *Technical Meeting Convention Rules*, the standard is forwarded directly to the Standards Council for action on issuance. Objections are deemed to be resolved for these documents. (See *Regs* at 4.5.2.5.)

VII. Step 4a: Council Appeals. Anyone can appeal to the Standards Council concerning procedural or substantive matters related to the development, content, or issuance of any document of the NFPA or on matters within the purview of the authority of the Council, as established by the *Bylaws* and as determined by the Board of Directors. Such appeals must be in written form and filed with the Secretary of the Standards Council (see *Regs* at Section 1.6). Time constraints for filing an appeal must be in accordance with 1.6.2 of the *Regs*. Objections are deemed to be resolved if not pursued at this level.

VIII. Step 4b: Document Issuance. The Standards Council is the issuer of all documents (see Article 8 of *Bylaws*). The Council acts on the issuance of a document presented for action at an NFPA Technical Meeting within 75 days from the date of the recommendation from the NFPA Technical Meeting, unless this period is extended by the Council (see *Regs* at 4.7.2). For documents forwarded directly to the Standards Council, the Council acts on the issuance of the document at its next scheduled meeting, or at such other meeting as the Council may determine (see *Regs* at 4.5.2.5 and 4.7.4).

IX. Petitions to the Board of Directors. The Standards Council has been delegated the responsibility for the administration of the codes and standards development process and the issuance of documents. However, where extraordinary circumstances requiring the intervention of the Board of Directors exist, the Board of Directors may take any action necessary to fulfill its obligations to preserve the integrity of the codes and standards development process and to protect the interests of the NFPA. The rules for petitioning the Board of Directors can be found in the *Regulations Governing Petitions to the Board of Directors from Decisions of the Standards Council* and in Section 1.7 of the *Regs*.

X. For More Information. The program for the NFPA Technical Meeting (as well as the NFPA website as information becomes available) should be consulted for the date on which each report scheduled for consideration at the meeting will be presented. To view the First Draft Report and Second Draft Report as well as information on NFPA rules and for up-to-date information on schedules and deadlines for processing NFPA documents, check the NFPA website (www.nfpa.org/docinfo) or contact NFPA Codes & Standards Administration at (617) 984-7246.